Gatwick Airport Northern Runway Project

Environmental Statement
Appendix 11.9.6: Flood Risk Assessment – Annex 7 - Culvert Assessment

Book 10

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1 Introduction

1.1. Context and Purpose

1.1.1 The surface access (highways) improvements proposed as part of the Northern Runway Project (the Project) interact with the following watercourses designated as a 'Main River' by the Environment Agency: Burstow Stream, Haroldsea Stream, Gatwick Stream, River Mole and Withy Brook, in addition to several ordinary watercourses.

1.1.2 The proposed highways improvement works would result in an increase in highways capacity and a corresponding increase in paved area, therefore, the Surface Access Highways Surface Water Drainage Strategy in **ES Appendix 11.9.6 Annex 2** [APP-148] has been developed to make best use of the existing surface water management network, while providing additional attenuation facilities where required and reconfiguration of existing infrastructure where that would provide wider flood risk benefit.

1.1.3 All watercourse crossings interacting with the surface access works are identified in Figure 1.1 and listed in Table 1.1.

Table 1.1: Culvert watercourse crossings

Culvert ID	Watercourse Crossing	National Grid Reference (NGR)
EX-CU1	Ordinary Watercourse (Unnamed Ditch)	TQ 30195 41719
EX-CU2	Ordinary Watercourse (Haroldsea Stream) (Main River from outlet)	TQ 29422 41655
EX-CU3	Main River (Gatwick Stream)	TQ 28541 41637
EX-CU4	Ordinary Watercourse (Unnamed Ditch)	TQ 27553 42551
PR-CU1	Ordinary Watercourse (Unnamed Ditch)	TQ 29373 41702
PR-CU1A	Ordinary Watercourse (Unnamed Ditch)	TQ 29403 41640
PR-CU1B	Ordinary Watercourse (Unnamed Ditch)	TQ 29360 41749
BTN-BR	Main River (River Mole)	TQ 27555 42545
LDN-BR	Main River (River Mole)	TQ 27591 42378

1.1.4 Three existing culverts lie on Main Rivers, two cross ordinary watercourses and remaining culverts cross unnamed watercourses or ditches.

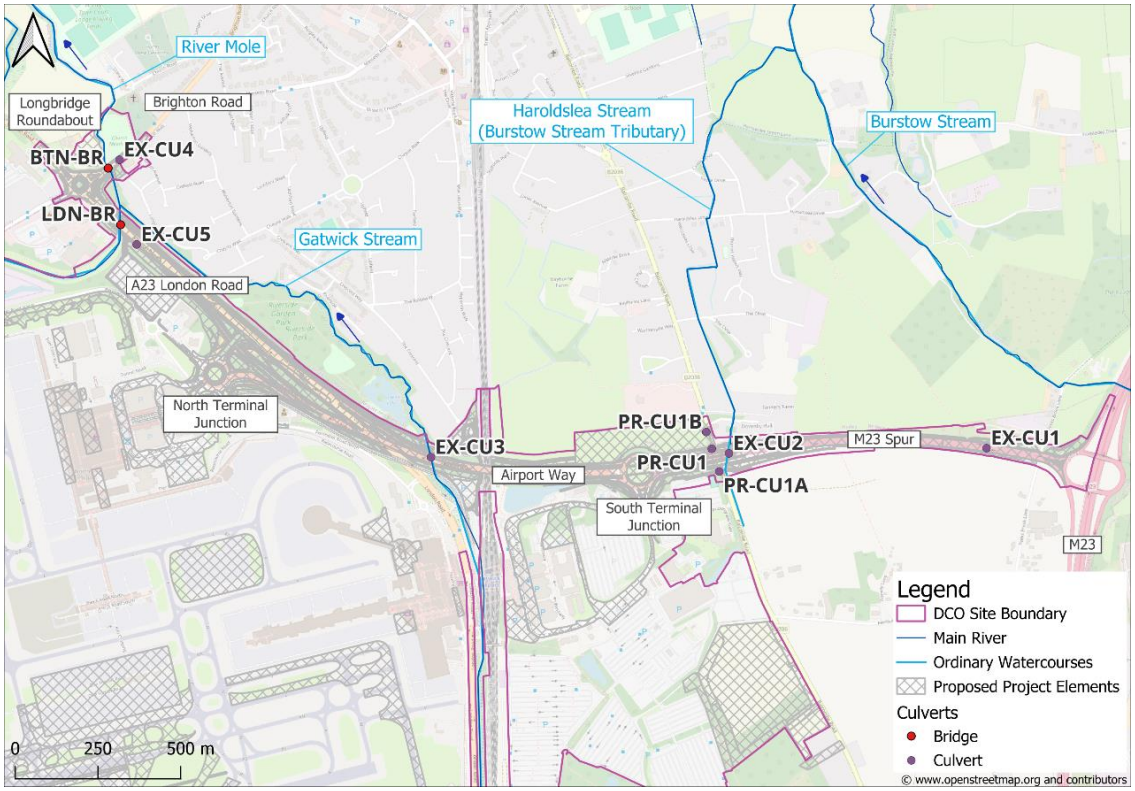

Figure 1.1: Location of culverts interacting with the highways works

1.1.5 This Culvert Assessment Technical Note addresses the following requests in the National Highways Relevant Representation, replicated in Deadline 1 Submission - 10.1.14 Statement of Common Ground (SoCG) Between Gatwick Airport Limited and National Highways – Version 2 [REP5-059]:

- 2.22.2.5 - *"The Applicant is requested to include assessment of impact on flood risk associated with the Tributary of the Burstow Stream, due to its interface with the SRN."*
- 2.22.3.3 - *"National Highways requests that the Applicant justifies the use of 400mm freeboard and complete blockage assessments, to quantify the residual flood risk should a blockage occur at the structures listed in Paragraph 7.2.31 [of ES Appendix 11.9.6: Flood Risk Assessment".*
- 2.22.3.4 - *"The Applicant is to confirm sizing and provide details of any assessment of the impact on flood risk and freeboard for EX-CU1 and EX-CU2 on Gatwick Spur road".*
- 2.22.3.5 – *"Concerning existing culverts EX-CU2 and EX-CU4, the Applicant outlines that these culverts are to be "extended to accommodate proposed road widening at these locations. Further information on the condition and capacity of the existing culverts are to be obtained following completion of the DCO process to inform the detailed design proposals." National Highways is concerned that the assessment is based on assumptions that have not been validated and may underestimate the flood risk impacts and any subsequent remedial works required. The Applicant is requested to clarify when these surveys will be conducted and*

whether there is a risk that the proposed order limits are sufficient to accommodate any mitigation that may be required"

- 2.22.3.6 - "*Based upon the information provided by the Applicant, depth difference mapping has not quantified the impact on flood risk on the works to the culverts on the Gatwick Spur trunk road. The Applicant is requested therefore to quantify the impacts of flood risk on the works to the culverts associated with the M23 Spur Road to ensure that the assessment is comprehensive"*

1.1.6 Paragraph 7.2.31 of the ES Appendix 11.9.6: Flood Risk Assessment [AS-078], noted in reference 2.22.3.3 of the SoCG between Gatwick Airport and National Highways [REP5-059] , states:

"The Project highway access works cross three waterbodies (Main Rivers) which have been hydraulically modelled by the Upper Mole hydraulic model namely:

- *A23 Airport Way crossing Gatwick Stream (Culvert [EX-CU3])*
- *A23 London Road Bridge crossing River Mole [(LDN-BR)]*
- *Brighton Road Bridge crossing River Mole [(BTN-BR)]"*

1.1.7 To address the requests listed in paragraph 1.1.5, culvert sizing assessments and blockage assessments have been completed for the relevant culverts, as listed in Section 2.

