highways england

A47 Wansford to Sutton Dualling

Scheme Number: TR010039

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6.3 Environmental Statement Appendices
Appendix 13.5 – Geomorphological assessment

APFP Regulation 5(2)(a)

Planning Act 2008

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

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Planning Act 2008

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

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Appendix 13.5 - Geomorphological assessment

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Captions

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1. Introduction

1.1.1. This report will describe the geomorphological setting of Wittering Brook that may be impacted by the construction of the A47 Wansford to Sutton (the Proposed Scheme). This survey was carried out to assess the current geomorphic setting of the watercourse. The survey also assessed any impacts due to realignment and other pressures, sediment transport potential and other factors.

1.1.2. The morphological stability of Wittering Brook is assessed in terms of planned infrastructure in the vicinity of the watercourse, with construction and operational impacts discussed and mitigation measures proposed.

2. Methods

2.1. Approach

2.1.1. A fluvial audit of Wittering Brook was undertaken. This involved both a desktop assessment and a walkover survey. The methods of both are summarised below. Guidance on designing the geomorphic walkover survey was taken from the DMRB standard on 'Hydromorphological assessment' (Highways England, 2020)

2.2. Desktop review

2.2.1. A desktop review of background and historical information related to the catchment watercourses was undertaken to characterise the geological setting of the catchment.

2.2.2. The following information sources were reviewed as part of the desktop assessment:

- superficial and bedrock geology maps of the catchment area from the British Geological Survey (BGS, 2020)
- historical Ordnance Survey (OS) maps from the National Library of Scotland (NLS, 2020)
- historical air photos and satellite imagery
- Water Framework Directive (WFD) monitoring data for the catchment (Environment Agency, 2020)
- documents related to land use and channel adjustments (for example Estate Papers, River Board and Water Authority records)
- reports documenting any previous research undertaken on the rivers

2.3. Geomorphic walkover survey

2.3.1. The walkover surveys were undertaken to ground truth evidence of geomorphic change and / or instability that may be impacted by the construction of the Proposed Scheme. Dominant geomorphic processes occurring on each river reach were also identified to ensure baseline conditions are adhered to, or improved upon, as far as possible.

2.3.2. The geomorphology competent expert (PhD, MSc, BSc (Hons)) has 12 years of experience in the water sector and has successfully delivered many geomorphological studies and reports, supporting technical assessments for large infrastructure projects.

2.3.3. The walkover survey was conducted in May 2020. A field tablet computer loaded with ArcGIS Collector was used to record key geomorphic features, processes and anthropogenic pressures whilst walking the length of the river. This approach enabled the production of more accurate mapping of the extent and location of features using the tablet's global positioning system (GPS) receiver. Subsequently, recorded features were automatically uploaded to a geographic information system (GIS) system.

2.3.4. The following information was recorded during the walkover surveys:

- typology of the river and whether this differed from what the predicted natural typology would be (see Table 2-1)
- the stability status of the channel, which characterises the dominant processes occurring within the reach (see Table 2-2 and Table 2-3)
- substrate of the channel
- significant areas of bank erosion or basal scour
- significant areas of deposition
- sources and type of sediment input to the channel (for example landslides, rock fall, bank erosion, tributary streams, poaching)
- anthropogenic pressures on the channel (for example bridges, bank protection, weirs, realignments, invasive species)

Table 2-1 Description of typologies used

Typology	Characteristics
Bedrock	Typically, steep gradient, bed and channel banks show significant areas of obvious bedrock. Cobbles and gravels may exist on the bed also. No floodplain development
Step-pool	Gradient still generally steep, with little floodplain development. Channel has regular or semi-regular well-developed steps, separated typically by pools. Substrate typically composed of large cobbles and boulders, with some gravels.
Plane-bed	A transitionary typology between step-pool and pool-riffle. Typically, moderate gradient, with some floodplain development, but channel often incised below floodplain. Featureless bed often armoured with cobbles. Irregular steps, and irregular bars might be present, as well as a relatively straight planform.
Pool-riffle	Generally shallow gradient, and a relatively wide floodplain. Planform becomes sinuous, with more obvious depositional features such as bars, and more signs of erosion on banks.
Active-meander	Shallow gradient, with a wide floodplain. Extensive depositional and erosional features, and well-developed meanders leading to a sinuous planform.

2.3.5. It is noted in practice, sometimes rivers go through a transitionary reach between typologies, or can be 'more' one typology than another. In these cases, it falls to the expert judgment of the geomorphologists surveying the watercourse to understand which typology is more dominant.

