A12 Chelmsford to A120 widening scheme
TR010060

6.3 ENVIRONMENTAL STATEMENT

APPENDIX 14.3 HYDROMORPHOLOGY ASSESSMENT

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A12 Chelmsford to A120 widening scheme

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ENVIRONMENTAL STATEMENT
APPENDIX 14.3 HYDROMORPHOLOGY ASSESSMENT

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1 Introduction

1.1.1 This report forms a geomorphological assessment for the proposed scheme as required under the Design Manual for Roads and Bridges (DMRB) LA113 Road Drainage and the Water Environment, Revision 1 (Highways England, 2020). The objective is to provide an outline of the riverine characteristics for the watercourses within the proposed scheme. This involves identifying salient fluvial features, including planform, cross-section, flow behaviour, bedforms, areas of erosion and accretion, and any pressures. The assessment supports and has informed the proposed scheme Environmental Statement.

2 Methodology and scope

2.1.1 A series of walkover surveys were undertaken in 2017 and augmented by contemporary desk study information which have been used to inform the Environmental Statement. This assessment would also support detailed design where structures will either interact with the watercourse channel, or likely cause changes in alignment, sediment entrainment and continuity, flow, and overall planform change.

2.1 Site walkover surveys

2.1.1 Geomorphology walkover surveys were conducted during a walkover of the area potentially impacted by the proposed scheme in 2017. No additional hydromorphology surveys have taken place, however surveys to inform Biodiversity Net Gain River Conditions Assessments have since assessed each watercourse in 2021. Images taken of each watercourse for these surveys record no additional changes to the watercourses since 2017. Eight Main Rivers were identified for further investigation (identified in Figure 14.1 of the Environmental Statement [TR010060/APP/6.2]):

- River Chelmer
- Boreham Brook
- the River Blackwater
- the River Brain
- the River Ter
- Rivenhall Brook
- Domsey Brook
- Roman River.

2.1.2 The surveys extended 500m either side of the current A12 and sought to characterise the nature of the river channel. These survey extents encompassed the locations where offline sections of the proposed scheme would cross these watercourses. Surveys assessed overall geomorphology (cross-sectional character, planform, flow behaviour), geomorphological forms (erosion and deposition), sediment sources, artificial barriers and features, key habitats, and vegetation character. The following sections provide a succinct overview of the findings of the walkover survey regarding these surveyed elements, providing supporting photographic evidence (see summary tables in Section 4 of this appendix). A summary table is provided for each of the watercourses individually. Table 4.9 details the drainage ditches that are also present within the study area in addition to those listed above.

2.2 Desk study

2.2.1 The desk study includes an interrogation of supplementary information, including aerial photographs and GIS, to consider the broader, catchment scale characteristics of the planform.

2.2.2 Key data sources include:

- Flood Estimation Handbook (FEH) (UK Centre for Ecology and Hydrology, 2021),
- Ordnance Survey mapping and aerial imagery (Ordnance Survey, 2021),
- Catchment Data Explorer (Environment Agency, 2020),
- Main Rivers (Environment Agency, 2021)
- Multi-Agency Geographical Information for the Countryside (MAGIC) map application (Department for Environment Food and Rural Affairs (DEFRA), 2021),
- Historical mapping (National Library of Scotland, 2021).

3 Historical channel characteristics

3.1.1 This section outlines a review of historical changes for each of the Main Rivers. Historical channel characteristics of the other watercourses present within the study area are summarised in Table 4.9 (Section 4.9 of this appendix).

3.1 River Chelmer

3.1.1 Generally, the planform of the River Cherwell remains largely unchanged since the earliest historical maps (1885). However, distribution of urbanised land use has altered significantly since 1885, with urbanisation further encroaching upon the channel and overtopping historical floodplains. Significant changes in land use were recorded in 1983 as the settlement of Springfield expanded to the east, towards the River Chelmer. This coincided with the construction of the A12 carriageway, which is aligned parallel with the River Cherwell at Chelmer Village, where it also crosses it. At the crossing point a bridge is marked on the latest maps where localised channel straightening has taken place.

3.2 Boreham Brook

3.2.1 Overall, the planform remains unchanged since the earliest historical maps, with the exception of the reach up- and downstream of the now Tyrell cottages, which were formally Boreham Mill. Here, a mill dam was present immediately upstream of Roman Road, where the reservoir would drain in the channel downstream. Additionally, an artificial mill leat would drain into Boreham Brook at a confluence located approximately 350m downstream of Roman Road. The mill dam and mill leat remained operational up until 1967, when the mill dam was converted to an active channel and a channel realignment, which saw the mill leat now operating as the main channel of Boreham Brook. This meant the

natural channel prior to the realignment had been abandoned. Moreover, an additional crossing was recorded on historical maps as the A12 was constructed in 1983. This, however, did not result in an additional channel realignment.

3.3 River Blackwater

3.3.1 The historical planform displays little to no changes since the earliest available historical maps (1885). The most significant historical changes took place as a result of gravel pits and reservoir excavations to the east of Witham (from 1980), which includes the Coleman Reservoir (*circa.* 1993). Furthermore, the construction of A12 took place from 1974 crossing the River Blackwater at Ashman's Bridge.

3.4 River Ter

3.4.1 Since the earliest known historical maps, the River Ter has been straightened to accommodate the Great Eastern Railway and Hatfield Bridge at Roman Road. Immediately upstream of Roman Road, the channel was dammed resulting in a reservoir. From 1964, planform changes took place, where the reservoir comprised of two widened channels was reverted to one with the northern channel abandoned. The River Ter was then realigned, relocating the channel away from Roman Road, giving a more natural channel bend as opposed to the angular bends present in older maps. This realignment took place to accommodate the construction of the A12 which occurred within the same period of time.

3.5 River Brain

3.5.1 Since 1962, the river has been realigned and straightened to accommodate both urbanisation and the construction of the A12. This led to the channel between Maldon Road Bridge (NGR: TL 82449 13897) and its confluence with the River Blackwater being relocated to the south by approximately 30 – 50m. This includes the confluence which was also relocated.

3.6 Rivenhall Brook

3.6.1 The majority of the historical planform of Rivenhall Brook has not changed since the earliest available historical map (1888) depicting a stable and fixed channel. The planform has changed so it flows by the settlement of Rivenhall End, between the Great Eastern Railway and Roman Road. Here, the earliest historical maps exhibit a largely straight channel with short lengths of angular channel bends. These suggest the planform was modified here, and not naturally formed. Since 1970 and towards present day, the alignment of the channel has shifted northwards where the channel bends were lost and replaced by a straight channel. The purpose of the realignment was to accommodate increased urbanisation of Rivenhall End where a newly constructed residential area was built.

3.7 Domsey Brook

3.7.1 The historical planform of Domsey Brook largely displays a channel that has since remained largely unchanged. Evidence of most change in the planform can be seen at the site of the A12, which has been constructed since 1970. Here, the channel was realigned and conveyed through Domsey Bridge exhibiting a straight channel with acute bends as it follows the toe of the highway embankment.

3.8 Roman River

3.8.1 Since 1888, the watercourse remains largely unchanged. However, where the A12 crosses the watercourse, historical maps exhibit extensive changes to the watercourse to accommodate the highway. These include a prolonged realignment, where the channels once gently sinuous planform has been replaced by a straight watercourse aligned to the toe of the highway footprint. Furthermore, the realignment has led to an extension to the length of the watercourse here, which is likely contributing to the local geomorphological conditions observed there.

4 Contemporary channel characteristics

4.1.1 The following section describes the catchment of each Main River crossed by the study area. This is defined as a 1km buffer circling the redline boundary of the proposed scheme. All watercourses are displayed in Figure 14.1 of the Environmental Statement [TR010060/APP/6.2].

4.1 River Chelmer

Catchment characteristics

4.1.1 The River Chelmer originates north-west of Thaxted (National Grid Reference (NGR): TL 5790 3186). Its length, from source to its confluence with the River Blackwater, is approximately 74km and its overall catchment area is approximately 213km^2. The bedrock geology is underlain by clay, silt and sand of the Palaeogene London Clay formation, whilst the surficial geology is predominately made up of Quaternary Till – diamicton, with alluvium, and river terrace deposits and glacial sand and gravel downstream of Chelmsford. Dominant land use is agricultural which combines both pastoral and arable farmland. Patches of urban settlement comprise of Thaxted, Great Dunmow and Chelmsford.

Channel form

4.1.2 The surveyed reaches of the watercourse exhibit an artificially straightened uniform channel with very few differentiating characteristics along its length. The planform comprised semi-sinusoidal/straightened meanders followed by long sections of uniform and straight reaches, which extended from the A12 crossing to south of Boreham Cottages (Photograph 1). The channel had a re-profiled trapezoidal cross-section with a slight embankment on either bank. The wide reed beds on both banks suggest the channel is over-deep and over wide, measuring approximately 9m wide and 1.5m in depth.

4.1.3 Bed substrate at the A12 crossing was predominantly silt and algal vegetation (biomass). However, fine gravel and sand material was found along the channel margins (Photograph 2). Macrophyte beds and biomass substrate was consistently high throughout the surveyed reach. Flow was consistently tranquil and uniform throughout, except at the Stoneham lock gate, and immediately downstream of it.

Riparian zone

4.1.4 River corridor vegetation was uniform and consisted primarily of large shrubs, namely nettles and brambles, and grasses on both banks. The right bank, upstream of the weir-sluice structure was fully vegetated by a covering of trees, which offered some shading. However, due to the orientation of the channel, sunlight still broke through the tree line and reached the watercourse throughout the year. This sunlight has allowed the bed to be covered by macrophyte beds (Photograph 3). Downstream of Stoneham lock gate, the right bank vegetation was the same as that of the left bank; comprising occasional single bank top trees, large shrubs and set back regular spaced willow trees. Due to the raised

embankment and over-deepened channel, the riparian zone was narrow and vegetated by reed beds, and large shrubs.

Modifications and pressures

4.1.5 The River Chelmer was not highly active exhibiting little evidence of erosion and/or deposition. Reedbeds were the exception exhibiting localised deposition. Therefore, it was likely that the surveyed reach was a sediment sink.

4.1.6 There were few modifications to the channel evidenced during the survey. The only modification or artificial structures along the River Chelmer were the presence of a weir and Stoneham lock, a lock gate used for navigational purposes (Photograph 4). Moreover, artificial bank reinforcement lined both banks, and also extended from Stoneham lock.

Summary

4.1.7 Table 4.1 summarises the principal hydromorphological features observed on site.

Table 4.1 Baseline description of hydromorphological quality elements

River Chelmer	
Quantity and dynamics of water flow	Water levels at the time of survey were average relative to the flow recorded along the watercourse. Flow was uniform and smooth throughout the entirety of the channel surveyed.
Connection to groundwater bodies	None observed.
River continuity	Continuity is prevented laterally by the reprofiled embankments and the over-deepened character of the river. Longitudinal connectivity is restricted by a weir and sluice gate which prevents the natural flow and sediment regime that would otherwise be in place. It restricts the movement of sediment and may be leading to sediment build up in the lee of the weir wall.
River depth and width variation	River width is approximately 9m across the length of the channel with an expected consistent depth of between 1m-1.5m.
Structure and substrate of the riverbed	The bed substrate consists of loose, mobile fine gravel and sand material.
Structure of the riparian zone	The riparian zone is relatively uniform. The embankments restrict the width of the riparian zone. For the length of the river, vegetation is predominantly large shrubs and grasses. There is a continuous lining of trees along the right bank until the weir-sluice; this then changes to a few sporadically growing trees. Trees are absent on the left bank.