1.1.8 The hydraulic capacity of culverts for ordinary watercourses have been used to inform their blockage risk. The culvert sizing has followed the guidance in the Construction Industry Research and Information Association (CIRIA) Culvert, Screen and Outfall Manual (C786) (CIRIA, 2019), as required by the Design Manual for Roads and Bridges (DRMB) (National Highways, 2021).

1.1.9 Hydraulic modelling results for the aforementioned three Main Rivers in paragraph 1.1.6 have been used to inform the blockage assessment at these three locations.

1.1.10 Existing Culvert 5 (EX-CU5) is a drainage ditch on the southern edge of the A23 which is not connected to a watercourse and is assumed to be a toe drain to the A23 road embankment. Therefore, EX-CU5 has not been considered in the culvert or blockage assessments.

2 Methodology

2.1. Approach

2.1.1 This Culvert Assessment considers the hydraulic capacity of culverts located under the M23 spur and the risk of a blockage occurring associated with the Project. The culverts assessed in the sizing and blockage assessments are listed in Table 2.1 (see Figure 1.1 for their location). Additional information for these culverts is presented in Appendix 1.

Table 2.1: Culvert Schedule

Culvert ID	Description	National Grid Reference (NGR)	Watercourse	Works	Culvert Dimensions (m)	Existing length (m)	Total Proposed length (m)	Applicable SoCG Reference (Paragraph 1.1.5)	Culvert Sizing Assessment Required and undertaken (Section 3)	Blockage Assessment Required and undertaken (Section 4)
EX-CU1	Unnamed Ditch M23 Spur culvert	TQ 30195 41719	Ordinary Watercourse	Unchanged	0.3 diameter	45	45	2.22.3.4 and 2.22.3.4	✓	✓
EX-CU2	Haroldsea Tributary M23 Spur culvert	TQ 29422 41655	Ordinary Watercourse (Main River from outlet)	Extension on southern side	1.05 diameter	60	64-64.5	2.22.3.4, 2.22.3.5, 2.22.2.5 and 2.22.3.6	✓	✓
EX-CU3	Gatwick Stream South Terminal culvert	TQ 28541 41637	Main River	Unchanged	4.6 x 2.7	81.7	81.7	2.22.3.3 and 2.22.3.4	×	✓
EX-CU4	Unnamed Ditch Brighton Rd culvert	TQ 27553 42551	Ordinary Watercourse	Extension on northern side	0.93 diameter	30	36	2.22.3.5 and 2.22.3.6	✓	✓
PR-CU1	Unnamed Ditch Balcombe Rd culvert	TQ 29373 41702	Ordinary Watercourse	New culvert	1.5 x 1	N/A	61	2.22.3.6	✓	✓
PR-CU1A	Unnamed Ditch Balcombe Rd culvert at the southern end of PR-CU1	TQ 29403 41640	Ordinary Watercourse	New culvert	1.5 x 1	N/A	61	2.22.3.6	✓	✓
PR-CU1B	Unnamed Ditch Balcombe Rd culvert at the northern end of PR-CU1	TQ 29360 41749	Ordinary Watercourse	New culvert	1.5 x 1	N/A	61	2.22.3.6	✓	✓
BTN-BR	A23 Brighton Road Bridge over River Mole	TQ 27555 42545	Main River	Widened by 10m	Span – 7.6m Width – 19.2m Depth – 3.2m	-	-	2.22.3.3	×	✓
LDN-BR	A23 London Road Bridge over River Mole	TQ 27591 42378	Main River	Widened by 7m	Span – 9.2m Width – 19.25m Depth – 1.22m Abutment length – 25.1m (40 deg Skew)	-	-	2.22.3.3	×	✓

3 Hydraulic Assessment for Culvert Sizing

3.1. Introduction

3.1.1 The hydraulic assessment for culvert sizing has included both an assessment of the existing culvert capacities, for EX-CU1, EX-CU2 and EX-CU4, and the design requirements for proposed culverts PR-CU1, PR-CU1A and PR-CU1B, in response to the National Highways Relevant Representation, specifically references 2.22.3.4 and 2.22.3.5 in the SoCG between Gatwick Airport and National Highways. It should be noted that the Project has only been progressed to outline design for the Development Consent Order (DCO) application and is therefore subject to further (detailed) design post any grant of development consent.

3.1.2 Culverts EX-CU3, BTN-BR and LDN-BR were not included in the hydraulic assessment for culvert sizing as the SoCG between Gatwick Airport and National Highways did not request their assessment.

3.1.3 Hydraulic assessment for culverts EX-CU1, EX-CU2 and PR-CU1 (including PR-CU1A and PR-CU1B) have been undertaken using REFH2 flow estimates. The existing culvert EX-CU4 is to be extended on the northern side and is assumed to be a flood relief culvert as such no hydrological assessment has been undertaken using REFH2 flow estimates. The culvert sizing assessment for EX-CU4 is presented in Section 3.4.

3.2. Climate Change

3.2.1 The National Highways Relevant Representation set out in paragraph 1.1.5 requests culvert sizing assessment and blockage assessments are undertaken to understand the fluvial flood risk impacts of Project in relation to the culverts listed in Table 2.1.

3.2.2 As noted in paragraph 3.7.8 of ES Appendix 11.9.6 Flood Risk Assessment [AS-078], according to Flood Risk Assessments: Climate Change Allowances guidance (Environment Agency, 2022a) the peak river flow allowance should be used when assessing the impact of climate change for Main Rivers. For the Project this is 20 per cent, given the 100-year design life for the surface access elements of the Project (Environment Agency, 2022b).

3.2.3 For ordinary watercourses and small catchments (less than 5km^2) peak rainfall intensity allowances are used to assess the impact of climate change, according to Flood Risk Assessments: Climate Change Allowances guidance (Environment Agency, 2022a). For the Project, the peak rainfall intensity climate chance allowance is 40 per cent, given the 100-year design life for the surface access elements of the Project, as noted in the FRA (Environment Agency, 2022b).

3.2.4 As all culverts requiring a culvert sizing assessment cross ordinary watercourses, noted in Table 2.1, and the highways drainage design has been based on a 1 per cent (1 in 100) AEP event plus 40 per cent climate change allowance for rainfall intensity, 1 per cent (1 in 100) AEP plus 40 per cent climate change has been used for this culvert sizing assessment.

3.3. Catchments and Flows

3.3.1 Design peak flow estimates at the EX-CU1, EX-CU2 and PR-CU1 culvert locations have been estimated from REFH2 methods using catchment descriptors and plot scale equations to determine flood hydrographs and predicted runoff for storms with a range of design events up to and including 1000 years. Winter rainfall event profiles were generated for each event and both localised and rural profiles were extracted.

3.3.2 Culvert catchment areas were determined based on a review of the following information:

- The FEH catchment boundary defined by FEH online. This delineates a single catchment draining approximately to PR-CU1, referred to as 'FEH1' within this document;
- Assessment of LiDAR data;
- Use of "SCALGO" software to identify localised depressions;
- Information available about the existing highway drainage network;
- Review of aerial photography; and
- National Highways Drainage Asset Database (HADDMs) for as-built drainage records.

3.3.3 Topographic survey and existing drainage survey information were not available at this stage of assessment. Therefore, appropriate assumptions have been made in the delineation of culvert catchment areas in absence of such information which would need to be verified at the detailed design stage.