2.3.6. A visual assessment of the dominant processes occurring on each reach were classified based on the criteria outlined in Table 2-2. This involved recording observations of erosional or depositional processes occurring within the channel.

2.3.7. Table 2-3 lists the observations and assessments conducted as part of the ST:REAM survey (Sediment Transport: Reach Equilibrium Assessment Method) to determine the stability status.

Table 2-2 Criteria for classification of dominant processes

Stability status	Characteristics
Erosional source	No evidence of deposition, only erosion.
Erosional exchange	Erosion dominant, but some small-scale depositional features present.
Balance exchange	Evidence of both deposition and erosion are both present on the reach.
Balance transport	Limited evidence of either deposition or erosion observed (generally bedrock channels or heavily modified channels have this classification)
Depositional exchange	Depositional features dominant, but some evidence of erosion observed.
Depositional sink	Only depositional features present (typically approaching lakes or confluences)

Table 2-3 Field observations indicating erosion or depositional dominant channels (Parker et al., 2015)

Dominant process	Indicators
Erosion	Terraces Old channels in floodplain Undermined structures Exposed tree roots Tree collapse (both banks) Trees leaning towards channel (both banks) Drowned trees in channel Narrow/deep channel Bank failures (both banks) Thick gravel exposure in the banks overlain by fines Armoured compacted bed
Deposition	Buried structures Buried soil horizons Many uncompacted ‘over loose’ bars Eroding banks at shallows Contracting bridge openings Deep, fine sediment overlying coarse particles in bed/banks Many unvegetated bars

3. Geomorphology surveys

3.1. Introduction

3.1.1. The following sections will describe the geomorphology survey undertaken noting the geomorphological conditions and any modifications to the channel which may impact the geomorphic stability.

3.2. Wittering Brook

3.2.1. A geomorphological map of the Mill Stream and Wittering Brook is presented in Annex A.

3.2.2. Mill Stream has a catchment area of approximately 22km^2 and rises approximately 5km west of the village of Wansford and flows in an easterly direction before entering the Wittering Brook approximately 1km north of the River Nene. The Wittering Brook has a catchment area of approximately 49km^2 and flows in a roughly southerly direction until it enters the River Nene approximately halfway between Wansford and the village of Sutton.

3.2.3. The underlying geology is somewhat complex, as the watercourse flows across the contact between two bedrock formations, the Inferior Oolite Group and the Lias Group. Both are composed of sandstones, mudstones, limestones and siltstones and thus are quite friable and susceptible to erosion.

3.2.4. The 1st edition Ordnance Survey (OS) maps show the Mill Stream and Wittering Brook in the area of the survey to have occupied their present courses with little evidence of channel migration since at least the late 19th century. This is common for small re-aligned watercourses that have been over deepened, which were likely realigned prior to the 1st edition OS maps. The entire watercourses in the survey area can be considered heavily modified in this respect, as there is little evidence from the planform of any natural features (for example, meanders and sinuosity).

3.3. Water Framework Directive (WFD) classification

3.3.1. The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 achieve ‘good’ status for all groundwater and surface waterbodies. The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 has been amended by the Floods and Water (Amendment etc.) (EU Exit) Regulations 2019/558 so as to continue to have effect. To achieve ‘good’ status overall, a water body must achieve good status in all the River Basin Management Plan (RBMP) assessment criteria (biological, hydro-morphological, physio-chemical and chemical quality), therefore, a

deterioration in one of these criteria may result in the water body failing to meet the Water Framework Directive (WFD) objectives.

3.3.2. Wittering Brook WFD water body (WBID: GB105032050350) current hydromorphological classification is set as 'not designated artificial or heavily modified'. It is part of the Nene Middle Operational Catchment.

3.3.3. Based on the 2019 status, the current Anglian RBMP, as shown by the Environment Agency's Catchment Data Explorer website (Environment Agency, 2020) indicates that the Wittering Brook's WFD water body overall classification is 'moderate'. Wittering Brook's WFD water body ecological status is limited to 'moderate' by the physico-chemical quality. The chemical status is classified as a 'fail' due to the presence of priority hazardous substances (polybrominated diphenyl ethers). The overall status is expected to remain at 'moderate' due to unfavourable balance of costs and benefits.