River Chelmer	
Morphological pressures	Prolonged channelisation of the watercourse for navigational purposes. Urbanisation encroaching on the watercourse including numerous crossings.
 **Photograph 1: Long uniform channel with marginal reed beds.**	 **Photograph 2: Sand and gravel substrate with algal vegetation.**
 **Photograph 3: Macrophyte beds.**	 **Photograph 4: Weir and lock gate at Stoneham lock.**

4.2 Boreham Brook

Catchment characteristics

4.2.1 Boreham Brook originates north of Boreham (NGR: TL 7584 1115). Its length is approximately 5.6km, from source to its confluence with the River Chelmer, and catchment area is approximately 17km^2. The bedrock geology comprises of clay, silt and sand of the Palaeogene London Clay formation, whilst catchment surficial geology is predominately made up of Quaternary Till – diamicton. Alluvium, head deposits and glacial sand and gravel are present along the channel and its floodplain. Dominant land use is agricultural which combines both pastoral and arable farmland. The catchment is also utilised for quarrying and the urban settlement of Boreham.

Channel form

4.2.2 The surveyed reaches of the watercourse exhibit an artificially straightened uniform channel with very few geomorphological characteristics along its length. Some engineered meanders were incorporated into the realignment, but these were not representative of natural processes. Also, the watercourse exhibited a re-profiled trapezoidal cross-section along the realigned reaches.

4.2.3 Bed substrate was largely indiscernible as a result of the channel being largely over-vegetated (Photograph 5). Where visible, bed substrate material comprised of silt (Photograph 6). Where flow was visible, this silt facilitated macrophytes along the channel margins. Flows were therefore tranquil and uniform throughout (Photograph 7), with the exception of tumbling flows observed at the Main Road culvert outlet at Boreham.

Riparian zone

4.2.4 Vegetation along the channel and riparian zone varied depending on adjacent land use. The realigned channel was lined by a constrained vegetated riparian corridor largely comprising of grass and regularly spaced deciduous trees along the right bank. Restriction to the vegetated riparian corridor arose from arable agricultural land uses. Elsewhere along the channel riparian vegetation comprised of a deciduous tree line along both banks.

Modification and pressures

4.2.5 A culvert allowing Boreham Brook to pass beneath Main Road was observed comprising of a raised outlet. At the outlet, an artificially stepped long profile attenuated flows as it approached the natural bed (Photograph 8).

Summary

4.2.6 Table 4.2 summarises the principal hydromorphological features observed on site.

Table 4.2 Boreham Brook baseline description of hydromorphological quality elements

Boreham Brook	
Quantity and dynamics of water flow	Water levels at the time of survey were average relative to the flow recorded along the watercourse. Flow was uniform and featureless throughout the watercourse. The stepped profile extending form a culvert outlet caused localised variation in flow dynamics.
Connection to groundwater bodies	None observed.
River continuity	Continuity is prevented laterally by the reprofiled banks of the realigned channel. No visible floodplain was observed. Longitudinal continuity was limited by the culvert crossing comprising of a raised outlet.
River depth and width variation	Width and depth not recorded whilst on site.
Structure and substrate of the riverbed	The bed substrate consists of silt.
Structure of the riparian zone	The riparian zone is relatively simple comprising of a deciduous tree line along the historical channel. At the realigned channel, riparian vegetation largely comprised of grass and regularly spaced trees.
 **Photograph 5: Over-vegetated realigned channel.**	 **Photograph 6: Silted bed substrate material**

Boreham Brook	
	
Photograph 7: Uniform flows upstream of Main Road culvert.	**Photograph 8: Artificial steps extending from Main Road culvert outlet.**

4.3 River Blackwater

Catchment characteristics

4.3.1 The River Blackwater originates south-west of Radwinter (NGR: TL 5919 3650) and from source to estuary measures approximately 76km long. The overall catchment has a catchment area of approximately 424km^2. Bedrock geology predominately comprises clay, silt and sand of the Palaeogene London Clay Formation with Cretaceous Lewes Nodular Chalk at its source. Catchment superficial geology is largely made up of till-diamicton, whilst alluvium, head deposits, river terrace deposits and glacial sand and gravels are present along the channel. Dominant land use is a combination of pastoral and arable agriculture, whilst Braintree, Kelvedon and Maldon are urban settlements within the study area.

Channel form

4.3.2 The surveyed reaches of the watercourse exhibited a reasonably variable channel with reaches of differing substrate, water width and depth, and vegetation. The planform was generally straightened and artificially modified. The channel appeared to have been embanked with regularly spaced, planted willow trees. However, there were occasional reaches of more sinuous, natural looking channel throughout the surveyed reach. The cross-section of the channel was overwide at some locations and was actively adjusting, as evidenced by marginal reed beds. Approximate average channel width varied between 4m and 9m with water depths varying between 0.4m – 1.5m.

4.3.3 Bed substrate was predominantly fine sediments along the surveyed reach with some pockets of coarser sediment particles. However, larger gravels and sands became readily observed downstream of the A12 culvert. These were typically loose and unsorted, able to mobilise freely.

Riparian zone and channel vegetation

4.3.4 Vegetation across the channel corridor and riparian zone was uniform throughout the river channel. Predominantly, the bank was bordered by shrub vegetation (brambles, nettles other smaller shrub plants), grasses and semi-continuous or regularly spaced lines of trees. Where trees were present, they offered shade and bank stability to the river, whilst gaps in the tree line provided refuge for aquatic macrophytes. This was observed downstream of the A12 bridge, near Kelvedon, at the confluence of the Rivers Blackwater and Brain. Aquatic macrophytes were also observed near High Street Bridge in Kelvedon were the channel upstream and downstream of the bridge comprised of a wide variety of aquatic macrophytes (Photograph 9).

4.3.5 The channel margin was typically lined by reeds and rushes, which narrowed the channel. This suggested the surveyed reach was a depositional system actively adjusting to its current flow and sediment regime. Some of the channel also appeared to be choked by vegetation.

Modification and pressures

4.3.6 The River Blackwater was crossed by multiple bridge structures along its length. However, only three structures required channel modification. These are: the A12 Culvert, the bridges that cross Little Braxted, the bridge on Maldon Road and the High Street Bridge in Kelvedon. At the A12, the culvert has been reinforced, and has modified the bed and banks of the channel creating steep concrete bank slopes, a narrower uniform channel and a uniform bed depth (Photograph 10). Here, the river has begun adjusting to the shallow gradient of the artificial bed by depositing sand and gravel sediments.

4.3.7 Downstream of the A12 culvert, the channel started to deposit sediment on the bank margins, allowing reed beds to form, subsequently narrowing the channel. The channel has a variety of differing macrophytic and terrestrial vegetation growing in the channel creating different channels of flow. Fish were spotted at this location suggesting that the flow variation, macrophytes and coarser substrate were providing habitat. The culvert did not restrict the longitudinal connectivity for flow and sediment greatly, with the presence of larger particles immediately downstream of the structure.

4.3.8 The High Street Bridge in Kelvedon has significantly widened the River Blackwater channel reinforcing the left bank upstream of the bridge and both left and right banks downstream of the bridge (Photograph 11). Neither bank side was very high; and both were likely to be overtopped with higher flows. This would allow for lateral connectivity.

4.3.9 The bridge on Maldon Road and the surrounding channel have slightly embanked the channel's course. It was likely that the artificial embankment has reduced the lateral connectivity of the river, preventing it from overtopping. The bridge itself also had the capacity to reduce the longitudinal connectivity as the bridge supports may trap any larger debris, e.g., branches, which would reduce the capacity of the bridge to convey flows of water.

4.3.10 The bridge in Little Braxted and the two associated culverts are likely to restrict longitudinal connectivity due to a reduced ability to convey flows downstream

(Photograph 12). This would allow water to pool behind, enhancing the potential the reach has for flooding the surrounding land.

4.3.11 Little erosion was observed within the River Blackwater. Any observation of erosion was localised to fallen trees, such as those at the confluence with the River Brain (Photograph 13). However, erosion was limited on a reach scale. (Photograph 13).

4.3.12 Principal sediment sources, aside from the two scour locations, were predominantly outfall pipes, which introduced sediments to the river channel. In particular, the outfalls from the gravel pits near Little Braxted have capacity to introduce sediments to the channel as was evident from sediments deposited in the channel where an outfall flow drains into the River Blackwater (Photograph 14). The presence of marginal reed banks along the River Blackwater choked the channel suggesting that channel margin deposition was occurring. This in turn provided ground for reeds to root in the channel, and further narrowing watercourse as it adjusted to its flow and sediment regime. Subsequently, the surveyed reach along the River Blackwater was judged to be a sediment sink.

Summary

4.3.13 Table 4.3 summarises the principal hydromorphological features observed on site.

Table 4.3 River Blackwater baseline description of hydromorphological quality elements

River Blackwater	
Quantity and dynamics of water flow	Water level during the time of the survey was average, relative to flows present along the watercourse. Water flow types were few. The majority of flows were smooth.
Connection to groundwater bodies	None observed.
River continuity	The river was found to be embanked for the majority of the length of its course so lateral connectivity is likely to be low with the exception of the downstream end where low artificial banks may allow the channel to overtop. Longitudinal connectivity is high with only two structures preventing the channels connectivity: the culverts at Little Braxted and Bridge on Maldon Road.
River depth and width variation	River width varied between 4m and 11m. Depth varied between 0.5m to 1.5m
Structure and substrate of the riverbed	Substrate for the length of the channel was found to consist of predominantly finer silty material. However, coarse particles were found at particular reaches e.g. near Little Braxted and downstream of the A12 Culvert.

River Blackwater	
Structure of the riparian zone	The riparian zone was uniform, with a bankside cover of large shrubs (brambles and nettles) and set back regularly spaced Willow trees. Occasional clumps of woodland or sections of semi-continuous linings of trees were also found.
Morphological pressures	Embankments and numerous bridges have led to morphological pressures leading to channel widening.
 **Photograph 9: Narrower culvert upstream of depositing channel.**	 **Photograph 10: Reinforced bank upstream, widened channel.**
 **Photograph 11: Narrow culvert, may easily become blocked.**	 **Photograph 12: Scour on inside of meander bend.**

River Blackwater	
	
Photograph 13: Silt deposition being vegetated immediately downstream of outfall.	**Photograph 14: Large quantities of macrophytes.**

4.4 River Ter

Catchment characteristics

4.4.1 The River Ter originates at Stebbing Green (NGR: TL 6831 2343). Its length is approximately 30.5km, from source to confluence with the River Blackwater, and overall catchment area is approximately 80km^2. Bedrock geology comprises of clay, silt and sand of the London Clay formation, and the surficial geology is largely made up of till-diamicton, with Glacial sands and gravels and Brickearth along the channel. Dominant land use is pastoral and arable agriculture, whilst Great Leigh and Hatfield Peverel make up urban settlements.

Channel form

4.4.2 The River Ter was a modified, straight channel with a heavily modified planform upstream of the A12 culvert. Downstream of the culvert, the channel became increasingly sinuous, and formed a field boundary to arable agriculture, a water treatment plant and small woodland.

4.4.3 The cross-section was trapezoidal in the upstream sections of the surveyed reach. It had a uniform depth and width of approximately 0.3m deep by 4m wide, and a uniform bank profile on both the left and right banks (Photograph 15). At the downstream end of the surveyed reach, channel dimensions were varied with widths of up to 6m and depths of approximately 0.1-0.5m

4.4.4 Bed substrate predominantly comprised of silty and gravelly deposits, whilst it exhibited variable flow. The flow character upstream of the A12 and spillway was predominantly tranquil due to the nature of the uniform bed structure. Downstream of the A12, short pool riffle sections have formed with deposited gravels and some areas of slower water present. These occurred in deep

meander pools and behind trees that had fallen into the channel (Photograph 16), which offered natural flow variation and habitat for small fish as was found.

4.4.5 The reach upstream of the spillway appeared to be a sediment sink with deposition occurring in-channel. This facilitated the formation of reed beds, a side bar and a large vegetated (grasses, shrubs and large trees) mid-channel bar (Photograph 17). is the mid-channel bar was observed immediately upstream of a spillway and formed of larger gravels and finer material in the lee of the structure. Despite this barrier, sediment had also deposited downstream, evidenced by silt and gravel deposition downstream of the spillway under the A12 culvert (again vegetated by shrubs and trees) and of the B1137 culvert.

