# Eston Road Highway Works Flood Risk Assessment

## Final

**May 2020**

**www.jbaconsulting.com**

South Tees Development Corporation

## JBA Project Manager

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## Revision History

| Revision Ref/Date | Amendments | Issued to |
|---|---|---|
| 26/05/2020 | Draft Report | Anthony Greally (Litchfield Planning) |
| 27/05/2020 | Final | Anthony Greally |
| | | |

## Contract

This report describes work commissioned by STDC. STDC's representative for the contract was Anthony Greally of Litchfield Planning. Mark McMillan and Nadeia Tourigny of JBA Consulting carried out this work.

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# 1 Introduction

## 1.1 Overview

This Flood Risk Assessment has been prepared as a supporting document for a detailed planning application for the following development:

*"Engineering operations including the widening of Eston Road, the formation of a new roundabout and internal access roads, works to enhance Holme Beck and associated hard and soft landscaping works."*

The development will create a new access and gateway arrival point into one of the early phases of regeneration within the South Tees Development Corporation's Master Plan area.

### 1.1.1 Scope

This FRA is based on a desktop review of the proposed development layout against available information. This assessment addresses existing flood risk to the development in addition to outlining a strategy that allows the site to be satisfactorily drained without increasing flood risk to others.

# 2 Development Location and Description

## 2.1 Description

The site extends over and area of 6.25 ha and is located within the Grangetown Prairie, 1.5km south of the River Tees estuary. The site encompasses Eston Road from the junction with the A66 to Middlesbrough Road East. The remainder of the site is brownfield land that was previously used for steel works. The land is now derelict comprising of areas of concrete slabs and hardstanding or rough scrub and neutral grassland. The topographical profile of the site generally falls from the south (13m AOD) to the north (9m AOD).

The predominant drainage path is the Holme Beck that flows north through the site towards the River Tees. The catchment of the beck upstream of the site is approximately 4km$^2$ and although it originates in the Cleveland Hills, Eston Moor) it is heavily modified by urban drainage and is the primary drainage route for Eston. The beck flows under the A66 in a 1.2m ovoid concrete culvert and enters the site to the east of the junction with Eston Road. The beck then flows north adjacent to Eston Road in an open slab lined channel for approximately 155m before entering a 1.2m diameter concrete culvert. The culvert then flows north under Eston Road for approximately 1.7km before becoming the Cleveland Channel and flowing towards the River Tees.

It is understood that both the A66 and Eston Road drain directly to the Holme Beck. The remainder of the site falls within the Holme Beck catchment and will contribute flows, but there are no visually identifiable formal drainage connections.

A site location plan has been included in Figure 2-1 and Appendix A.