3.3.4 The adopted catchments for EX-CU1, EX-CU2 and PR-CU1 culverts are identified in Figure 3.1, Figure 3.2 and Figure 3.3 respectively.

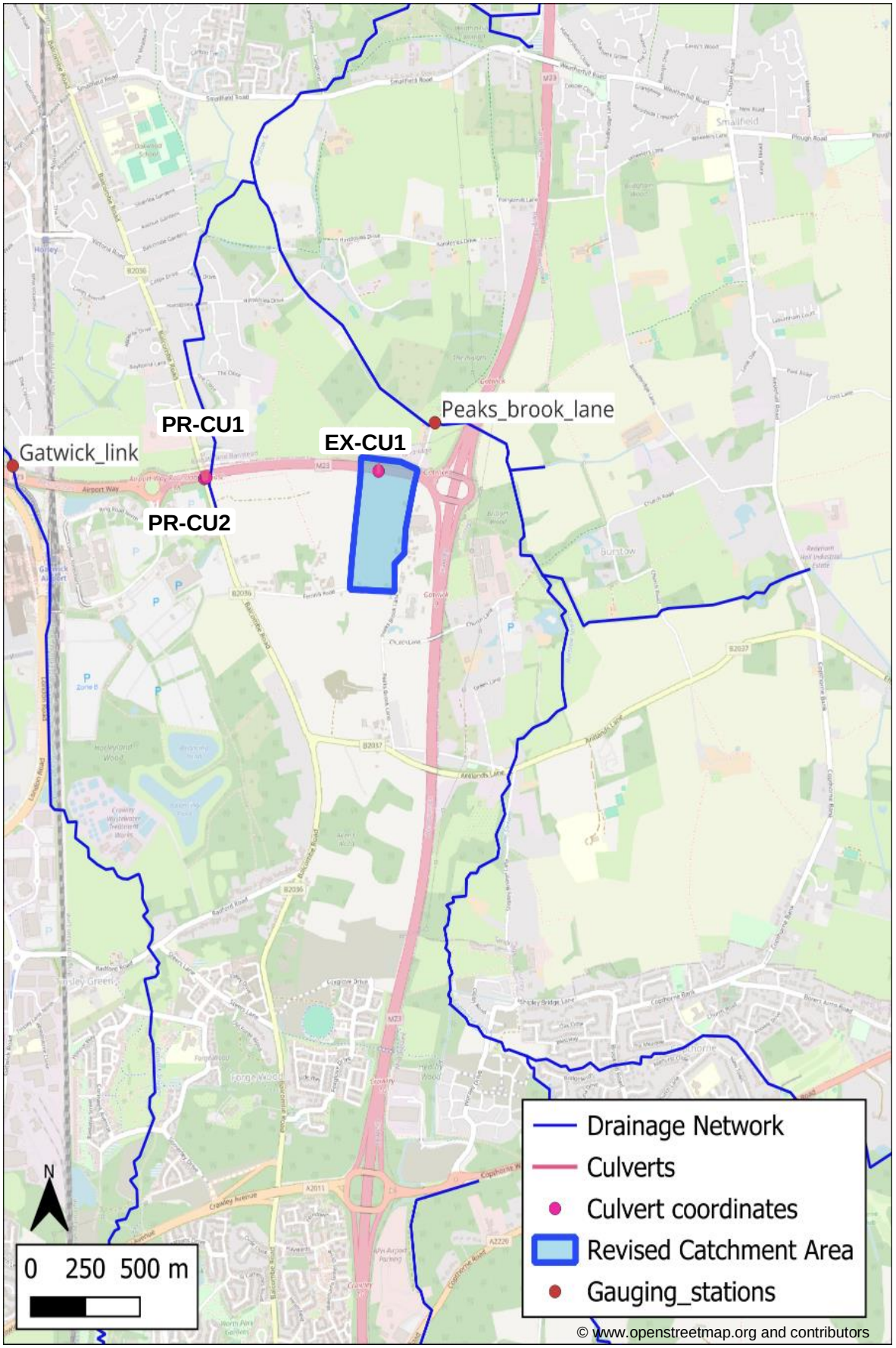

Figure 3.1: EX-CU1 Catchment

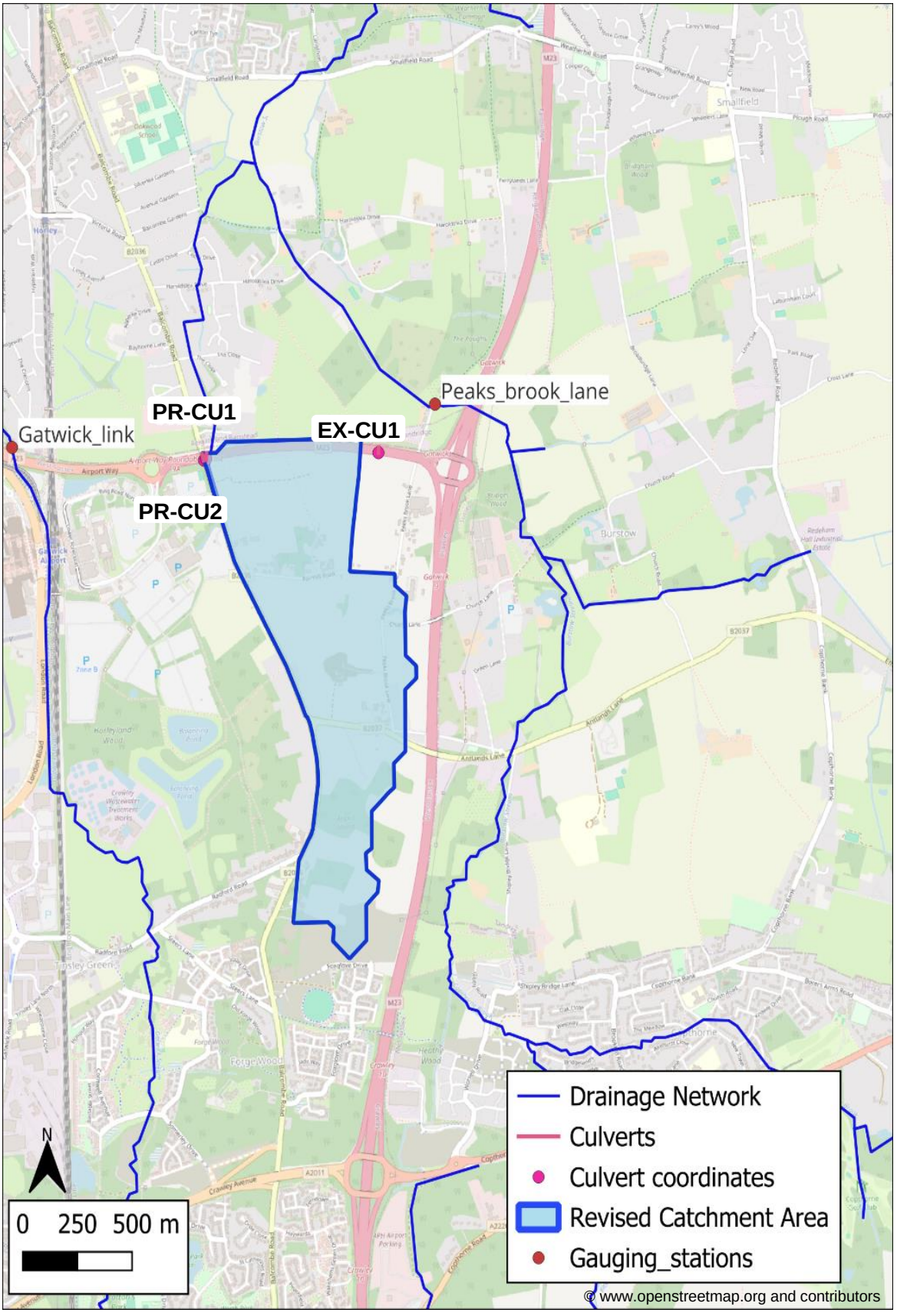

Figure 3.2: EX-CU2 Catchment

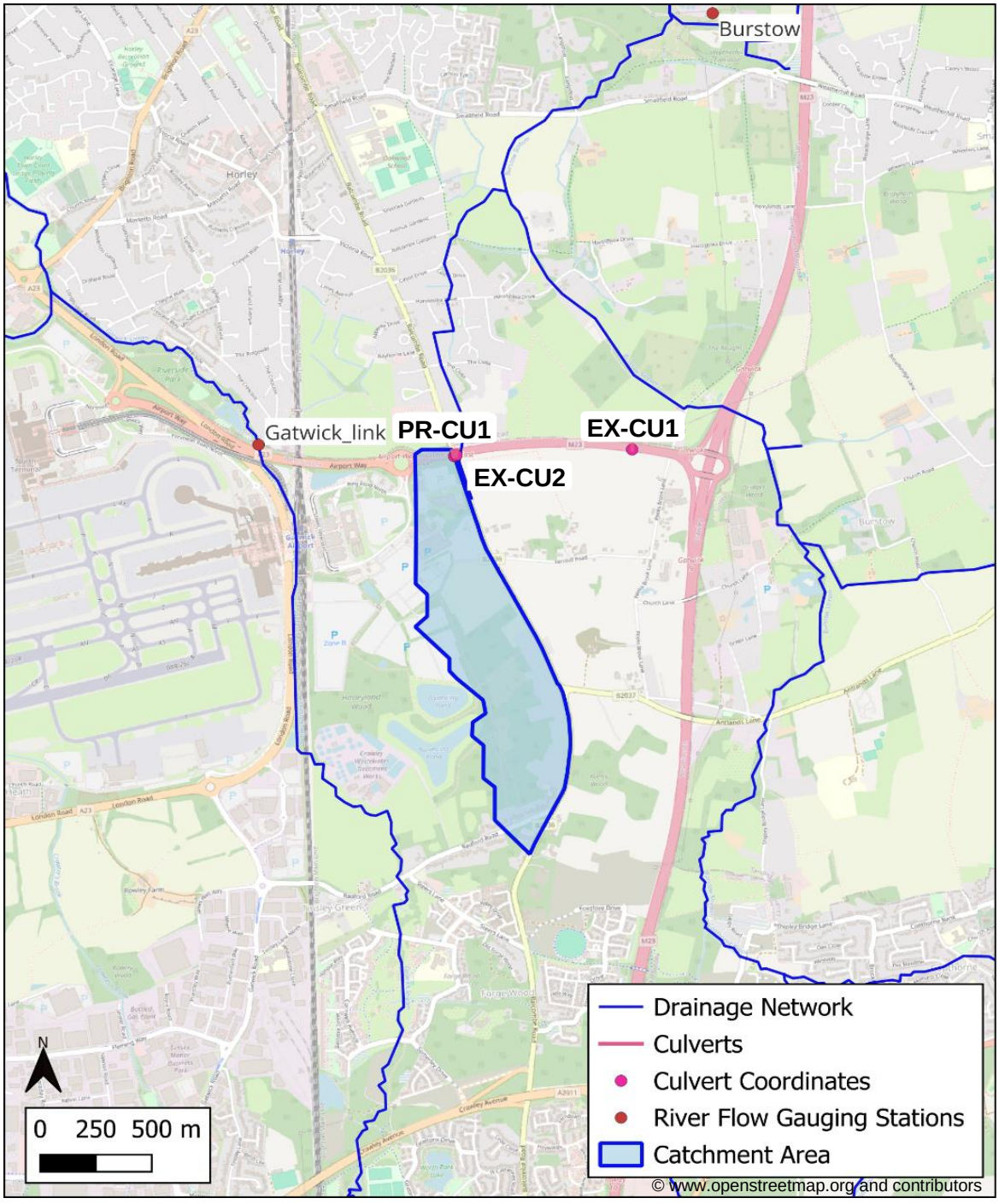

Figure 3.3: PR-CU1 Catchment

3.4. Culvert Sizing

3.4.1 Preliminary culvert sizing was determined using Figures A7.1 and A7.2 from the CIRIA Guidance C786 (Culvert, Screen and Outfall Manual) (2019). This indicated the required size for the proposed culverts, which was then compared to the designed culverts to determine the adequacy of their hydraulic capacity. Proposed culvert sizing has allowed for freeboard and embedment depths in accordance with CIRIA C786. As stated in **ES Appendix 11.9.6 Annex 2** [APP-148], the proposed culverts shall be designed in accordance with West Sussex County Council (WSCC) LLFA Culvert Policy.

3.4.2 The results of the hydraulic assessment for culvert sizing are presented in Table 3.1 'Culvert Sizing Hydraulic Assessment for the 1 per cent AEP event plus 40 per cent Climate Change' and are as follows:

- One existing culvert, EX-CU1 was found to have insufficient capacity in the 1 per cent (1 in 100) AEP event with 40 per cent climate change, the design event (see Section 3.2).