4.4.6 Downstream of the culvert the channel was incised, with higher banks than the upstream reach. The channel also narrowed and became more sinuous. This increase in sinuosity was evidenced by bank scour and undercutting, in addition to silty and gravelly deposits found predominately along inner channel bends. This reach regularly widened and narrowed with the presence of vegetation (likely to have taken root on silty side deposits), and large pools measuring up to 6m wide and 5m in length. Combined, these observations suggest the downstream reach was much more dynamic than upstream.

Riparian zone and channel vegetation

4.4.7 Large trees and shrubs lined the majority of the riparian corridor and offered shading and protection to the river channel and river banks. In the upstream reach only one large area was open to the light, this area had recently been cleared of trees as was evident from a large log pile. Within the channel a reed bed had formed along the left ban along with the growth of macrophyte vegetation. Similarly, a few small openings occurred in the downstream end of the reach, in which reed beds have taken root. Downstream of the Environment Agency gauging station (NGR: TL 7864 1075) the trees gave way to a second large open area along the channel. Here, the channel has become overgrown with emergent reed beds, almost choking the channel, a sign of further sediment deposition.

Modifications and pressures

4.4.8 Significant modifications have been made to the channel. The presence of the spillway underneath the existing A12 acted a barrier to coarse sediment movement (Photograph 17 and 18). Culverts also conveyed flow beneath both the A12 and the B1137. Approximately 100m downstream of the A12, a large pipe crosses the watercourse. Its purpose is not known.

4.4.9 Approximately 1km downstream of the existing A12, an Environment Agency gauging station was observed (NGR: TL 7864 1075) (Photograph 19 and 20). At these structures, both the bed and banks are reinforced. All convey flow downstream efficiently.

Summary

4.4.10 A summary of the principal hydromorphological features observed on site is included in Table 4.4.

Table 4.4 River Ter baseline description of hydromorphological quality elements

River Ter	
Quantity and dynamics of water flow	Water levels at the time of the survey were typically average for flows recorded along this watercourse. Flow types were varied, with smoother runs in the upper reach above the B1137 culvert and the spillway and much more varied flows in the lower reach. Riffle pool sections, meander pools and localised flow variations caused by fallen trees.
Connection to groundwater bodies	None observed.
River continuity	Longitudinal connectivity is restricted by a spillway structure that allows water and sediment to pool and settle behind it. Whilst flow is still maintained it is slowed significantly leading to deposition which has led to the formation of a vegetated mid channel bar, this has further slowed water flow around the island. Some aspect of sediment movement is still present as is evidenced by deposition immediately downstream of the spillway structure in the middle of the channel and on the channel edges with silt and gravel deposition at the A12 and B1137 culverts, and a large silt side bar developing on the left bank of the A12 culvert which has been colonised by shrub vegetation and a large tree at the downstream end. The culverts do not appear to restrict longitudinal connectivity. Laterally, the river is confined at its upstream end by profiled banks and bankside reinforcement, which likely prevents all but the larger flood events from overtopping the river banks.
River depth and width variation	The river was approximately 4-10m in width with depth varying from 0.5 -1.5m.
Structure and substrate of the riverbed	The bed substrate typically consisted of fine silty materials with gravel present at the water's edge, particularly in the upstream reaches. In the downstream reaches, more gravel was present particularly at the immediate downstream of the B1137 culvert and at the bridge downstream of the Environment Agency gauging station. Gravels also appeared in channel allowing for the formation of ripples pool systems.

River Ter	
Structure of the riparian zone	The riparian zone typically consisted of shrubs and large trees which afforded shade and bankside stability to the channel. Where tree cover was not present the riparian zone was uniform with grasses, brambles and nettles present alongside lengths of reed beds. Himalayan Balsam is present at the site.
Morphological pressures	Spillways and culverts convey flows along the channel but act as a barrier to sediment by replacing the natural bed and banks of the channel.
 **Photograph 15: Uniform trapezoidal channel.**	 **Photograph 16: Tree felled dam, affecting flows.**
 **Photograph 17: Spillway.**	 **Photograph 18: Environment Agency gauging station. Vegetated mid-channel bar at the spillway.**

River Ter	
	
Photograph 19: Environment Agency gauging station	**Photograph 20: conditions at the Environment Agency gauging station**

4.5 River Brain

Catchment characteristics

4.5.1 The River Brain originates south-east of Great Bardfield (NGR: TL 6928 2895). From source to its confluence with the River Blackwater, the watercourse is approximately 27km long, and has an overall catchment area of approximately 70km^2. The bedrock geology comprises of the London Clay Formation, and the surficial geology is made up of Till – Diamicton, with alluvium, glacial sand and gravels and Brickearth along the channel. The dominant land use is a combination of pastoral and arable agriculture, whilst urban settlements are represented by Braintree.

Channel form

4.5.2 Within the study area, the surveyed reaches exhibit a straightened channel with a large, restored reach which has been artificially restored along part of it. Additionally, a short sinuous section was observed between the B1016 and B1389. Passing beneath the B1389, the channel returned to a straightened planform, as it flowed towards the confluence with the River Blackwater. The river corridor extended across Witham Park, bordered by residential housing on either bank. The river channel was approximately 5.5m wide extending to 7m wide closer to the confluence, but narrowed with the presence of reed beds taking root on deposited silt material, with a depth ranging from 0.3-1.5m.

4.5.3 A dredged secondary channel drained into the River Brain at the park west of Witham Hockey and Cricket Club (NGR: TL 8217 1396). This reach was sinuous and previously acted as a mill leat, according to historical maps.

4.5.4 The bed substrate was predominantly fine gravels to large gravels and cobbles. However, there were channel reaches where silts deposited in the channel and blanketed the underlying coarser material beneath (Photograph 21). In some areas, these gravels appeared consolidated and even armoured the bed.

4.5.5 Flow across the channel was typically pool-riffle with deep meander pools slowing down the flow. Downstream of the A12, flows were channelled around alternating reed beds which offered a variety of flow speeds and refugia for smaller fish.

4.5.6 The River Brain was an active river displaying evidence of erosion and depositional features. Sediment sources along the channel's length were present in areas of poaching and bank scour and undercutting (Photograph 22). Outfalls also supplied sediments to the system. Depositional features within the channel were evidenced by the covering of the gravel bed by silty materials. This deposition of sediments along the channel margin allowed reed beds to take root at the downstream end of the surveyed reach (Photograph 23). Overall, this channel was most likely a sediment source and is currently adjusting to historical modifications.

Riparian zone

4.5.7 Vegetation across the channel corridor and riparian zone was predominantly grasses overbank. Bank tops comprised of a semi-continuous line of trees, which offered shading to the channel and bank stability. There were occasional breaks in the tree line which allowed extensive macrophyte beds to take root in the unconsolidated gravel bed. Downstream of the A12, vegetation on the embankment tops was replaced by a grass track on both sides with set-back regularly spaced willow trees and extensive alternating reed beds and macrophytes within the embanked channel. At the confluence with the River Blackwater, the reed bed expanded in area.

Modifications and pressures

4.5.8 Modifications to the channel were few. A large culvert (Brain bridge) under the A12 was present comprising of an artificial channel bed and two tracks. The first track is only marginally higher than the riverbed, which appeared to have been widened across this section. At the time of survey, water was flowing over the lower track and had deposited large amounts of silt on it (Photograph 24). Where sediment had accumulated along the artificial channel bed in the culvert, vegetation had taken root.

4.5.9 Downstream of the reinforced bed and banks, the channel had begun to incise into its bed, creating a deep pool directly downstream of the culvert. Railings in place to separate the track from the channel acted as a trash screen, with woody debris washed downstream and subsequently caught on the railing. The presence of woody debris continued to catch further debris from upstream leading to localised deposition.

4.5.10 Four reinforced outfalls were positioned in the channel (Photograph 23), entering the channel at a perpendicular angle flat with the channel bank and set back from the channel angled with the direction of flow. These outfalls were sources of water, sediment and pollution.

Summary

4.5.11 Table 4.5 summarises the principal hydromorphological features observed on site.

Table 4.5 River Brain baseline description of hydromorphological quality elements

River Brain	
Quantity and dynamics of water flow	Flow levels within the river were typically average for flows recorded along this watercourse. The flow was varied. Presence of pool riffle sequences, deeper meander pools and smooth areas of flow
Connection to groundwater bodies	None observed.
River continuity	Longitudinal and lateral connectivity are maintained in this channel upstream of the A12 the river is free to overtop its banks. There is one purpose-built embankment in the park on the inside of a meander bend. Downstream of the A12, despite the river overtopping the artificial channel present that is part of the culvert structure, lateral connectivity is restricted. The channel is embanked at a height of approximately 0.7m.
River depth and width variation	The river is approximately 5.5 – 7m high with reeds narrowing the channel to <1m in width. Water depth ranges between 0.4m – 1m
Structure and substrate of the riverbed	The riverbed consists of gravel sediments with some areas overlain by silty material. Generally, this gravel bed is poorly sorted unconsolidated material, however there are small reaches of consolidated armoured gravel bed. These sections are those overlain by silty material.
Morphological pressures	Brain bridge compounds flows and sediment conveyance leading to a heavily silted channel immediately upstream of it. The bridge also replaced natural bed and bank material altering flows and leading to scour immediately downstream.

River Brain	
	
Photograph 21: Coarse material overlain by silts.	**Photograph 22: Undercut banks and scour.**
	
Photograph 23: Set back outfalls.	**Photograph 24: High silt deposition along trackway.**

4.6 Rivenhall Brook

Catchment characteristics

4.6.1 Rivenhall Brook originates south of Braintree (NGR: TL 7825 2124). From source to its confluence with the River Blackwater, the watercourse is approximately 9.5km long and catchment area approximately 17km^2. Bedrock geology predominately comprises of clay, silt and sand of the Palaeogene London Clay. Catchment superficial geology is largely made up of till-diamicton, whilst alluvium, Kesgrave deposits (sands and gravels) and peat are present along the channel. Dominant land use is a combination of pastoral and arable agriculture, whilst Silver End and Rivenhall village make up urban settlements.

Channel form

4.6.2 The surveyed reaches exhibit a straightened uniform channel with very few differentiable characteristics along its length. A modified trapezoidal cross-section (Photograph 25) exhibited a steep/near vertical left bank and shallow right bank which had been poached (Photograph 26).

4.6.3 The channel appeared over-wide and exhibited uniform and featureless flows, with the exception of some rippled flows where the channel narrowed (Photograph 27). This led to a consolidated bed comprising of fine to medium gravel with silts (Photograph 28).

Riparian and channel length vegetation

4.6.4 The channel and riparian corridor were predominately lined by shrubs, whilst a deciduous tree line also occupied the left bank. A tree line was present along some of the right bank, however it comprised of regularly spaced deciduous trees which helped to provide some shade along the channel.

4.6.5 Where unshaded, riparian vegetation was uniform comprising largely of grass and shrubs (Photograph 29).

Modifications and pressures

4.6.6 Numerous footpaths crossed the watercourse approximately 500m downstream of the A12 have led to localised widening of the watercourse and increased silt (Photograph 30). The straightened and trapezoidal channel had also contributed to the uniform flows and consolidated bed.

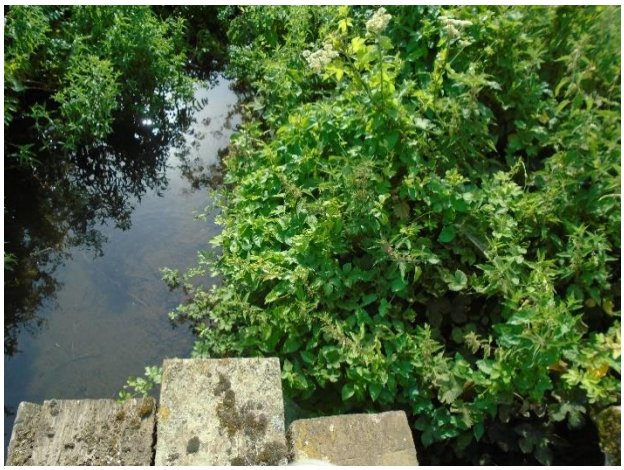
Summary

4.6.7 Table 4.6 summarises the principal hydromorphological features observed on site.

Table 4.6 Rivenhall Brook baseline description of hydromorphological quality elements

Rivenhall Brook	
Quantity and dynamics of water flow	Water levels at the time of the survey were average. Flow appeared to be largely uniform and featureless.
Connection to groundwater bodies	None observed
River continuity	Lateral continuity appeared impeded by a steep right-hand bank, whilst connectivity with the floodplain was improved along the left bank.
River depth and width variation	Dimensions not recorded.
Structure and substrate of the riverbed	The bed substrate typically consisted of fine silty materials and medium gravels. Bed was consolidated and poorly sorted.