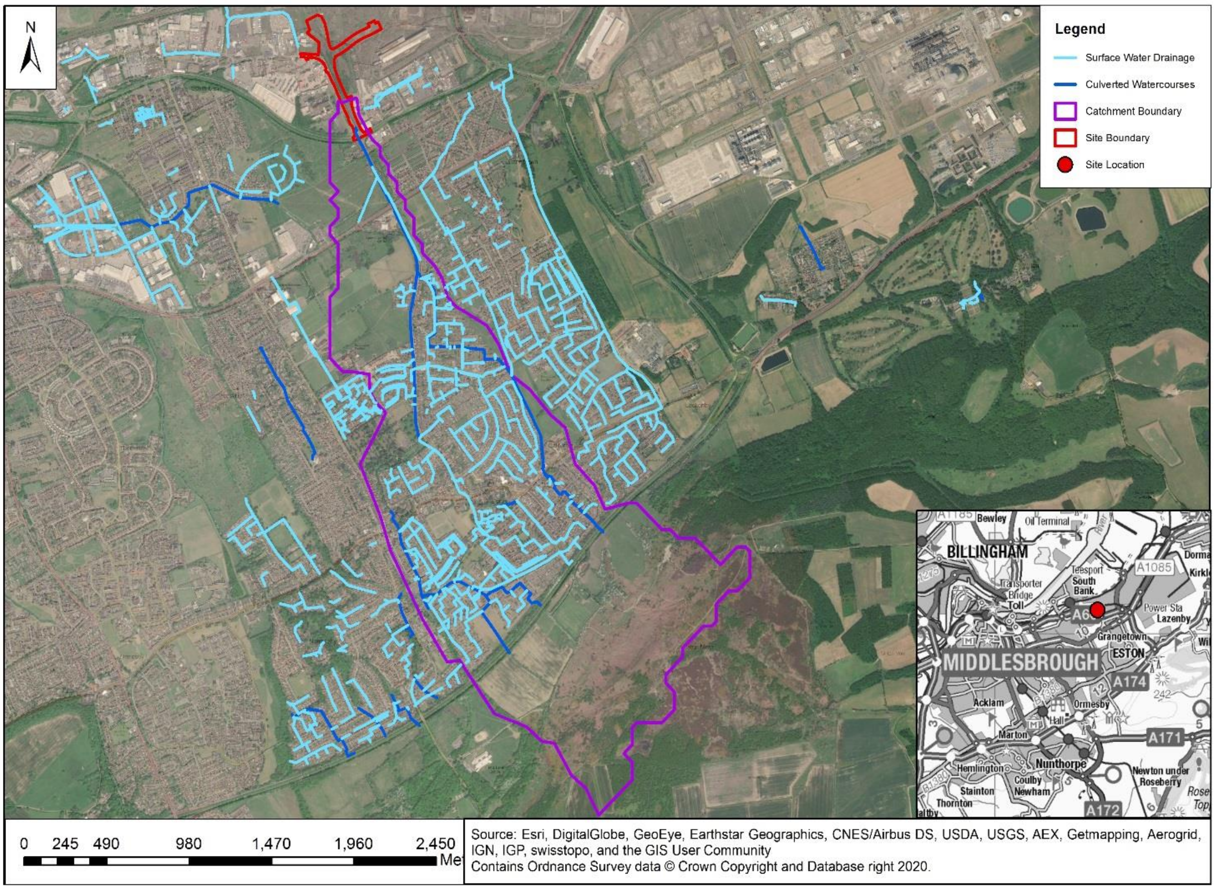


**Figure 2-1: Holme beck Catchment**

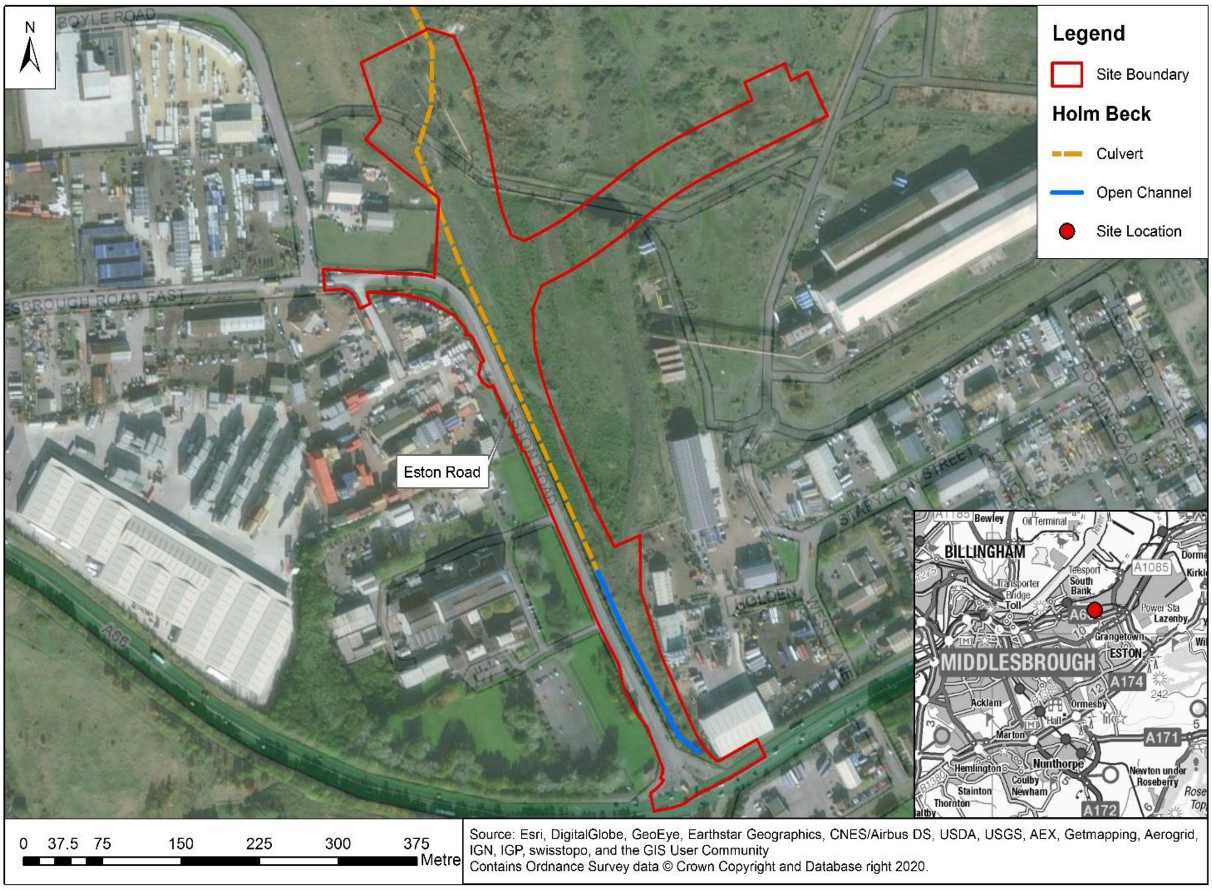


**Figure 2-2: Site Location and Redline Boundary**

## 2.2 Scope of Development

The proposed development layout is included in Appendix A. Eston Road runs north north west from the junction with the A66 before turning through 90° and heading west. At the turning point it is proposed to incorporate a roundabout with two spurs; one heading north and the other heading east to aid future development. The development will consist of approximately 1.22 ha of new road surface.