- Culverts EX-CU2, PR-CU1, PR-CU1A and PR-CU1B were found to have sufficient hydraulic capacity for the design event. With regards to PR-CU1, PR-CU1A and PR-CU1B, it is assumed that the existing ditch has adequate capacity to deal with the calculated peak flows and the proposed culvert can be installed with adequate cover.

- Existing culvert EX-CU4 is assumed to be a flood relief culvert (see Figure A. 2), as confirmed through a review of overland flow paths from the Upper Mole hydraulic modelling results. EX-CU4 has a diameter of 930mm, and assumptions based on Figure A7.1 from CIRIA Guidance C786 (Culvert, Screen and Outfall Manual) (2019) indicate a maximum flow of 0.7m^3/s for this culvert. Based on hydraulic modelling undertaken for the Project the peak flow in the River Mole under the Brighton Road Bridge (BTN-BR), approximately 45m south along the Brighton Road from EX-CU4, with the Project in place has been estimated as 73m^3/s in the 1 per cent AEP + 40 per cent CC event. It can be seen that the peak flows through EX-CU4 would be negligible (less than one per cent) in proportion to the flows in the River Mole. Therefore, considering EX-CU4 would operate as a flood relief culvert for peak flows in the River Mole, it is assumed that a blockage in the culvert would not affect fluvial flood risk.