3.3.4. Table 3-1 below lists the reasons for Wittering Brook not achieving 'good' overall status:

Table 3-1 Wittering Brook WFD water body (WBID: GB105032050350) Reasons for Not Achieving Good Status (Environment Agency, 2020)

Id	Significant Water Management Issues (SWMI)	SWMI Certainty	Activity	Activity Certainty	Category	Category Certainty	Business Sector	Classification Element
482889	Point source	Probable	Sewage discharge (continuous)	Confirmed	Water industry	Confirmed	Waste water treatment	Phosphate
482891	Diffuse source	Probable	Poor nutrient management	Probable	Agriculture and rural land management	Probable	Agriculture - arable	Phosphate
510448	Diffuse source	Probable	Poor livestock management	Probable	Agriculture and rural land management	Probable	Agriculture - livestock	Phosphate
533176	Diffuse source	Suspected	Transport drainage	Suspected	Urban and transport	Probable	Urban	Phosphate

3.3.5. With respect to the Proposed Scheme, it can be seen that the existing WFD status is probably lowered by the presence of phosphates being washed into the watercourse from agricultural fields, using roads as pathways. No further information is available on the contribution of the transport sector to the elevated phosphate concentrations or which roads it is being channelled through. Phosphorous can be transported in both dissolved and sediment bound forms.

3.4. Geomorphological walkover

3.4.1. This section describes the conditions found on the geomorphological walkover survey undertaken in May 2020. A geomorphological map of the Mill Stream and Wittering Brook is presented in Annex A. The walkover survey began at the downstream end of the culvert under the A1 on the Mill Stream and continued downstream to the confluence with Wittering Brook, ending at the confluence of Wittering Brook with the River Nene.

3.4.2. Despite the WFD status classifying the watercourse as 'not heavily modified', it is clear that significant modification has occurred throughout the reach, which shall be described below.

Caption 3.1 - downstream outlet of culvert under A1

3.4.3. At the upstream end, the culvert (approximately 2m in width) under the existing A1 road appears to be too small to allow successful conveyance of sediment, as

the downstream end was observed to be very silted up (Caption 3.1). The watercourse has been significantly straightened and over deepened, running for approximately 400m from the culvert until it enters a mill pond next to a historic working mill on Sacrewell Farm (Caption 3.2). The watercourse goes through a series of weirs, and sluices through the farm, maintained as part of the original working mill structures.

Caption 3.2 - Looking downstream at Sacrewell Farm mill pond.

3.4.4. Downstream of the mill area, the watercourse continues flowing in an easterly direction through a straightened agricultural channel. This reach, while lacking sinuousity, bank erosion or other features of a natural pool riffle typology, has some evidence of gravel bedforms on the channel bed suggesting a partial recovery (Caption 3.3).

3.4.5. The channel turns at a 90 degree angle and flows due south, being met by another drain from the north. The channel continues to be a straightened ditch and becomes significantly over deepened and silted up. Historic mapping suggests that this channel realignment may be due to an old railway line, now dismantled.

Caption 3.3 - Straightened channel downstream of Sacrewell Farm.

3.4.6. The channel enters a woodland as it approaches the A47, where the channel becomes shallower again. At the time of survey, recent evidence of out-of-bank flow on the right bank was observed (Caption 3.4.)

Caption 3.4 - Floodplain on right bank of channel, recently inundated.

3.4.7. The culvert under the A47 is approximately 1.5m in diameter, and appears appropriately sized for the channel, with no blockages noticed (Caption 3.5). Downstream of the culvert, the channel runs in a relatively sinuous course until it reaches its confluence with the River Nene, where the survey ended (Caption 3.6).

Caption 3.5 - Existing culvert under the A47.

Caption 3.6 - Confluence with the River Nene.

3.5. Discussion

3.5.1. Despite the WFD classification of 'not designated artificial or heavily modified', the surveyed Mill Stream and Wittering Brook cannot be considered a 'natural' watercourse due to its long history of modification from mill works, agriculture and transport infrastructure. However, its current WFD status is classed as moderate, which suggests that it has the potential to have good ecological function. One of the reasons for not achieving good status is suspected to be phosphates from transport drainage.

3.5.2. Further, the current dimensions of the culvert under the existing A47 appears to be of a sufficient size to allow suitable conveyance of sediment. Any design of an extended culvert should ensure that there is no loss in width or height to the culvert so that current sediment transport processes are unaffected.