Rivenhall Brook	
Structure of the riparian zone	The riparian zone comprised of a deciduous tree line shading the watercourse, whilst shrubs made up the understory.
Morphological pressure	Footbridges along the study reach lead to some localised widening of the channel and accumulations of fine sediment.
 **Photograph 25: Uniform channel downstream reed lined and trapezoidal.**	 **Photograph 26: Poaching on bank with larger particles instream.**
 **Photograph 27: Rippled flows as channel narrowed for vegetation.**	 **Photograph 28: Consolidated bed substrate.**

Rivenhall Brook	
	
Photograph 29: Shaded channel with shrubs lining the banks.	**Photograph 30: Footbridge with some local widening and increased siltation.**

4.7 Domsey Brook

Catchment characteristics

4.7.1 Domsey Brook originates south-west of Marks Tey (NGR: TL 88920 22610). From source to its confluence with the River Blackwater, the watercourse is approximately 8.8km long and catchment area approximately 24km^2. Bedrock geology predominately comprises of clay, silt and sand of the Palaeogene London Clay, and the surficial geology is predominately made up of Till – diamicton, whilst alluvium, head deposits and river terrace deposits are present along the channel its floodplain. Dominant land use is arable agriculture.

Channel form

4.7.2 The surveyed reaches exhibit a small watercourse with a predominantly straightened planform, forming as a field boundary along the upper surveyed reach. Its cross-section, form, and dimensions varied downstream of the land west of Easthorpe and towards its confluence with the River Blackwater. Predominantly, the cross-section was uniform and trapezoidal (Photograph 31) where depths ranged from 0.3m to 0.5m. Widths varied from 2m near Easthorpe to 4m close to the confluence. A short reach beneath the road bridge at Inworth Road was an exception to these conditions. Here, the watercourse was split into two separate shallow channels with a minimum depth of 0.1m (Photograph 32).

4.7.3 The bed substrate was predominantly silty, although gravel deposits were found beneath the bridge at Inworth Road. There were earthen banks here, also. Very little evidence of erosion or deposition was found within the catchment, with the exception of the gravel deposits at the bridge.

4.7.4 Flow was tranquil in the upstream tributaries and throughout the main channel. There was occasional stagnant water and/or impounded flows in the upstream reaches where vegetation had overgrown and choked the channel. In addition, the water had become turbid. Further downstream, close to the confluence, a scum had developed on the water's surface.

Riparian zone and channel vegetation

4.7.5 The watercourse was predominantly lined with trees present on either or both banks offering shade and bankside stability. Under the tree canopy, the banks were typically lined with nettle and bramble shrubs, whilst grasses grew between them. Vegetation appeared to be present within the channel as well with macrophytes in more open areas of the channel.

Modifications and pressures

4.7.6 The watercourse was modified in a number of places, predominantly via bridging and culverting at the A12 and Inworth Road. These limited the natural connectivity of the river both longitudinally and laterally, preventing flows from being conveyed downstream. In the case of the culvert at the confluence of Domsey Brook with the River Blackwater and the bridge at Inworth Road, there was bankside reinforcement. The high banks at the bridge restricted the channel, preventing any movement and/or lateral adjustment. These pressures also affected sediment conveyance and continuity within the reach.

Summary

4.7.7 Table 4.7 summarises the principal hydromorphological features observed on site.

Table 4.7 Domsey Brook baseline description of hydromorphological quality elements

Domsey Brook	
Quantity and dynamics of water flow	Water levels at the time of the survey were typically smooth and slow throughout. However, reaches of the river appeared to be stagnant, allowing vegetation terrestrial growth and water scum to form on the surface.
Connection to groundwater bodies	None observed.
River continuity	Longitudinal connectivity appeared to be predominantly unimpeded with no obstructions. Reaches of the river were found to be culverted under roads or footpaths creating a bottleneck for flows or overgrown with vegetation having a similar but reduced effect. Lateral connectivity appears to be limited to the river channel with little evidence of overtopping. It is likely that where bottlenecking of the longitudinal connectivity would increase lateral connectivity as waters rise beyond a natural height.

Domsey Brook	
River depth and width variation	The river was approximately 2-5m in width and an average of 0.5m in depth.
Structure and substrate of the riverbed	The bed substrate typically consisted of fine silty materials with one instance of gravel deposits under the road bridge at Inworth Road.
Structure of the riparian zone	The riparian zone across the Domsey Brook consisted of a uniform riparian zone consisting of brambles and nettles with a semi-continuous tree coverage offering shade and bank stability. These riparian trees extended on either or both banks, with more significant woodland patches at the downstream end. In the upstream reaches there is no significant border between the agricultural land use on the bank tops as the river is used for field drainage.
Morphological pressure	Bridging and culverting have led to connectivity issues, whilst bank reinforcements is also present at Inworth Road bridge.
	
Photograph 31: Trapezoidal channel with turbid water.	**Photograph 32: Two channel system, gravels present.**

4.8 Roman River

4.8.1 Due to access constraints, only a short reach of the Roman River was surveyed. This location is downstream of the A12 culvert.

Channel characteristics

4.8.2 Roman River originates in Great Tey (NGR: TL 8668 2509). From source to estuary the watercourse is approximately 23.6km long and catchment area approximately 61km^2. Bedrock geology predominately comprises of clay, silt and sand of the Palaeogene London Clay. Catchment superficial geology is largely made up of till-diamicton, whilst alluvium, head deposits, Kesgrave deposits (sands and gravels), interglacial lacustrine deposits and patches of cover sand are present along the channel. Dominant land use is arable agriculture, whilst Colchester occupies the north-eastern catchment boundary.

Channel form

4.8.3 The surveyed reaches exhibit a straightened, uniform channel with an artificial trapezoidal cross-sectional (Photograph 33). Evidence of erosion was present with some bank undercutting. This suggested that the study site within Roman River acts as a source of sediment supply to other sections of the catchment. The presence of undercutting banks also suggested that Roman River was adjusting towards a more stable system.

4.8.4 The bed material comprised fine gravels with pockets of coarse gravel particles and debris along the channel bed and banks (Photograph 34). Bank material was earthen, whilst flow was tranquil, with some change at the occasional riffle.

Riparian and channel vegetation

4.8.5 The watercourse was shaded entirely by the surrounding wooded area offering protection from higher temperatures. The presence of bankside trees and bankside roots supported the channel banks with bankside roots. Furthermore, fallen branches and other woody material offered potential habitats for macroinvertebrates. Aside from the surrounding woodland, bankside vegetation comprised of grasses and small shrubs, offering little extra reinforcement. There was no vegetation in the channel.

Modifications and pressures

4.8.6 Morphological pressures were concentrated at Roman River culvert where the channel had been straightened to accommodate both the culvert crossings and the A12 carriageway. As a result, the channel was locally uniform and lacked in differential hydromorphological characteristics.

Summary

4.8.7 Table 4.8 summarises the principal hydromorphological features observed on site.

Table 4.8 Roman River baseline description of hydromorphological quality elements

Roman River	
Quantity and dynamics of water flow	Water levels at the time of the survey over the observable reach were smooth, with the presence of ripples further upstream.

Roman River	
Connection to groundwater bodies	None observed.
River continuity	Longitudinal connectivity appeared to be unimpeded with no obstructions upstream or downstream visible from the access points available. Lateral connectivity is limited to the immediate bankside and bank slopes with flows otherwise impeded by the high sloped banks that appeared to continue upstream and downstream for the length of the reach channeling flows down the river.
River depth and width variation	The river was approximately 1.5-2m in width and 0.3m in depth for the entire observable reach.
Structure and substrate of the riverbed	The bed substrate consisted of poorly sorted fine gravels with some coarse gravel particles and debris.
Structure of the riparian zone	The riparian zone across the observable reach consisted of simple (one species) and uniform (two species) bank edges of shrub vegetation but was also surrounded by trees which offered shade and some bank stability. These riparian trees extended on both banks, more so the right than the left (due to the presence of the A12 beyond the left bank), offering isolation from surrounding land usage
Modifications and pressures	Culvert crossing and realignment at the A12 has led to an unenergetic and uniform watercourse.
	
Photograph 33: Uniform trapezoidal channel.	**Photograph 34: Fine gravel and debris substrate.**

4.9 Other watercourses

4.9.1 A number of agricultural field drains, identified from the desk study and some of which assessed further during reconnaissance surveys, would also be potentially impacted by the proposed highway improvements. These watercourses are listed in Table 4.9 along with a rough description of their location. Figure 14.1 of the Environmental Statement [TR010060/APP/6.2] displays the location of each watercourse described in this section.

Table 4.9 List of Ordinary Watercourses / agricultural field drains potentially affected

Watercourse	Description
Ordinary Watercourse 1b (tributary of the River Chelmer)	Ordinary Watercourse 1b originates approximately 1km west of the proposed scheme, in Dukes Park Industrial Estate, north of Chelmer Village and east of the A12. It flows eastwards through pastoral agriculture and managed recreational land, through the A12 culvert and towards the River Chelmer. Planform is straight, lacking morphological features within the channel, and is encroached by vegetation along unshaded lengths. The channel planform appears largely unchanged with exception to a realignment following the construction of the A12 from 1983.
Ordinary Watercourse 1a (tributary of the River Chelmer)	Ordinary Watercourse 1a has its source approximately 0.5km west of the proposed scheme, in Springfield Business Park, north of Chelmer Village and west of the A12. The channel flows east, where it is culverted beneath the industrial estate, and flows into a small reservoir beneath the A12 via a culvert and towards its confluence with Ordinary Watercourse 1. The channel is largely impounded upstream of the A12, whilst downstream it acts a field drain and boundary. With the exception of some channel widening, the watercourse is hydromorphologically inactive. Historically, the watercourse has been used as a field drain, pre-dating historical maps (prior 1874). Modifications began from 1983 with the construction of the A12, where it was culverted, and then further culverted and impounded following the expansion of the adjacent industrial estate (present day).
Ordinary Watercourse 1 (tributary of the River Chelmer)	Ordinary Watercourse 1 originates at Colchester Road, approximately 0.5km west of the proposed scheme, in Springfield Business Park. The channel flows eastwards through numerous road culverts in the business park, through the A12 culvert and towards the River Chelmer. The channel is generally a culverted drainage channel upstream of the A12 and acts as a field boundary and drain downstream and is hydromorphologically inactive. Planform is largely straight.