Table 3.1: Culvert Sizing Hydraulic Assessment for the 1 per cent AEP event plus 40 per cent Climate Change

Culvert Ref.	Culvert Identification	Culvert Crossing	Length of the Culvert (m)	ReFH2 Flow Estimate (m^3/s)	Estimated Required Culvert Diameter – Hydraulic Capacity (m)	Estimated Pipe Culvert Diameter (Plus freeboard & Embedment) (m)	Proposed Culvert Type (Pipe/Box)	Recorded (Existing) Pipe Culvert Diameter/Box Culvert Span (m)	Comments
EXCU1	Existing to be retained	Ordinary Watercourse (Assumed culvert crossing for drainage ditch)	45	0.29	0.60	See Comments	Pipe	0.30	Existing culvert hydraulic capacity was found to be insufficient and the estimated pipe culvert diameter including freeboard is greater than the diameter of the existing culvert. Further hydraulic checks have been undertaken using HY8 package to establish potential pipe surcharge conditions for which HY8 results indicated the peak water level reaching 60.25m, well below the proposed road level of 62m indicating no flood risk to the proposed highway alignment. Additionally, as the existing culvert remains unchanged with the Project, any offsite flood risk assumed to remain unchanged from the Project. (See Summary and Recommendations in Section 5 of this technical note)
EXCU2	Existing culvert to be extended	Ordinary watercourse (Main river from outlet)	80	1.62	1.05	See Comments	Pipe	1.05	Existing culvert hydraulic capacity found to be adequate. Proposed culvert length includes approximately 4m of culvert extension for online widening on westbound carriageway. The culvert extension will be on a like-for-like basis so will retain existing pipe culvert geometry and gradient to ensure hydraulic capacity and flow conveyance through the existing culvert will be maintained. Therefore, the hydraulic capacity of the proposed culvert will remain unchanged from this assessment. As such any offsite flood risk assumed to be negligible from the proposed culvert extension. (See Summary and Recommendations in Section 5 of this technical note)
PR-CU1	Proposed culvert	Ordinary watercourse		1.11	1.05	1.58	Box	1.5m x 1m	Assumed that existing ditch has adequate capacity to deal with the calculated peak flows. Assumed that proposed culvert can be installed with adequate cover.
PR-CU1A	Proposed culvert	Ordinary watercourse		1.11	1.05	1.58	Box	1.5m x 1m	
PR-CU1B	Proposed culvert	Ordinary watercourse		1.11	1.05	1.58	Box	1.5m x 1m	

3.4.1 Conclusions from culvert sizing assessment are:

- One culvert, EX-CU1 would be retained without alteration. Its existing culvert hydraulic capacity was found to be insufficient however as the culvert is not changing in this location due to the Project no change in flood risk would be anticipated;
- Two culverts, EX-CU2 and EX-CU4 would be extended on a like-for-like basis (i.e. with same dimensions and gradient). The hydraulic culvert sizing assessment undertaken indicates that EX-CU2 would have adequate hydraulic capacity. EX-CU4 is a flood relief culvert and as such no hydrological assessment has been undertaken using REFH2 flow estimates. Based on hydraulic modelling undertaken for the Project, peak flows through EX-CU4 would be negligible (less than one per cent) in proportion to the flows in the River Mole. Therefore considering EX-CU4 would operate as a flood relief culvert for peak flows in the River Mole, it is assumed that a blockage in the culvert would not affect fluvial flood risk.
- The three proposed culverts, PR-CU1, PR-CU1A and PR-CU1B were assumed to have sufficient capacity and therefore no change in flood risk would be anticipated.

3.4.2 For all culverts assessed, it is recommended that a detailed drainage survey be undertaken to confirm existing pipe inverts/levels and to establish the existing pipe capacity to inform their detailed design. Topographic survey is also required to determine the capacity of existing ditches and the extent of existing ditches at upstream and downstream ends of pipe crossings. Hydraulic modelling may also be required for the aforementioned culverts at detailed design stage.

4 Blockage Assessment

4.1. Methodology

4.1.1 An initial assessment of the blockage risk for all the culverts listed in Table 2.1 has been undertaken in accordance with the Environment Agency (2019) Blockage Management Guide and is presented in Table 4.1: Culvert Blockage Assessment.

4.1.2 The blockage assessment identifies potential pinch points and considers three elements of blockage risk:

- Receptors that are susceptible to flood or scour damage;
- Pathways to a receptor; and
- and sources of debris.

4.1.3 The risk score is calculated using the following equation:

$$Risk\ score = ((Source\ score + Pathway\ score) / 2) \times Receptor\ score$$

The source score considers vegetation, man-made sources (such as fly-tipping or material storage), sediment, and volume (considering contributing watercourse length and debris accumulation). The pathway score assesses the likelihood of debris transport and accumulation, and the receptor score identifies receptors including risk to life, critical infrastructure, property and environment). A score of 1 to 1.75 is then classified as Low risk, 2 to 4.5 is Medium risk and 5 to 9 is a High risk of a blockage occurring.

4.1.4 The data quality score (DQS) is calculated using the following equation:

$$\text{Data Quality Score} = (\text{DQS Source} + \text{DQS Pathway} + 2\text{DQS Receptor}) / 4$$

The data quality scores (DQS) also consider where data improvements might have the most impact on the risk score. A DQS of 1 indicates the best information available was used, 2 indicates known deficiencies in the data and 3 highlights gross assumptions in the data.

4.1.5 Where further assessment identifies the need for a trash or security screen to reduce risks, these would be included at the detailed design stage.

4.2. Results

4.2.1 The results of the blockage assessment are presented in Table 4.1, PR-CU1 includes PR-CU1A and PR-CU1B. As noted in Table 2.1 these three proposed culverts are the same diameter and located along the same watercourse over a distance of approximately 150m. Therefore, PR-CU1, PR-CU1A and PR-CU1B are assumed to share the same blockage risk.

4.2.2 Existing culverts EX-CU1 and EX-CU2 demonstrate a risk score of 5.00 and 5.50, indicating a high risk of blockage whereas all other culverts demonstrated a risk score of 4.50, indicating a medium risk of blockage; meaning further investigation is needed to provide a more detailed assessment during subsequent design phases. Data scores of 1.94 to 2.27 indicate known deficiencies across the data.

Table 4.1: Culvert Blockage Assessment

Culvert Name	Works	Step 5. Assess Risk and Uncertainty							Step 6. Next Steps		
		Receptor score	Pathway score	Source score	Risk Score	Receptor Data Quality	Pathway Data Quality	Source Data Quality	Data Quality Score	Risk	Next Steps (During subsequent detailed design phase)
EX-CU1	Existing to be retained	2.00	3.00	2.00	5.00	2.00	2.00	2.00	2.00	High	Do something (which may involve detailed assessment)
EX-CU2	Existing to be extended	2.00	3.00	2.50	5.50	2.25	2.00	1.75	2.06	High	Do something (which may involve detailed assessment)
PR-CU1	Proposed	2.00	2.50	2.00	4.50	2.00	2.00	1.75	1.94	Medium	Do something (which may involve detailed assessment)
EX-CU3	Existing to be extended	2.00	1.50	3.00	4.50	2.25	2.00	1.83	2.08	Medium	Do something (which may involve detailed assessment)
EX-CU4	Existing to be retained	2.00	1.50	3.00	4.50	2.67	2.00	1.75	2.27	Medium	Do something (which may involve detailed assessment)
BTN-BR	Widened by 10m	2.00	1.50	3.00	4.50	2.67	2.00	1.75	2.27	Medium	Do something (which may involve detailed assessment)
LDN-BR	Widened by 7m	2.00	1.50	3.00	4.50	2.67	2.00	1.75	2.27	Medium	Do something (which may involve detailed assessment)

** Steps 5 and 6 of the Environment Agency (2019) Blockage Management Guide.*

5 Summary and Recommendations

5.1.1 Culvert sizing and blockage assessments for all required watercourses of the Project have been undertaken to address requests in the National Highways' Relevant Representation, replicated in the Deadline 1 Submission - 10.1.14 Statement of Common Ground Between Gatwick Airport Limited and National Highways – Version 2 [REP5-059]. This consults ES Appendix 11.9.6: Flood Risk Assessment [APP-137] and the Surface Access Highways Surface Water Drainage Strategy in **ES Appendix 11.9.6 Annex 2** [APP-148]

5.1.2 The Culvert Blockage Assessment considers the hydraulic capacity of watercourses for the Project and the risk of a blockage occurring. The Upper Model hydraulic model results have been used to inform the blockage assessment at these three main waterbodies namely:

- A23 Airport Way crossing Gatwick Stream (Culvert EX-CU3);
- A23 London Road Bridge crossing River Mole (LDN-BR); and
- Brighton Road Bridge crossing River Mole (BTN-BR).