4. Impacts of Proposed Scheme

4.1.1. Wittering Brook currently passes through the A47 embankment via an existing masonry arch culvert, Wansford Sluice. For improved buildability, upstream flood management and future maintenance requirements, the existing culvert will be replaced. The replacement structure, Wansford Sluice Extension, will be constructed slightly west of the existing culvert with short inlet and outlet realignments. This will maintain the watercourse passage of Wittering Brook beneath the widened embankment of the new A47 dual carriageway alignment. The downstream end of the A1 culvert is to be extended to accommodate the A1/A47 free flow link road. The length of the extension is to be confirmed at the detailed design stage.

4.1.2. The proposed replacement structure is a buried reinforced concrete box with capacity for the 1 in 100-year (including a 65% climate change allowance) design flood event. The structure also features mammal ledges for safe passage of wildlife to either side of the A47 embankment. General arrangement drawings of the structures can be found in (**TR010039/APP/2.6**) and a complete description of the Proposed Scheme can be found in Chapter 2 of the Environmental Statement (The Proposed Scheme) (**TR010039/APP/6.1**).

4.2. Construction impacts

4.2.1. The temporary works in the vicinity of the watercourse has the potential to mobilise sediment and contaminants from surface water runoff to watercourses from road construction activities such as vegetation removal, earthworks, materials management and the use of plant and vehicles.

4.2.2. The modification to the culverts under the A1 and the A47, and the minor watercourse diversion planned for the construction, also has the potential to mobilise sediment and contaminants. As stated, the river has the potential to achieve good ecological status, therefore, any increase in sedimentation caused by construction activities would have an impact on this status potential.

4.3. Operational impacts

4.3.1. The proposed culverts will result in the loss of existing riparian channel bed and banks. An additional 36m of culvert is proposed under the existing A47, from the current 24m culvert to be replaced with a new 60m box culvert.

4.3.2. There is a potential for new road surfaces to transport phosphates from agricultural runoff into the watercourse, as is assessed in the WFD status as an ongoing reason for not achieving Good Status.

4.3.3. The proposed culverts are unlikely to have any significant impact on sediment transport in the watercourse, provided that there is no change in conveyance capacity for any sediment that is transported. Artificial culvert beds may decrease channel roughness and may increase velocities and thus sediment transport rates in the local reach, which has the potential to impact the geomorphic stability of the watercourse over the longer term.

4.3.4. A key operational impact on the geomorphological features of the watercourses from the Proposed Scheme is sedimentation. Increases in hard standing areas due to the presence of the road surface and associated infrastructure has the potential to increase surface water runoff, and with it, increased sediment being washed into the Wittering Brook. This coupled with the associated increase in traffic volumes will result in an increase in pollutant loads, including sediment, in highway runoff being discharged into the Wittering Brook.

4.3.5. Another key impact of the Proposed Scheme on the geomorphology features of the Wittering Brook would be on channel stability. The main area in which channel stability may be impacted is the proposed minor realignments of the watercourse upstream and downstream of the new Wansford Sluice Extension culvert.

5. Mitigation during construction and operation

5.1.1. Consultation with the Environment Agency (EA) and Peterborough City Council was undertaken to discuss the Proposed Scheme's impacts and mitigation requirements.

5.1.2. Length-for-length de-culverting is not considered feasible in this case, therefore additional mitigation measures to ensure compliance with WFD objectives were considered.

5.1.3. For no deterioration in river water quality, aquatic ecology, and hence the WFD status of the river, robust silt management during construction and operation of the Proposed Scheme is required. Sediment should be controlled as close to the source as possible, and sediment traps should be installed alongside new drainage measures. These should be maintained with regular inspection and cleaning.

5.1.4. It is proposed to create an area of new ponds, ditch and wetland between the A1 and Sacrewell Mill on land adjacent to the Mill Stream. The proposed habitat would improve water quality and increase biodiversity and is provided, in part, to mitigate the loss of water vole habitat due to the proposed A47 Wansford Sluice Extension. Also, there is an opportunity to re-meander the straightened section of the Mill Stream watercourse (upstream of the mill pond) to create improved riverine habitat.

5.1.5. These wetland creation schemes may have the potential to mitigate the loss of riparian habitat by the culvert extensions, but also may impact the geomorphological stability of the channel. Further analysis would need to be undertaken at detailed design stage.

5.2. Construction

5.2.1. Offline construction of the minor watercourse realignment and the culvert should be done to minimise releasing sediments into the watercourse prior to operation.

5.2.2. Location details of the proposed mitigation measures can be found on the Environmental Masterplan (**TR010039/APP/6.8**).