Watercourse	Description
Ordinary Watercourse 2 (tributary of the River Chelmer)	Ordinary Watercourse 2 originates north of Springfield Business Park approximately 0.5km west of the proposed scheme, exhibiting a straightened planform. The channel flows south-east passing through industrial land and several culverts including the A12 crossing. Downstream of the A12, the channel flows through arable agricultural land before joining Ordinary Watercourse 1. The channel is a straightened and over-vegetated drainage channel, lacking significant depositional features and erosion. Its function was to form a field boundary since 1874 and has been modified by the construction of Springfield Business Park and the A12, which took place from 1983.
Ordinary Watercourse 3 (tributary of Boreham Brook)	Ordinary Watercourse 3 has its source at Bulls Lodge quarry (NGR: TL 73306 12362) from where it flows south towards Boreham Brook, north of the A12. The channel exhibits a straight planform where it acts a drainage ditch and land boundary. Therefore, no significant hydromorphological processes or depositional features are likely.
Ordinary Watercourse 28 (tributary of the River Ter)	Ordinary Watercourse 28 has a predominately straight planform and originates north of the proposed scheme. From its source, the watercourse flows south past pastoral agricultural land, through the A12 culvert and through arable agricultural land before draining into the River Ter. Desk-based hydromorphological observations suggest the channel acts as a field boundary and drainage channel lacking in significant depositional features and erosion. Historical analysis suggests it was realigned in 1949, whilst culverting for the A12 took place from 1983.
Ordinary Watercourse 31/31b (tributary of the River Ter),	Ordinary Watercourse 31/31b has a predominately straight planform and originates approximately 0.2km north of the A12. From there, it flows south-east through pastoral agricultural land, through the A12 culvert and through arable agricultural land before draining into the River Ter spillway. Desk-based hydromorphological observations suggest that the channel acts as a field boundary and drain. It lacks any significant depositional features or erosion, appearing over-vegetated, with no changes likely since 1937 (according to historical maps).
Ordinary Watercourse 7 (tributary of the River Blackwater)	Ordinary Watercourse 7 has its source north-east of the A12 and Hatfield Peverel and has a predominately straight planform. The water course flows south-east as it passes through arable agricultural land present both up- and downstream of the A12 culvert before meeting the River Blackwater. Hydromorphological observations (desk study) suggest the channel forms a land boundary and drainage channel exhibiting no depositional features or extents of erosion. Historical analysis suggests the current channel planform pre-dates historical mapping (pre-1874). Culverting of the channel at side roads was recorded from 1971, with the A12 (previously roman road) upgrade from 1983.

Watercourse	Description
Ordinary Watercourse 32 (tributary of the River Blackwater)	Ordinary Watercourse 32 has its source south of the A12. It is largely straight and passes through arable agriculture areas before draining into the River Blackwater. The channel acts as a field boundary and drain, exhibiting no significant depositional features or erosion, appearing largely dry and overgrown by vegetation.
Ordinary Watercourse 9 (tributary of the River Blackwater)	Ordinary Watercourse 9 originates north-east of the A12 at Witham. From there, the channel typically flows east, flowing through residential areas prior to crossing the A12 and passing though arable agricultural land before draining into a series of spillway channels linked to the River Blackwater. The channel is used as a drainage channel, lacking morphological variation.
Ordinary Watercourse 9a (tributary of the River Blackwater)	Ordinary Watercourse 9a has its source east of the A12 and Witham and flows southwards to the River Blackwater. The channel acts as a drainage channel, exhibiting no significant depositional features or erosion. The channel was realigned from 1974, exhibiting no sign of change since then.
Ordinary Watercourse 9b (tributary of the River Blackwater)	Ordinary Watercourse 9b originates south-east of the A12 at Witham. From there, the watercourse flows south-east towards the River Blackwater as a drainage channel and surface water pathway. No observable channel is defined along its alignment, therefore hydromorphological processes are likely to be absent.
Ordinary Watercourse 9c	Ordinary Watercourse 9c originates south-east of the A12 at Witham. From there, the watercourse flows north-east towards Ordinary Watercourse 9b as a surface water pathway. No observable channel is defined along its alignment, therefore hydromorphological processes are likely to be absent.
Ordinary watercourse 9d (tributary of the River Blackwater)	Originating south-east of the A12 in Wickham Bishops, Ordinary Watercourse 9d flows north-west towards the River Blackwater. The watercourse appears dry and vegetated, likely to act as a gully during flood events. No hydromorphological processes are likely along this channel with no depositional features or erosion observed.
Ordinary watercourse 9e (tributary of the River Blackwater)	Ordinary Watercourse 9e originates south-east of the A12 at Ishams Chase. From there, the watercourse flows west towards the River Blackwater as a surface water gully. Conditions appear dry and vegetated along the channel with significant hydromorphological processes appearing absent.
Ordinary watercourse 9f (tributary of the River Blackwater)	Ordinary Watercourse 9f originates south-east of the A12 at Wickham Bishops. From there, the watercourse flows north-east towards the River Blackwater as a drainage channel. Conditions appear dry and vegetated with significant hydromorphological processes appearing absent.

Watercourse	Description
Ordinary watercourse 9g (tributary of the River Blackwater)	Originating in Wickham Bishops, Ordinary Watercourse 9g flows north-west towards the River Blackwater. The channel appears to largely be a dry and vegetated drainage channel, where visible, and presents no significant hydromorphological processes or depositional features.
Ordinary watercourse 9h	Ordinary Watercourse 9h is a drainage ditch originating east of the River Blackwater and the A12. Flowing west towards Unnamed Watercourse 9g, draining near to the River Blackwater confluence. Ordinary Watercourse 9h is a straight channel presenting no likely hydromorphological processes or depositional features.
Ordinary watercourse 9i (tributary of the River Blackwater)	Ordinary Watercourse 9i is a straight channel originating from an access track east of the A12 in Witham (NGR: TL 83461 14444). Artificial in form, the watercourse is purposed for agricultural drainage. Therefore, exhibiting no significant geomorphological processes and or depositional features.
Ordinary Watercourse 10 (tributary of the River Blackwater)	Ordinary Watercourse 10 has its source in Western Industrial Estate, east of the A12, in Witham. From there the predominately straightened channel flows typically south-east, likely culverted beneath the industrial estate, out of the A12 culvert and towards the River Blackwater. Hydromorphological observations suggest the channel is a drainage channel lacking morphological features. Historical analysis suggests the channel has been predominately used as a field boundary but was extensively culverted for an industrial estate from 1971, and for the A12.
Ordinary Watercourse 11 (tributary of the River Blackwater)	Ordinary Watercourse 11 has its source near to Forest Road in Witham, west of the A12 – flowing south-east towards the River Blackwater, passing beneath an industrial estate and the A12, and past a quarry and pastoral agriculture land, whilst exhibiting a gently sinuous planform. Hydromorphological observations (desk study) suggest the channel acts as a field boundary and drainage channel. Where visible, the channel lacks depositional features, whilst field-based photographs show an over vegetated channel. Historical analysis suggests the channel was excavated from 1955 and culverted from 1993.
Ordinary Watercourse 12 (tributary of the River Blackwater)	Ordinary Watercourse 12 has its source at Rivenhall Oaks Golf course, north-east of the A12. From there the channel flows south-east towards Ordinary Watercourse 11, exhibiting a predominately gently sinuous planform as it passes through both pastoral and arable agricultural land and a quarry. Hydromorphological observations suggest the channel acts as a land boundary and drainage channel with no depositional features or erosion, appearing largely dry. Historical analysis suggests the channel has not altered since 1874, with exception of being culverted and realigned for the A12 from 1983.
Ordinary Watercourse 12a (tributary of the River Blackwater)	Ordinary Watercourse 12a has its source south of the A12, from where it flows south through agricultural fields, through two reservoirs and towards the River Blackwater. The channel has a straightened planform. Desk-based hydromorphological observations suggest the channel is a surface water pathway with no distinguishable channel.

Watercourse	Description
Ordinary Watercourse 13 (tributary of the River Blackwater)	Ordinary Watercourse 13 has its source south of the A12, from where it flows south through agricultural fields, Coleman's Reservoir and towards the River Blackwater. The channel has a straightened planform. Desk-based hydromorphological observations suggest the channel acted as field boundary and drain and lacked significant depositional features or erosion. The construction of Coleman's Reservoir from 1990 has since formed part of the channels drainage system.
Ordinary Watercourse 13a	Ordinary Watercourse 13a is sourced immediately north of Coleman's reservoir and flows south-west towards Ordinary Watercourse 13. From its source, Ordinary Watercourse 13a exhibits a straight channel used for drainage. This artificial channel, although obscured by vegetation is unlikely to present any significant hydromorphological processes and/or depositional features.
Ordinary Watercourse 15a (tributary of Rivenhall Brook)	Ordinary Watercourse 15a has its source south of the A12, from where it typically flows south-east towards Rivenhall Brook. The channel passes arable agricultural land and a deciduous plantation, exhibiting a largely straight planform. Hydromorphological observations suggest the channel acts as a field boundary and drain and is mostly obscured by riparian vegetation. Field observations highlight that the channel is largely dry and heavily vegetated where active flows only occur during periods of heavy rainfall.
Ordinary Watercourse 15 (tributary of Rivenhall Brook)	Ordinary Watercourse 15 has its source north of the A12 near to the east bank of Rivenhall Brook. The straightened channel flows through deciduous woodland as it flows south-east towards Rivenhall Brook. The channel acts as a field boundary and drainage channel for a plantation and displays a lack of significant depositional features and erosion. Historical analysis suggests the drainage channel was excavated from 1938 and has remained since, only culverted from 1983 for the A12.
Ordinary Watercourse 17 (tributary of the River Blackwater)	Ordinary Watercourse 17 originates north of the A12 and has a gently sinuous planform. The channel initially flows south-west through plantation woodland, towards the A12, before flowing south-east, passing beneath the A12 and towards the River Blackwater, as it flows by recreational land and arable agriculture. Hydromorphological observations suggest the channel is largely used as a field boundary and drainage channel.
Ordinary Watercourse 33 (tributary of the River Blackwater)	Ordinary Watercourse 33 originates at Church Hill upstream of the proposed scheme. It flows in a southerly direction. The channel exhibits a slight sinuosity to some of its planform, however it is largely straight acting as a land boundary and field drain. The nature of the bends suggest it is a passive channel with no evidence of significant natural processes and not depositional features.

Watercourse	Description
Ordinary Watercourse 18 (tributary of the River Blackwater)	Ordinary Watercourse 18 originates along Highfields Lane, Kelvedon, south of the A12. The channel exhibits a straightened planform as it flows north-west towards the River Blackwater. This channel acts as a field boundary and field drain. Historical analysis suggests the channel was excavated from 1968 and has not been altered since excavation.
Ordinary Watercourse 21 (tributary of the River Blackwater)	Ordinary Watercourse 21 originates at Windmill Hill, south of the A12. From its source the channel flows typically north-west towards the A12 and the River Blackwater. The channel has a straightened planform as it passes both pastoral and arable agricultural land. This is a field drain. Historical analysis suggests channel modification has been limited to realignment near to the confluence with the River Blackwater from 1968 and the A12 culvert from 1983.
Ordinary Watercourse 35 (tributary of the River Blackwater)	Ordinary Watercourse 35 originates by Ewell Hall Chase upstream of the proposed scheme. It flows in a northerly direction.
Ordinary Watercourse 21a (tributary of the River Blackwater)	Ordinary Watercourse 21a has its source south-east of the A12, where it flows north-west through an A12 culvert and towards the River Blackwater passing arable agricultural fields and exhibiting a straightened planform. Desk-based hydromorphological observations suggest the channel acts a field drain. Historical analysis suggests the channel was realigned from 1973 following construction of the A12 and a sewage works.
Ordinary Watercourse 34 (tributary of Domsey Brook)	Ordinary Watercourse 34 originates by Inworth upstream of the proposed scheme. It flows in a northerly direction and exhibits a straightened planform, absent of any significant hydromorphological deposits or processes.
Ordinary Watercourse 34A	Ordinary Watercourse 34A originates 400m west of Inworth Road from where it flows east along a straightened and culverted channel before draining into Ordinary Watercourse 34. The watercourse exhibited now significant hydromorphological processes or depositional features. Historical analysis does not depict the watercourse until present day maps.
Ordinary Watercourse 34B	Ordinary Watercourse 34B originates approximately 300 south-west of Inworth Road and flows as a surface water pathway towards Ordinary Watercourse 34. As it is a surface water pathway only active during flood events, no defined channel is observable and therefore no significant hydromorphological processes and features are present. Historical maps do not depict any historical channel how topographic lines suggest the surface water pathway could be present there.