5.1.3 The assessment of hydraulic capacity of culverts for ordinary watercourses including preliminary culvert sizing has been undertaken using CIRIA Culvert, Screen and Outfall Manual (C786), as required by DMRB. It is noted that appropriate assumptions have been made in absence of topographic survey and existing culvert information. The culvert sizing assessment has concluded the following:

- One culvert, EX-CU1 would be retained without alteration. Existing culvert hydraulic capacity in the 1 per cent AEP with 40 per cent climate change allowance was found to be insufficient. However, as this existing culvert is not affected due to the Project, no change in flood risk against the future baseline situation would be anticipated.
- Two culverts, EX-CU2 and EX-CU4 would be extended on a like-for-like basis (i.e. with same dimensions and gradient). The hydraulic culvert sizing assessment undertaken indicates that the EX-CU2 would have adequate hydraulic capacity. EX-CU4 is a flood relief culvert and as such no hydrological assessment has been undertaken using REFH2 flow estimates. Based on hydraulic modelling undertaken for the Project, peak flows through EX-CU4 would be negligible (less than one per cent) in proportion to the flows in the River Mole. Therefore, considering EX-CU4 would operate as a flood relief culvert for peak flows in the River Mole, it is assumed that a blockage in the culvert would not affect fluvial flood risk.
- The three proposed culverts, PR-CU1, PR-CU1A and PR-CU1B were assumed to have sufficient capacity and therefore no change in flood risk would be anticipated.

5.1.4 A preliminary assessment of the blockage risk for all watercourse crossings has been undertaken in accordance with the Environment Agency (2019) Blockage Management

Guide. The initial blockage assessment highlights a need for further assessment at the detailed design stage with greater information to be made available to improve understanding of the potential for blockage risk.

5.1.5 Additional information required for the detailed assessment process should consider including detailed site surveys (to include topographic surveys for all watercourses and drainage surveys to capture existing culverts details), where necessary to undertake detailed hydrological assessment and hydraulic modelling of existing and proposed culverts, site walkovers and monitoring of watercourses. The detailed assessment process should use this additional information to quantify debris volume, probability and degree of blockage, rate of blockage, impacts on water levels and/or flood extents (with and without blockage), flood damages (with and without blockage) and overall risk to confirm the potential blockage risk for all culverts studied in this assessment.

6 References

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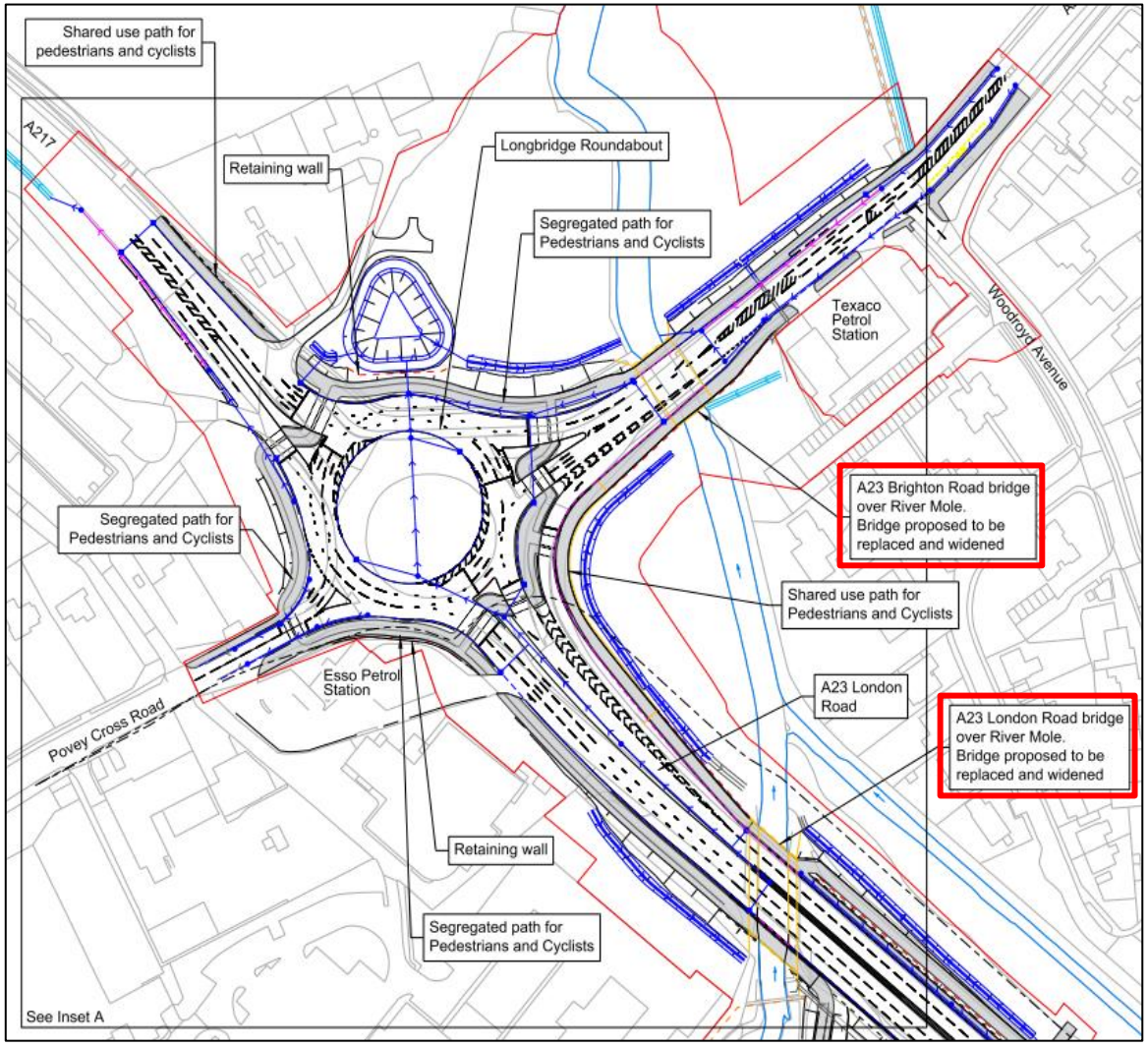
Appendix 1: Drawings and Photographs for Culverts




BR-BTN Looking upstream


BR-LDN Looking upstream

Figure A. 1: Proposed Drainage Strategy Drawing, indicating BR-BTN and BR-LDN, and associated photographs.