5.2.3. The design of the measures would be undertaken at detailed design stage in consultation with the Environment Agency, Peterborough City Council and other stakeholders.

5.3. Operation

5.3.1. To minimise geomorphological impacts on the watercourses, the culvert designs, and associated watercourse diversion where it ties into the existing watercourse, must maintain existing flow and sediment conveyance. The installation of natural sediment beds and mammal ledges within the culvert would minimise the impact on channel connectivity including the aquatic ecology, should the A1 Mill Stream culvert require replacement.

5.3.2. An assessment of pollution impacts from routine runoff to surface waters was undertaken using Highways England Water Risk Assessment Tool (HEWRAT). This assessment establishes potential impacts of pollutants (including sediment) in routine highway runoff for the Proposed Scheme upon the watercourses within the study area and the requirement for mitigation measures to adequately reduce the risk. The routine runoff assessment and spillage assessment shows that there is a negligible impact following dilution in the channel for both soluble and sediment-bound pollutants when the additional measures from the drainage design have been included. Water quality treatment measures include infiltration basins and vegetated detention basins. There is also an intention in the proposed drainage design to provide filter drains. However, these are to be considered further during detailed design. All three of these measures facilitate sediment removal with treatment efficiencies of 50% and 60% for detention basins and filter drains, respectively (DMRB CG501; Highways England, 2020). The output from the runoff assessments can be found in Appendix 13.3 (Surface water quality assessment) (**TR010039/APP/6.3**) and the proposed drainage design can be found in Appendix 13.2 (Drainage strategy) (**TR010039/APP/6.3**).

5.3.3. Site specific design of the outfalls has not been undertaken at preliminary design. Outfall design should ensure the outfall structure is set back from the channel bank and bed to minimise the impact on flow and sediment conveyance. The outfall should be placed at location that is geomorphologically active (erosion, deposition or channel migration). Scour protection should be incorporated into the design to ensure no bank or bed erosion results from the discharge to the watercourse. Outfall design should comply with the guidance set out in CIRIA's Culvert, screen and outfall manual (Benn. J. *et al.*, 2019).

6. Conclusion

6.1.1. The Wittering Brook is a tributary of the River Nene, flowing south and entering the Nene close to the village of Wansford.

6.1.2. The watercourse's WFD status is 'moderate' and not classified as heavily modified or artificial, albeit the survey found that the watercourse is heavily modified throughout the surveyed reach. Diffuse phosphate pollution from agricultural sources, using transport infrastructure as pathways, is listed as one of the reasons for not attaining 'good' status.

6.1.3. The Proposed Scheme would install a new culvert underneath the A47. The Proposed would also require the downstream extension of the A1 culvert to accommodate the A1 / A47 free flow link road although the design of the culvert is still to be determined. The culvert under the A47 will be a 60m long concrete box culvert, with minor realignment of the watercourse immediately upstream and downstream.

6.1.4. Construction impacts upon the channel would be primarily due to increased siltation of the channel due to the construction of the new culverts and minor realignments planned.

6.1.5. Operational impacts would be primarily sedimentation being channelled into the watercourse from transport pathways (road drainage).

6.1.6. Mitigation should include robust silt measures during both construction and operation, to ensure no additional siltation occurs within the channel.

6.1.7. Should infrastructure be required in channel, it is recommended to carry out hydraulic modelling to specifically determine the shear stress present on the channel banks and the proposed infrastructure. This will allow structures to be designed to withstand expected hydraulic loading from the flow of water. This would also give an understanding on the likely changes to flow regimes any infrastructure may cause, which could have an impact on erosion rates of the channel.