Watercourse	Description
Ordinary Watercourse 34C	Ordinary Watercourse 34C originates approximately 365m east of Perrywood Garden Centre and flows north-west as a surface water path towards Ordinary Watercourse 34. As a surface water path, which is only active during flood events, Ordinary Watercourse 34C does not exhibit any significant hydromorphological features or processes. Furthermore, the watercourse also lacks a defined channel. Historical analysis also fails to record the presence of the watercourse, however indentations in the topographic lines suggests this surface water pathway may have been present before the earliest available maps (1885).
Ordinary Watercourse 23 (potential tributary of Domsey Brook)	Ordinary Watercourse 23 has its source north of the A12 and London Road, from where it flows south towards London Road, bordered by residential properties. The channel is a straightened drainage ditch exhibiting a homogeneous channel. The channel appears dry, whilst historical maps do not depict its presence.
Ordinary Watercourse 37b (tributary of Domsey Brook)	Ordinary Watercourse 37b has its source south of the A12, from where it flows south towards Ordinary Watercourse 37, passing arable agriculture and managed recreational land, whilst exhibiting a largely straightened planform. The channel acted as a field boundary and drain, and lacked significant depositional features and erosion, appearing overgrown by vegetation. Historical analysis suggests the channel has remained unchanged since its excavation prior to the earliest historical mapping (pre-1874).
Ordinary Watercourse 37 (tributary of Domsey Brook)	Ordinary Watercourse 37 has its source south of the A12, from where it flows south towards Domsey Brook, passing arable agriculture and managed recreational land, whilst exhibiting a largely straightened planform. The channel acts as a field drain and lacks significant depositional features and erosion, appearing overgrown by vegetation. Historical analysis suggests the channel has remained unchanged since its excavation prior to the earliest historical mapping (pre-1874).
Ordinary Watercourse 24 (tributary of Domsey Brook)	Ordinary Watercourse 24 has its source south of the A12, where it flows south-east towards Ordinary Watercourse 37 exhibiting a straightened planform as it passes arable agricultural land. It acts as a field drain.
Ordinary Watercourse 40 (tributary of Domsey Brook)	Ordinary Watercourse 40 is a drainage ditch originating south of Easthorpe Road. Aerial imagery depicts an undefined channel where the watercourse acts as a surface water pathway exhibiting no hydromorphological deposits or processes.
Ordinary Watercourse 39 (potential tributary of Domsey Brook)	Ordinary Watercourse 39 is a drainage ditch originating south of Easthorpe Road. It flows in a southerly direction exhibiting a straightened planform lacking in hydromorphological deposits or processes.

Watercourse	Description
Ordinary Watercourse 38 (tributary of Domsey Brook)	Ordinary Watercourse 38 has its source immediately south of the A12, where it flows south before meandering east towards Domsey Brook. The channel has a largely straightened planform as it passes arable agricultural land. Desk-based hydromorphological observations were mostly obscured by riparian vegetation but suggest the watercourse acts as a field drain.
Ordinary Watercourse 38b (tributary of Domsey Brook)	Ordinary Watercourse 38b has its source immediately south of the A12, where it flows south before meandering east towards Ordinary Watercourse 38. It is largely straightened and passes arable agricultural land and a plantation. It acts as a morphologically inactive field drain.
Ordinary Watercourse 42 (potential tributary of Domsey Brook)	Ordinary Watercourse 42 is a drainage ditch originating south of the A12 near Potts Green. It flows in southerly direction and exhibits a straightened planform lacking in hydromorphological significance, where deposits and natural processes are not present.
Ordinary Watercourse 41 (potential tributary of Domsey Brook)	Ordinary Watercourse 41 is a drainage ditch originating between Easthorpe and Potts Green. The channel is largely indiscernible due to the presence of vegetation. Where visible, the channel appears to be absent in hydromorphological deposits and features with vegetation heavily encroaching the watercourse.
Ordinary Watercourse 36b (tributary of Roman River)	Ordinary Watercourse 36b originates in Marks Tey just north-west of the A12 and the Crescent. The channel has a largely straightened planform as it flows north-west, passing pastoral and arable agricultural land, residential properties, and a railway and road culvert before draining into the Roman River. This acts as a field drain with a paucity of morphological features.
Ordinary Watercourse 36 (tributary of Roman River)	Ordinary Watercourse 36 originates in Marks Tey. It flows in a northerly direction and exhibits a straightened planform. Where visible, the channel appears to lack hydromorphological deposits and processes.
Ordinary Watercourse 26 (potential tributary of Roman River)	Ordinary Watercourse 26 originates south-east of the A12. The channel has a straightened planform, passing arable agricultural land as it flows north towards Ordinary Watercourse 26a. This acts as a field drain with a small number of morphological features.

Summary

4.9.2 From desk study, Ordinary Watercourses assessed along the proposed scheme exhibit the following general characteristics:

- straightened and artificial drainage channels;
- trapezoidal channels lacking in channel form and features due to lack of continuity in geomorphological processes;

- watercourses largely act as field boundaries where riparian vegetation is either restricted by fields, comprising grass and regularly spaced deciduous trees;
- flows are largely uniform or imperceptible; some watercourses exhibit an artificially ephemeral flow regime, only flowing as surface waters drain into the watercourse.

4.10 Ponds and other surface water bodies

4.10.1 In addition to watercourses, numerous ponds were assessed as part of the proposed scheme. The baseline conditions of the scoped in ponds are detailed in Table 4.10 and locations illustrated on Figure 14.1 of the Environment Statement [TR010060/APP/6.2].

Table 4.10 Baseline conditions of scoped in ponds

Pond reference	Easting	Northing	Description and hydrological connectivity
Design section 1			
P163	574187	207917	Online pond connected to Ordinary Watercourse 1b, tributary of the River Chelmer. To the east of the existing A12 mainline south of the proposed scheme. Online feature used for drainage. Largely dry and heavily vegetated. Likely caused by channel widening at culvert inlet, as well as backing up of flows due to undersized culvert. No hydromorphological significance.
P162	574106	207963	Online pond connected to Ordinary Watercourse 1b, tributary of the River Chelmer. To the east of the existing A12 mainline south of the proposed scheme. Online feature used for drainage. Largely dry and heavily vegetated. Likely caused by channel widening at the culvert outlet. No hydromorphological significance.
P303	574027	207964	Offline Pond to the west of the existing A12 mainline, south of the proposed scheme. Approximately 20m distance from Ordinary Watercourse 1b.
P153	573971	208050	Offline pond to the west of the existing A12 mainline and approximately 15m north of Ordinary Watercourse 1b.
P148	574023	208323	Online pond connected to Ordinary Watercourse 1a. Located to the west of the proposed scheme within Springfield Business Park. Approx. 15m in length. Online feature used for drainage and possible flood risk mitigation. Largely dry and heavily vegetated. Excavated recently for conveying flood flows. No hydromorphological significance.

Pond reference	Easting	Northing	Description and hydrological connectivity
P132	573894	208351	Online pond upstream of P148 on Ordinary Watercourse 1a. Located to the west of the proposed scheme within Springfield Business Park. Approx. 100m length and 20m width.
P159	573644	208335	Small (approximately. 6m wide) pond upstream of P132 and P148 on Ordinary Watercourse 1a. Located within Springfield Business Park to the west of the proposed scheme.
P122	574557	208628	Offline pond located to the east of the proposed scheme. Surrounded by Ordinary Watercourse 1 & 1a. Approx. 220m width.
P309	574671	208474	Offline pond located to the east of the proposed scheme. Surrounded by Ordinary Watercourse 1 & 1a. Approx. 220m width at widest point.
P136	574580	208379	Offline pond located to the east of the proposed scheme. Surrounded by Ordinary Watercourse 1 & 1a. Approx. 100m width at widest point.
P302	573817	208724	Offline pond located to the east of the proposed scheme within Springfield Business Park. Approx. 25m width. North of a tributary of Ordinary Watercourse 1.
P301	573818	208795	Offline pond located to the east of the proposed scheme within Springfield Business Park. Approx. 15m width. South of a tributary of Ordinary Watercourse 1.
P120	574046	209142	Online pond connected to Ordinary Watercourse 2. Located to the west of the proposed scheme between the existing A12 mainline and the A130 roundabout. Approx. 50m width at widest point. Online feature used for drainage and possible flood risk mitigation. Largely dry and heavily vegetated. No hydromorphological significance.
P121	574607	208949	Online pond connected to a tributary of the River Chelmer. Narrow and approx. 100m in length. Located to the east of the proposed scheme.
P173	574737	208970	Online pond connected to a tributary of the River Chelmer. Narrow and approx. 130m in length. Located to the east of the proposed scheme.
P119	574491	209308	Offline pond to the east of the proposed scheme and the B1137 – Main Road. Likely manmade sue to rectangular formation. Serves Bayeswater Fisheries. Approx. 265m in length.

Pond reference	Easting	Northing	Description and hydrological connectivity
P107	578203	211403	Online pond connected to Ordinary Watercourse 28. Located to the south of the proposed scheme. Approx. 10m in width. Online feature used for drainage. Largely dry and heavily vegetated. No hydromorphological significance.
P315	578324	211553	Online pond located on River Ter just north of the proposed scheme where the scheme crosses the River Ter. Approx. 10m in width and assumed manmade due to square formation.
P312	578323	211433	Online pond on a tributary of River Ter. Pond is located to the south of the proposed scheme and B1137 – The Street.
P319	578342	211381	Online pond on a tributary of River Ter. Pond is located to the south of the proposed scheme and B1137 – The Street. Downstream of P319.
P106	578505	211363	Offline located to the south of the proposed scheme and B1137 – The Street. Approx. 15m wide.
P105	578578	211796	Offline pond located to the north of the proposed scheme. Approx. 15m wide.
P152	579082	212112	Offline pond to the north of the proposed scheme. Located within the housing estate in Hatfield Peverel. Approx. 31m width.
P131	579216	212110	Offline pond to the north of the proposed scheme. Located to the east of the housing estate in Hatfield Peverel. Approx. 20m width.
P104	579245	212121	Offline pond to the north of the proposed scheme. Located to the east of the housing estate in Hatfield Peverel. Approx. 40m width.
P101	580096	212057	Offline pond located to the south of proposed scheme, adjacent to the east of Ordinary Watercourse 7. Approx. 230m width. Large and artificial water feature. No morphological features and likely used for flood risk mitigation. No hydromorphological significance.
P97	580703	212623	Offline pond to the south of the proposed scheme, located to the south of Latneys side road. Approx. 10m width.
P98	580768	212532	Offline pond to the south of the proposed scheme, located to the south of Latneys side road and P97. Approx. 20m width. Confirmed Great Crested Newt Pond.

Pond reference	Easting	Northing	Description and hydrological connectivity
P91	581423	212905	Offline pond located to the south of the existing A12 mainline and proposed scheme. Approx. 40m width. Confirmed Great Crested Newt Pond.
P90	581793	213091	Offline pond located to the north of the existing A12 mainline and proposed scheme. Adjacent to Gershwin Boulevard. Approx. 160m width.
P337	581757	213134	Offline pond located to the north of the existing A12 mainline and proposed scheme. Immediately north of P90. Assume man-made due to rectangular formation. Approx. 30 in length.
P332	581747	213170	Offline pond located to the north of the existing A12 mainline and proposed scheme. Immediately north of P90. Assume man-made due to rectangular formation. Approx. 30 in length.
Design section 2			
P87	582148	213005	Offline pond located to the south of the A12 mainline and proposed scheme. Approx. 10m width. Offline feature used for drainage. No morphological features, largely dry, silted and vegetated. No hydromorphological significance.
P84	583042	213985	Offline pond to the west of the existing A12 mainline and proposed scheme. Approx. 60m width.
P83	583043	214036	Offline pond to the west of the existing A12 mainline and proposed scheme. Immediately north of P84. Approx. 65m width.
P333	583006	214290	Offline pond (ditch) to the east of the existing A12 mainline and proposed scheme. Approx. 377m in length.
P331	583030	214644	Offline pond (ditch) to the east of the existing A12 mainline and proposed scheme. Approx. 330m in length.
P76	583060	214981	Offline pond located to the east of the existing A12 mainline and proposed scheme. Approx. 225m in length. Additional group of ponds further away from carriageway to the east (P78, P349, P341, P321). Offline and artificial features likely used as gravel pits previously. No hydromorphological significance.
P77	583085	214989	Offline pond located to the east of the existing A12 mainline and proposed scheme. Approx. 250m in length. Additional group of ponds further away from carriageway to the east (P78, P349, P341, P321). Offline and artificial features likely used as gravel pits previously. No hydromorphological significance.