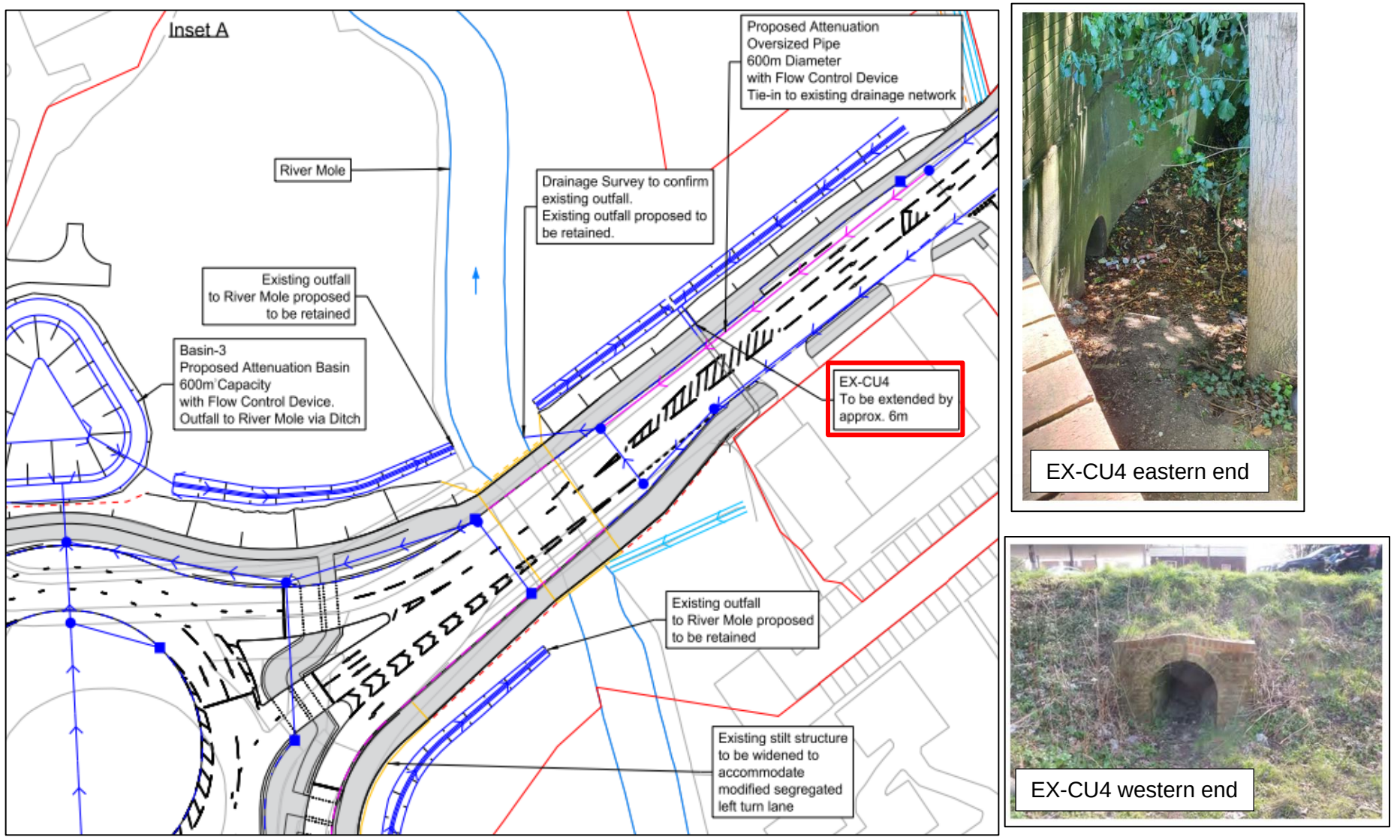


Figure A. 2: Proposed Drainage Strategy Drawing, indicating EX-CU4, and associated photos.

Figure A. 3: Proposed Drainage Strategy Drawing, indicating EX-CU5, and associated photos.

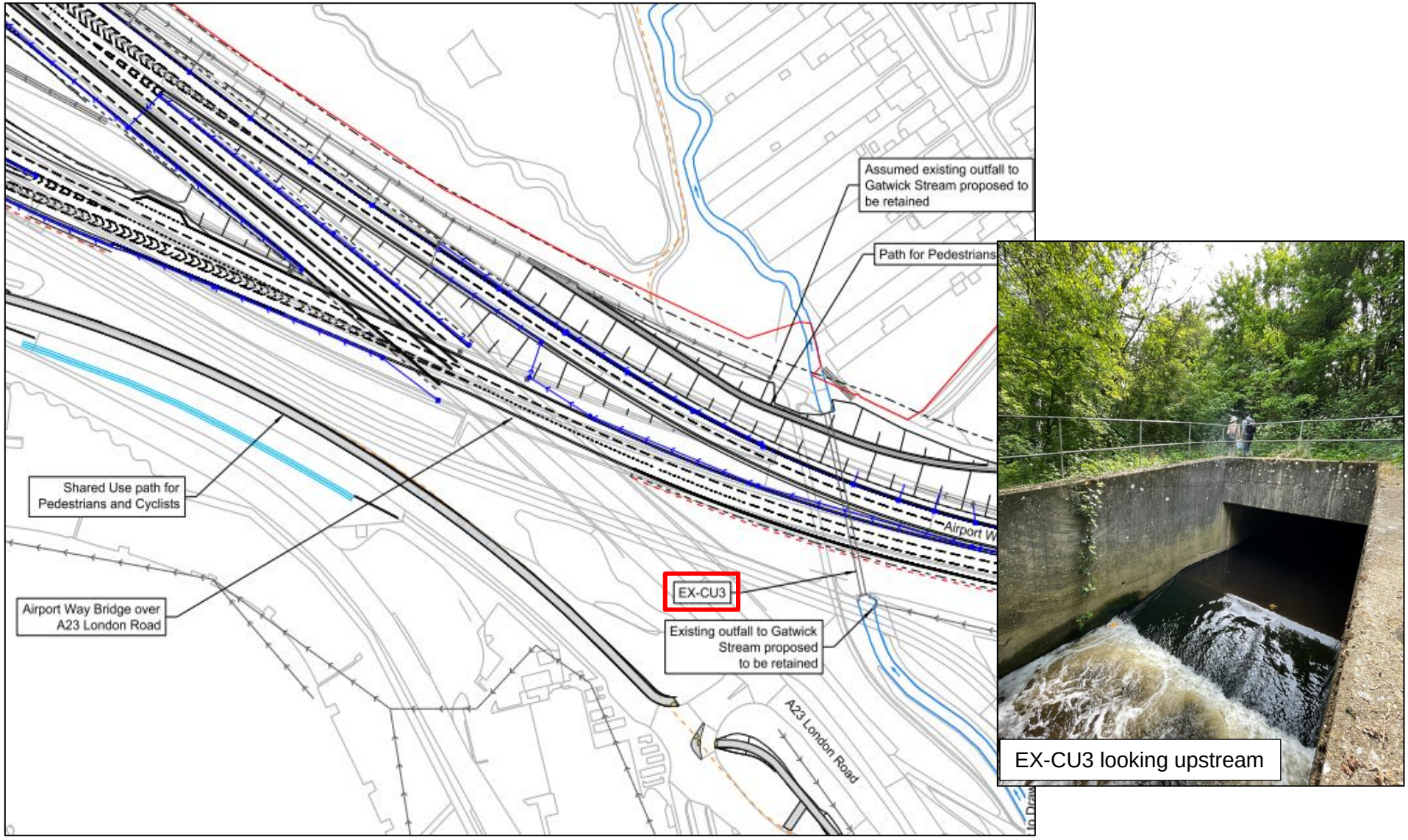


Figure A. 4: Proposed Drainage Strategy Drawing, indicating EX-CU3, and associated photos