7. References

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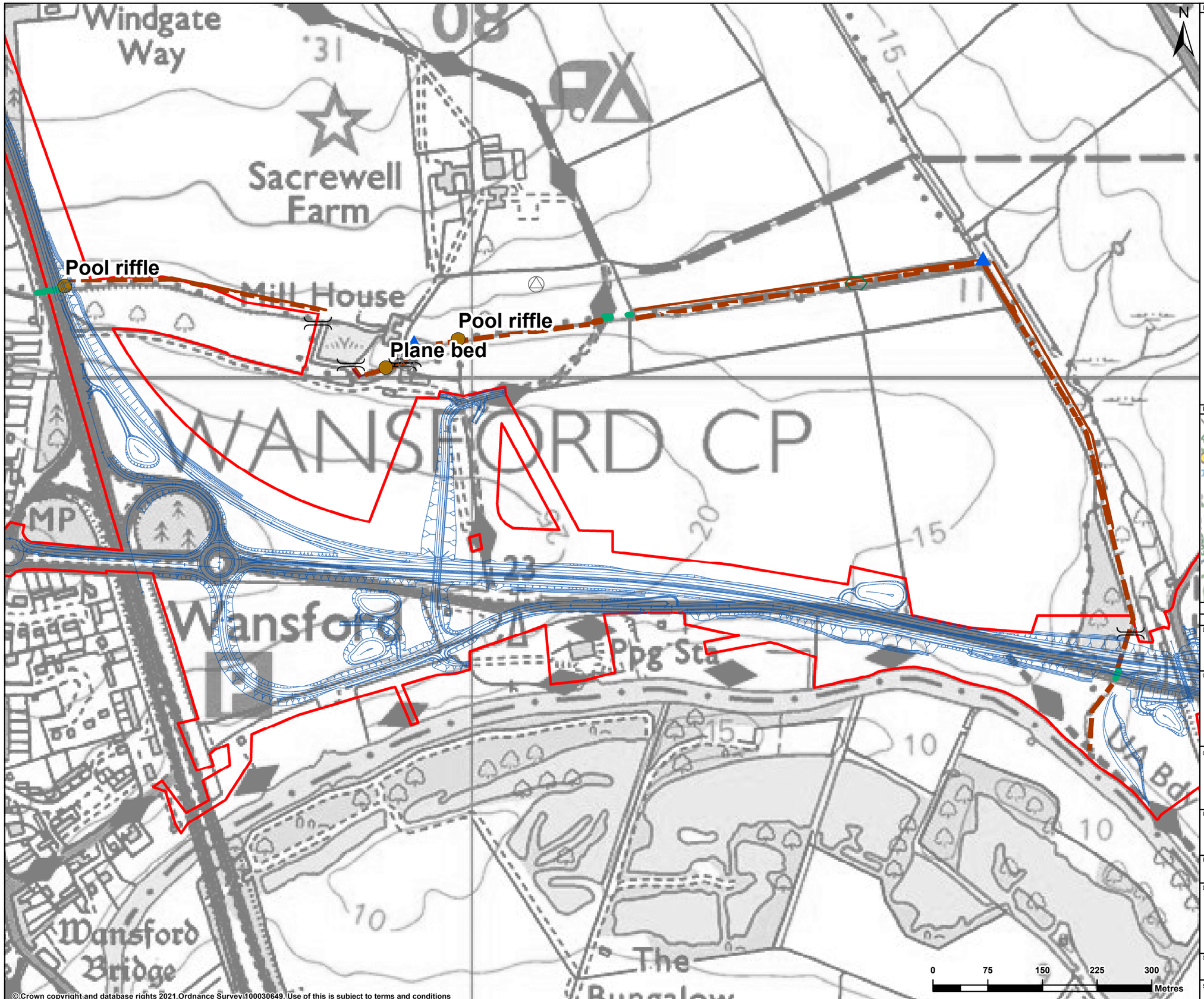
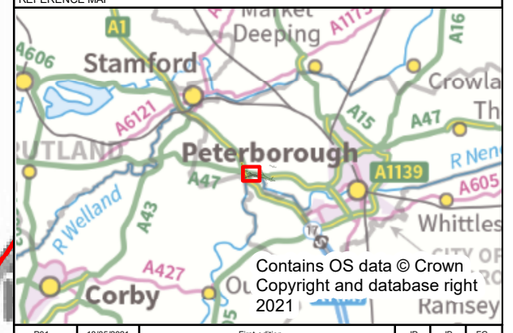
Annex A. Geomorphological Survey Map



LEGEND

- A47 - Proposed Design
- Pool
- Riffle
- Tributary/Drain
- Poaching
- Bed_protection
- Bed_erosion
- Typology
- Bank Erosion
- Weir
- Bridge
- Existing realignment
- Grey Bank Protection
- Embankment
- Culvert
- Proposed Scheme boundary

REFERENCE MAP



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P01	18/05/2021	First edition	JP	JB	FG

DESIGNER

SWECO

CONTRACTOR

GallifordTry

CLIENT

highways england

PROJECT TITLE

A47 WANSFORD TO SUTTON

PROJECT STAGE

PCF STAGE 3

DRAWING TITLE

GEOMORPHOLOGICAL SURVEY MAP

SUITABILITY

FOR REVIEW AND COMMENT

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A3	1:5,000	S3

DRAWING NUMBER

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