Pond reference	Easting	Northing	Description and hydrological connectivity
P75	583300	215029	Offline pond located to the east of the existing A12 mainline and proposed scheme. Approx. 250m in length. Additional group of ponds further away from carriageway to the east (P78, P349, P341, P321). Part of Coleman's Cottage Fishery.
P74	583307	215136	Offline pond located to the east of the existing A12 mainline and proposed scheme. Approx. 250m in length. Additional group of ponds further away from carriageway to the east (P78, P349, P341, P321). Part of Coleman's Cottage Fishery.
P79	583203	214901	Offline pond located to the east of the existing A12 mainline and proposed scheme. Approx. 250m in length. Additional group of ponds further away from carriageway to the east (P78, P349, P341, P321).
P327	583111	214947	Offline pond located to the east of the existing A12 mainline and proposed scheme. Approx. 30m in width. Additional group of ponds further away from carriageway to the east (P78, P349, P341, P321).
P335	583086	214830	Offline pond located to the east of the existing A12 mainline and proposed scheme. Approx. 35m in width. Additional group of ponds further away from carriageway to the east (P78, P349, P341, P321).
P79	583203	214901	Offline pond located to the east of the existing A12 mainline and proposed scheme. Approx. 180m in length. Additional group of ponds further away from carriageway to the east (P78, P349, P341, P321).
P344	583038	215737	Offline pond located to the west of the proposed scheme, within Western Industrial Estate. Approx. 120m in length. Assume man-made due to rectangular formation. Offline feature used for drainage. No morphological features, largely dry, silted and vegetated. No hydromorphological significance.
P345	583086	215827	Offline pond located to the west of the proposed scheme, within Western Industrial Estate. Approx. 44m wide. Confirmed Great Crested Newt Pond. Online and artificial feature likely used as gravel pits previously. No hydromorphological significance.

Pond reference	Easting	Northing	Description and hydrological connectivity
P71	584066	215853	Online pond connected to River Blackwater. Located to the south of the proposed scheme and to the west of Braxted Road. Approx. 420m at widest point. Colemans Reservoir (used for irrigation for local gold centers). Large, artificial waterbody with no morphological features or natural processes. No hydromorphological significance.
P70	583802	216187.	Offline pond located to the north of the proposed scheme. Pond is crossed by the proposed scheme, potential to be lost as a result. Approx. 15m width at widest point.
P69	583813	216197	Offline pond located to the north of the proposed scheme. Pond is crossed by the proposed scheme, potential to be lost as a result. Pond is likely to be man-made as is square in formation. Approx. 16m wide.
P68	583830	216211	Offline pond located to the north of the proposed scheme. Pond is crossed by the proposed scheme, potential to be lost as a result. Approx. 15m width at widest point.
P66	584589	216861	Offline pond to the south-east of the proposed scheme. Approx. 120 in length.
P65	584704	217051	Offline pond to the south-east of the proposed scheme. Approx. 40 m wide.
P384	584567	217099	Offline pond located within the proposed scheme footprint. Potential to be lost as a result of the proposed scheme. Approx. 50m in length. Assumed man-made due to rectangular formation.
P64	584581	217170	Offline pond located within the proposed scheme footprint. Potential to be lost as a result of the proposed scheme. Approx. 25m in length. Offline and straight features likely used for drainage and flood risk mitigation. No morphological features and no significance to hydromorphology.
P63	584560	217195	Offline pond to the west of the proposed scheme. Approx. 18m wide. Offline feature used for drainage. No morphological features, largely dry, silted and vegetated. No hydromorphological significance.
P62	584834	217242	Offline pond located to the south of the proposed scheme and existing A12 mainline. Approx. 30m width. Artificial and used for ornamental purposes. No morphological features and no significance to hydromorphology.

Pond reference	Easting	Northing	Description and hydrological connectivity
P59	584943	217551	Offline pond located to the north of the proposed scheme. Approx. 35m length. Offline feature used for drainage. No morphological features, largely dry, silted and vegetated. No hydromorphological significance.
Design section 3			
P46	586284	217918	Online pond located to the north of the proposed scheme. Connected to Ordinary Watercourse 21. Approx. 60m in length.
P43	586844	217862	Offline pond located to the south of the proposed scheme. Approx. 40m width.
P42	586971	218620	Offline pond located to the north-west of the proposed scheme. Approx. 20m wide. Offline feature used for drainage. No morphological features. No hydromorphological significance.
P40	587732	218935	Offline pond located to the east of the proposed scheme. Approx. 50m wide. Offline and straight features likely used for drainage and flood risk mitigation. No morphological features and no significance to hydromorphology.
P39	587813	219150	Offline pond located to the east of the proposed scheme. Approx. 45m wide. Located to the north of an unnamed watercourse. Offline feature used for drainage. No morphological features, largely dry, silted and vegetated. No hydromorphological significance.
P34	588094	220349	Online pond connected to Ordinary watercourse 37b. Located to the north-west of the proposed scheme. Approx. 25m wide. Online feature (OW32) likely used for drainage. No morphological features visible and largely dry and vegetated. No hydromorphological significance.
P25	589993	221509	Online pond connected at both ends to Domsey Brook. Watercourse is crossed by the scheme. Approx. 70m wide.
P24	590243	221872	Offline pond to the south of the proposed scheme. Located south of Easthorpe Green. Approx. 65m wide.
P23	590310	221899	Offline pond to the south of the proposed scheme. Assume man-made due to square formation. Located south of Easthorpe Green. Approx. 8m wide.
P22	590324	221968	Offline pond to the south of the proposed scheme. Located east of Easthorpe Green. Approx. 25m wide. Adjacent to P21.

Pond reference	Easting	Northing	Description and hydrological connectivity
P21	590344	221986	Offline pond to the south of the proposed scheme. Located east of Easthorpe Green. Approx. 25m wide. Adjacent to P22.
P20	590316	222019	Offline pond to the south of the proposed scheme. Assume man-made due to rectangular formation. Located east of Easthorpe Green. Approx. 10m wide.
P19	590328	222043	Offline pond to the south of the proposed scheme. Located east of Easthorpe Green. Approx. 20m wide.
P16	590755	222510	Offline pond to the north of the proposed scheme. Approx. 15m wide. Offline feature used for drainage. No morphological features, largely dry, silted and vegetated. No hydromorphological significance.
P11	591493	223366	Offline pond located to the south-east of the scheme, off Hall Chase. Approx. 10m width. Artificial and used for ornamental purposes. No morphological features and no significance to hydromorphology.
P7	591615	223296	Offline pond located to the south-east of the scheme, off Hall Chase. Approx. 40m width. Confirmed Great Crested Newt Pond.
P455	591673	223451	Offline ditch located to the south-east of the proposed scheme. Approx. 400m in length. Linear offline feature used for drainage of parking area. No morphological features, as well as being dry and heavily vegetated. No hydromorphological significance.
P1	592227	224304	Offline pond to the north of the proposed scheme. Approx. 100m wide. Located approximately 20m north of Roman River.
P442	592708	224234	Offline pond to the south of the proposed scheme. Approx. 40m wide. Offline feature used for drainage. Previously larger and used for drainage channels present prior to realignment of Roman River for A12. No morphological features and no significance to hydromorphology.
P440	592924	224295	Online pond located to the south of the proposed scheme. Connected toa tributary of Roman River. Approx. 60m wide.
P433	592959	224257	Offline pond located to the south of the proposed scheme. Approx. 25m wide.
P15	591011	222816	Offline feature used for drainage. No morphological features, largely dry, silted and vegetated. No hydromorphological significance.

Pond reference	Easting	Northing	Description and hydrological connectivity
P44	586870	217739	Offline feature used for drainage. No morphological features, largely dry, silted and vegetated. No hydromorphological significance.
P354	584567	217099	Offline and straight features likely used for drainage and flood risk mitigation. No morphological features and no significance to hydromorphology.
P99	579894	212656	Offline water feature used for drainage. Largely dry with no features and heavily vegetated. No hydromorphological significance.
P133	581479	212558	Artificial pond used for drainage. Consists of no morphological features, whilst appearing largely dry and heavily vegetated. No hydromorphological significance.

5 Appraisal and recommendations

5.1.1 The proposed scheme would result in the following changes to the A12 carriageway, all of which would likely have local impacts on the hydromorphology of watercourses:

- construction of new culvert crossings;
- extension of existing culvert crossings;
- widening of bridges;
- channel realignments;
- construction of new outfall structures for routine road drainage;
- excavation of new cut-off ditches; and
- modification to existing drainage channels to accommodate increases in road drainage.

5.1.2 As such, general recommendations are split into the following:

- culverts;
- bridge widening;
- channel realignments; and
- outfalls and drainage structures.

5.2 Culverts

Impact assessment

5.2.1 New culverts are proposed to allow the following watercourses to pass beneath the proposed scheme:

- Rivenhall Brook
- Domsey Brook
- Roman River
- Ordinary Watercourses 7, 11, 12, 13, 13a, 17, 23, 24, 26, 37, 37b.

5.2.2 Construction of new culverts would likely lead to disturbance of bed and bank material, loss of riparian vegetation and both bankside and in-channel works, all of which would lead to localised scour of the banks. Moreover, in-channel works would lead to localised compaction of bed material, which would likely reduce sediment transport downstream. However, any effects as a result of culvert construction, would be localised to the working area and cease soon after construction has been completed. Furthermore, any effects would be mitigated by standard good practice mitigation measures as described in Chapter 14:

Road drainage and the water environment (Section 14.10) of the Environmental Statement [TR010060/APP/6.1].

5.2.3 The presence of new culverts would likely lead to localised changes in sediment transport dynamics. Scour of the banks and accumulation of sediment at the inlet and outlet are likely results of changes to flow dynamics within the culvert. Furthermore, scour could facilitate temporary channel instability as the watercourses adjust to the presence of the new culvert. However, given the temporary nature of this and the lack of historical change amongst the watercourses within the study area, these impacts are unlikely to be significant.

5.2.4 Ordinary Watercourse 11 does exhibit lateral adjustment. Likely to take place during bankfull flows, given its artificial cross-section. The culverts along this watercourse would likely facilitate increased channel instability causing further lateral adjustment. Additional mitigation has been considered and is detailed in Chapter 14: Road drainage and the water environment (Section 14.10 and 14.12) of the Environmental Statement [TR010060 /APP/6.1], as well as in the recommendations section below.

5.2.5 Culverts would be extended at the following watercourses:

- Roman River
- Ordinary Watercourses 1a, 1, 2, 7, 9, 10 and 21a.

5.2.6 Effects arising from construction of culvert extensions does not differ to that described for new culverts. However, culvert extensions are less likely to cause a significant change to baseline conditions. The diameter of culvert extensions would typically match the existing structure, therefore there would be comparatively little difference in flow dynamics to those occurring pre-extension. Sediment transport dynamics would go through similar changes, as scour of banks would take place as the watercourses adjust to their new location. These changes would, however, not lead to any significant effects on channel hydromorphology.

Recommendations

5.2.7 The construction of new and extended culverts would follow good practice: ‘Culvert, screen and outfall manual’ (C786) (CIRIA, 2019). To summarise, the following recommendations would be incorporated as standard mitigation for the design of culverts:

- New culverts to include culvert diameters that match that of the natural channel.
- Limit the length of newly constructed culverts and extensions to prevent loss of the natural bed and banks.
- Bury the invert beneath the natural bed of watercourses to allow the continuation of sediment conveyance and reduce the impact on local flow dynamics.
- Tie-in new and extended culverts with the bank to prevent the outflanking of the culvert by fluvial processes

- Install baffles along the culvert bed to encourage flow variation, sedimentation and the restoration of the natural riverbed and sediment conveyance.