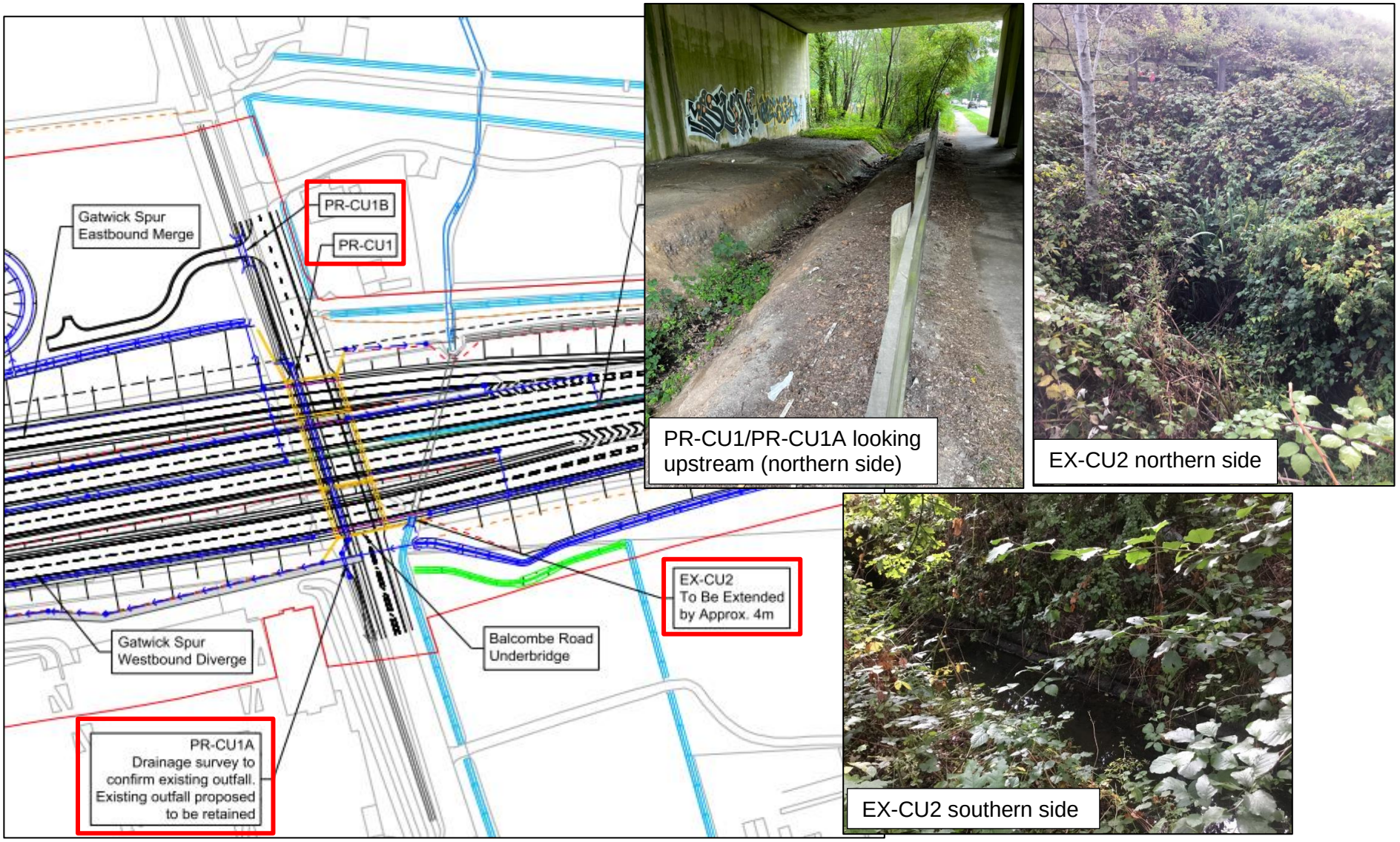


Figure A. 5: Proposed Drainage Strategy Drawing, indicating EX-CU2, PR-CU1, PR-CU1A and PR-CU1B, and associated photos.

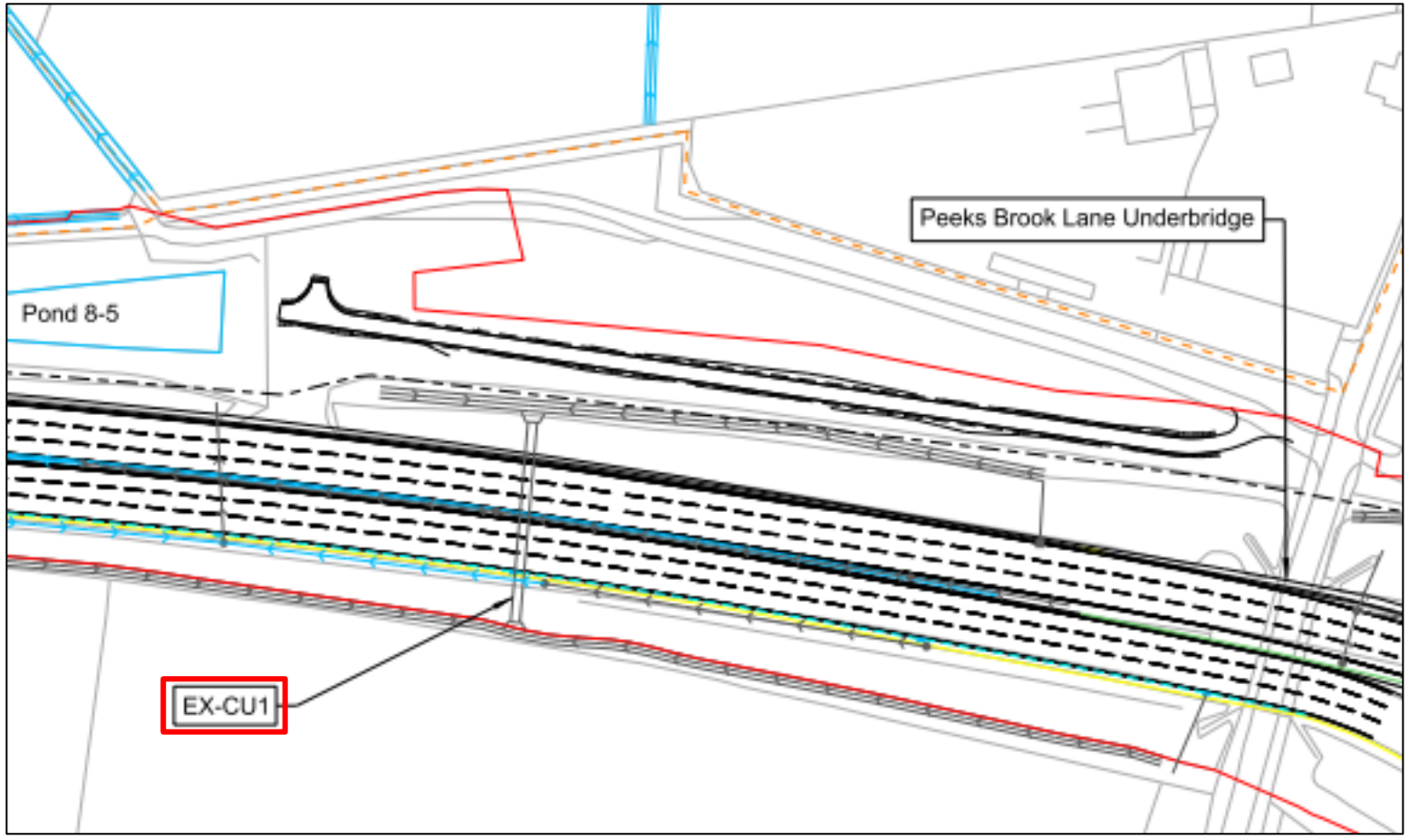


Figure A. 6: Proposed Drainage Strategy Drawing, indicating EX-CU1.