- Where the outlets or inlets tie in with channel or realignment, these tie in points to involve realigning the channel to gently bend and not be tied into perpendicular bends.

5.2.8 Additional mitigation to reduce the likelihood of significant effects as a result of culverts are as follows:

- The culvert on Ordinary Watercourse 11 could lead to significant effects along the channel. Therefore, bank protection would be installed along the channel within the Order Limits boundary. This would mitigate significant effects associated with bank scour and increased lateral adjustment along the channel. Additionally, baffles would be provided with the culvert to provide refuges and sediment augmentation to aid fish passage. Monitoring of Ordinary Watercourse 11 would take place to determine whether bank protection is working appropriately.

- Changes to the alignment of the culvert crossing at Ordinary Watercourse 11 were considered, in an attempt to shorten the culverted channel. However, this would require realignment of Ordinary Watercourse 11 to tie-in the realignment appropriately to the alternative culvert alignment. This option would encroach on the neighbouring quarry (Coleman's Quarry) and was therefore considered inappropriate.

5.3 Bridge widening

Impact assessment

5.3.1 Bridge widening is to be carried out on the River Brain. This would involve extending the abutments of Brain Bridge. As a result of the bridge widening, scour would likely occur along the banks, whilst the bridge is being widened and once operational. However, any scour would remain localised to the bridge, given the largely stable planform along the River Brain. This scour would also be temporary, limited to construction periods and as the watercourse adjusts to the widened presence of the abutments.

5.3.2 Ashman's bridge would also require widening. This would likely lead to localised scour along the banks of the River Blackwater, where sheet piling is to take place. Furthermore, where Ashman's footbridge is being relocated construction activity is likely to lead to additional localised scouring of bank material.

5.3.3 Domsey Bridge would also be widened and would involve a channel realignment to avoid any long-term loss to riverine habitats. Changes here would likely lead to some localised scour at the inlet during construction and as the realigned channel adjusts to the extension. Aggradation could also take place, but this is an existing process, therefore changes to Domsey bridge are unlikely to exacerbate this.

Recommendations

5.3.4 The following recommendations are provided for bridge widening:

- Bed and bank reinforcement to only be considered if potential erosion, due to new or extended structures, cannot be prevented.
- If piers are required for the new or existing bridges, they would be designed to allow the passage of large woody debris.
- Baffles would be installed along both the existing and extended crossing bed to facilitate flow variation, fish passage and sediment conveyance along the crossing.

5.4 Channel realignments

Impact assessment

5.4.1 Channel realignments are proposed for the following watercourses:

- Rivenhall Brook
- Domsey Brook
- Roman River
- Ordinary watercourses 1, 2, 7, 9, 10, 15, 21, 24, 34b, 34c and 37b

5.4.2 Channel realignments would be excavated offline to the existing watercourse. Therefore, any effects would be limited to when the realignments are tied-in with the existing channel. Localised scour of the banks at the tie-in locations would comprise adverse effects on hydromorphology, however scour would cease once the channel has adjusted to its new location.

5.4.3 For the proposed scheme, realignments to the Main Rivers (Roman River, Rivenhall Brook and Domsey Brook) would be designed to accommodate and/or improve local hydromorphology. A gently sinuous planform has been incorporated into the preliminary design and gravel augmentation would form of pool-riffle sequences, in order to generate natural processes along the channels. As such, any impacts would likely be positive in comparison to existing conditions.

5.4.4 Rivenhall Brook would be shortened as a result of the proposed scheme, which would reduce the channel gradient and could lead to increases in scour of the bed and banks. However, the current alignment follows field boundaries suggesting realignment and straightening had taken place. As such, the agreed design traits of gentle sinuosity and gravel augmentation would work to facilitate natural processes and regulate flows.

5.4.5 Channel adjustments would be temporary to the proposed realignments and limited to bank scour at tie-in locations. It is unlikely that any adjustment would be extensive or long-term.

Recommendations

5.4.6 To mitigate the effects of realignments, the following measures are recommended:

- excavate a two-stage channel along the main river realignments and, where practicable or feasible, Ordinary Watercourses.
- For Roman River, the lack of space means a two-stage channel cannot be excavated. Instead, a one stage channel would comprise of varied bottom widths to promote berm creation and habitat variability.
- maintaining the existing gradient of the channel and ensuring the channel does not shorten facilitating downstream channel adjustment and erosion
- conversely, ensuring the channel does not over-lengthen, reducing the overall gradient of the realigned reach and facilitating fine sediment accretions
- where practicable encouraging natural processes and flow variation by excavating a gently sinuous planform
- transposing natural bed material present along the existing channel
- installing decomposable geotextile bank protection along the upper banks to encourage vegetation establishment and channel stabilisation

5.5 Outfalls and drainage ditches

Impact assessment

5.5.1 Outfalls are to be constructed on the following watercourses:

- River Chelmer
- Boreham Brook
- River Ter
- River Brain
- Domsey Brook
- Roman River
- Ordinary Watercourses 1a, 1, 2, 7, 9, 10, 11 12, 13, 13a, 15a, 17, 21a, 23, 24, 26, 31/31b, 32, 37, 38, 38b, 39, 40 and 41

5.5.2 Construction of new outfalls and drainage ditches would take place offline to the watercourses. Therefore, any effects would be limited to where and when the outfalls are tied into the channel. Effects would be limited to scour of the bed and banks.

5.5.3 The presence of outfall structures could lead to significant effects on the following watercourses:

- River Chelmer
- Boreham Brook
- River Ter
- River Blackwater
- Domsey Brook
- Roman River

5.5.4 The proposed outfalls would be located either on or near to channel bends. As such, their presence could disrupt local natural processes within the channel. As such channel instabilities could take place as the extent of bank scour that naturally occurs along a meander bend changes. Therefore, to mitigate such effects, additional mitigation is recommended, as described in Chapter 14: Road drainage and the water environment (Section 14.10) of the Environmental Statement [TR010060/APP/6.1].

5.5.5 The presence of outfalls and new drainage ditch confluences along the ordinary watercourses are also likely to cause channel instability. This would take place due to the artificial cross-sections typical of the drainage channels. However, this is largely a result of the ephemeral flow regimes and artificial cross-sections typical of drainage channels. Such impacts are likely to cease once the channel has adjusted to the outfall.

Recommendations

5.5.6 The construction and extension of outfall structures would preferably align with good practice which can be found in the CIRIA guidance document, ‘Culvert, screen and outfall manual’ (C786) (CIRIA, 2019). To summarise, the following are recommended:

- Outfall structures would be set back from the banks of the channel to avoid any significant disruption to natural processes and to avoid scour outflanking the structure.
- The apron of the outfall structure would include wing walls to appropriately tie the structure in with natural bank material.
- The pipe would not protrude into the channel and be submerged below the water line, if practicable, to prevent scour.
- Outfalls and drainage channel confluences would be aligned downstream at a 45° angle to prevent flows along the watercourse from stilling.
- Install green bank protection around the outfall structure to reduce the potential for bed and bank scour associated with increased flows.

5.5.7 Some outfalls are located on the channel bends of the following watercourses:

- River Chelmer
- River Blackwater
- Boreham Brook
- River Ter
- Domsey Brook
- Roman River

5.5.8 Additional mitigation would be required here to mitigate additional scour and channel instability, bank protection would be installed to prevent outflanking and significant effects on in-channel processes. Monitoring would take place to determine whether such bank protection is appropriately working.

5.6 Cadent gas pipeline diversion

Impact assessment

5.6.1 The gas pipeline diversion would cross five watercourses:

- River Blackwater
- Ordinary Watercourses 9f, 9g, 9h and 9i.

5.6.2 Construction of the pipeline would lead to no changes to the River Blackwater, as the construction would be carried out using trenchless crossings. However, open cut crossings would likely be used for the ordinary watercourses. This would likely lead to bank destabilisation as excavations take place, whilst in-channel work would lead to bed substrate compaction. Additional impacts would include the removal of riparian vegetation and any in-channel vegetation present along the watercourses. However, these watercourses represent artificial drainage channels, which have been assessed as being largely dry and only flowing following heavy rainfall events. Therefore, impacts would be limited to heavy rainfall events and unlikely to lead to any significant effects.

The pipeline would be located beneath the reinstated channel of the Ordinary Watercourses; therefore, no impacts would arise from their presence.

Recommendations

5.6.3 The construction of open cut crossings would be mitigated through minimising, where practicable, vegetation clearance and in-channel works.

6 Conclusion

6.1.1 Field observations took place upstream and downstream of the existing A12, where its influence on channel morphology was frequently observed.

6.1.2 Overall, the assessed watercourses are stable features within the landscape. Any significant changes in channel planform have been limited to realignments localised to small residential areas and the construction of the A12 carriageway. There is little distinction between land use and catchment geology throughout the study area. Variability largely tied to superficial deposits along the main channels of each surveyed catchment.

6.1.3 Realignments and crossing structures had led to localised uniformity in flow and channel morphology. In two cases, the crossing structures have impeded river continuity leading to localised fine sediment aggradation at the inlet of Domsey Bridge and Brain Bridge. These issues also highlight the potential catchment-wide issues with sediment management, given the agricultural nature of each catchment. Furthermore, additional pressures have also influenced flow and channel morphology, such as bank reinforcement and channelisation. This was observed along both the River Blackwater and River Chelmer, the latter of which was modified for navigational purposes.

6.1.4 Impacts arising from the proposed scheme elements such as culverts, bridges, outfalls and realignments would involve localised scour of bed and banks, whilst channel instabilities are also likely. However, with Standard mitigation, as described in Section 5 of this appendix and in Chapter 14: Road drainage and the water environment (Section 14.10) of the Environmental statement [TR010060/APP/6.1], these impacts would not lead significant effects on most watercourses.

6.1.5 Significant effects could however take place if additional mitigation, as described in Section 5 of this appendix and Chapter 14: Road drainage and the water environment (Section 14.10) of the Environmental statement [TR010060/APP/6.1], is not carried out.

References

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Acronyms

Abbreviation	Term
BGS	British Geological Survey
DMRB	Design Manual for Road and Bridges

Glossary

Term	Definition
Bed substrate	The material that rests at the bottom of a stream and along the channel margins.
Discharge	The volume of flow passing a point in a given time period.
Flow dynamics	The manner in which flow behaves, i.e., turbulent flows, non-energetic and laminar flows.
Hydromorphology	The scientific study of the form and function of rivers and the interaction between streams and the landscape around them.
Main River	A watercourse shown as such on the Main River Map, and for which the Environment Agency has responsibilities and powers. N.B. Main River designation is not an indication of size, although it is often the case that they are larger than Ordinary Watercourses.
Meandering channel	A single channel that follows a winding course, with a sinuosity ratio typically over 1.5.
Ordinary Watercourse	All watercourses that are not designated Main River, and which are the responsibility of Local Authorities or, where they exist, Internal Drainage Boards. Note that Ordinary Watercourse does not imply a “small” river, although it is often the case that Ordinary Watercourses are smaller than Main Rivers.
Outfall	Point of discharge into a waterbody.
Planform	The birds-eye view of the channel and the form of the channel from that perspective.
Pools and riffles	Periodic undulations in bed elevation where relatively shallow, coarse-grained riffles are separated by deeper pools.
Reach	A length of river along which the channel controls are sufficiently uniform to allow a fairly consistent morphological structure to be maintained.
Realignment	The artificial relocation, or straightening, of a river channel to accommodate structures, flood control, or navigation.
Riparian zone	The corridor of land which runs along the banks of a river channel. If vegetated, it is known as the vegetated riparian zone.
Runoff	The movement of water above and below the surface.

Term	Definition
Sinuosity	The degree in which a channel meanders, a sinuous channel generally has a sinuosity ratio between 0 and 1.5.
Surface water runoff	Rainwater (including snow and other precipitation) which is on the surface of the ground (whether or not it is moving), and has not entered a watercourse, drainage system or public sewer.