# 3 Flood Risk Assessment

## 3.1 Fluvial and Tidal

Based on Environment Agency (EA) defined Flood Zones, 100% of the site's red line boundary is located in Flood Zone 1. It is noted that these Flood Zones are based on modelled undefended fluvial and tidal flood extents and do not consider future climate change implications.

Since the original Tees tidal model was developed by the EA, JBA have undertaken an update to the model on behalf of the EA. The update to the model was based on the UKCP18 uplift values utilising 2017 for a base year for extreme sea levels. The table below summarises the results of the updated modelling on the uplift (mm) per epoch.

**Table 3-1: Tees Tidal UKCP18 Tees Tidal Uplift Value**

| Uplift | Epoch | Updated uplift value (mm) |
|---|---|---|
| Present day uplift | 2017-2019 | 0.011 |
| UKCP18 2070 uplift | 2019-2070 | 0.488 |
| UKCP18 2100 uplift | 2019-2100 | 0.947 |
| UKCP18 2030 uplift | 2019-2030 | 0.071 |
| UKCP18 2050 uplift | 2019-2050 | 0.249 |

**Table 3-2: Tees Tidal UKCP18 Tees Tidal Climate Change Uplift Levels**

| Events | 2017-2019 (present day) | 2030 | 2070 | 2100 |
|---|---|---|---|---|
| T2 (2 year) | 3.45 | 3.52 | 3.94 | 4.40 |
| T100 (100 year) | 3.98 | 4.05 | 4.47 | 4.93 |
| T200 (200 year) | 4.08 | 4.15 | 4.57 | 5.03 |
| T1000 (1000 year) | 4.33 | 4.40 | 4.82 | 5.28 |

A review of the LiDAR for the site indicates the topographic low point is 7.6 mAOD, which is 2.32m above the T1000 plus allowance for climate change flood level. The site is therefore assessed to be at very low risk of fluvial and tidal flood risk and suitable for all land uses.

## 3.2 Surface Water

### 3.2.1 EA Maps

Environment Agency defined Risk of Flooding Surface Water (RoFSW) mapping indicates that the proposed development is at low risk of surface water flooding. It is noted that there is no significant flow route indicated in the Holme Beck adjacent to the site. The Holme Beck is culverted for much of its reach upstream and the prevailing exceedance overland flow paths do not direct flow from the upper catchment towards the site. There is no evidence of overland flow paths from outwith the site boundary entering the site. It is considered that surface water flood risk to the site is low.

The EA flood maps show very little surface water flood risk for the 1 in 100 year event within the site boundary.

A small extent of ponding for the 1 in 1000 year event is noted on the northern section of the existing Eston Road.

Residual surface water flood risk will be managed within the design of the gateway hub and is outlined in Section 4 of this report

### 3.2.2 Surface Water Modelling

The characteristics of the Holme Beck catchment (small, heavily modified and urban) make it difficult to assess flood risk arising from surface water off site. To overcome this, a surface water hydraulic model was developed in Infoworks ICM as part of the wider development of the South Tees Regeneration Site. The key inputs to ICM are:

- Design Rainfall
- Digital Terrain Model (DTM)
- Model Roughness and Runoff

**Design Rainfall Events**

Rainfall estimates were generated using the Flood Estimation Handbook (FEH) with Depth-Duration -Frequency (DDF) Modelling used to provide a baseline rainfall. The FEH can be used to generate DDF curves for any 1 km grid point. A DDF curve relates storm duration to total rainfall depth, with different curves representing different return periods of events.

The design standard for assessing development flood risk from surface water is the 1 in 100 year flood event with an allowance for climate change. Current recommendations for the impact of climate change for surface water is 20% with a design test at 40%. As such the 1 in 100 year + 40% has been used to assess flood risk to the proposed development.

**Digital Terrain Model**

The ground model was developed using Lidar data. The model domain covers an area of 8,887 ha. ICM builds a mesh of triangular elements with varying cell size based on the terrain. This allows for flat areas to be modelled with large elements and undulating areas to be represented with small elements. The combination allows for faster run times and improved model stability. In this instance much of the model domain was represented with minimum element areas was 25 $m^2$ and maximum element areas of 100 $m^2$. For the area contained within the South Tees Regeneration Site, an area of approximately 1,755 ha, the mesh element areas were refined to 1 $m^2$ and 25 $m^2$ for minimum and maximums respectively.

The default roughness for the modelled area was set to a Manning’s value of 0.05. Ordnance Survey Data was used to identify areas of open water, woodland, roads, green spaces and properties. For these areas, the default roughness was overwritten with the values presented in Table 3-1.

The model geometry is shown in Figure 3-1.

**Table 3-1: Land Use Roughness Values**

| Land Use | Adopted Roughness Value (Manning's 'n') |
|---|---|
| Open Water | 0.035 |
| Woodland | 0.125 |
| Roads | 0.0125 |
| Green Spaces | 0.045 |
| Properties | 0.1 |

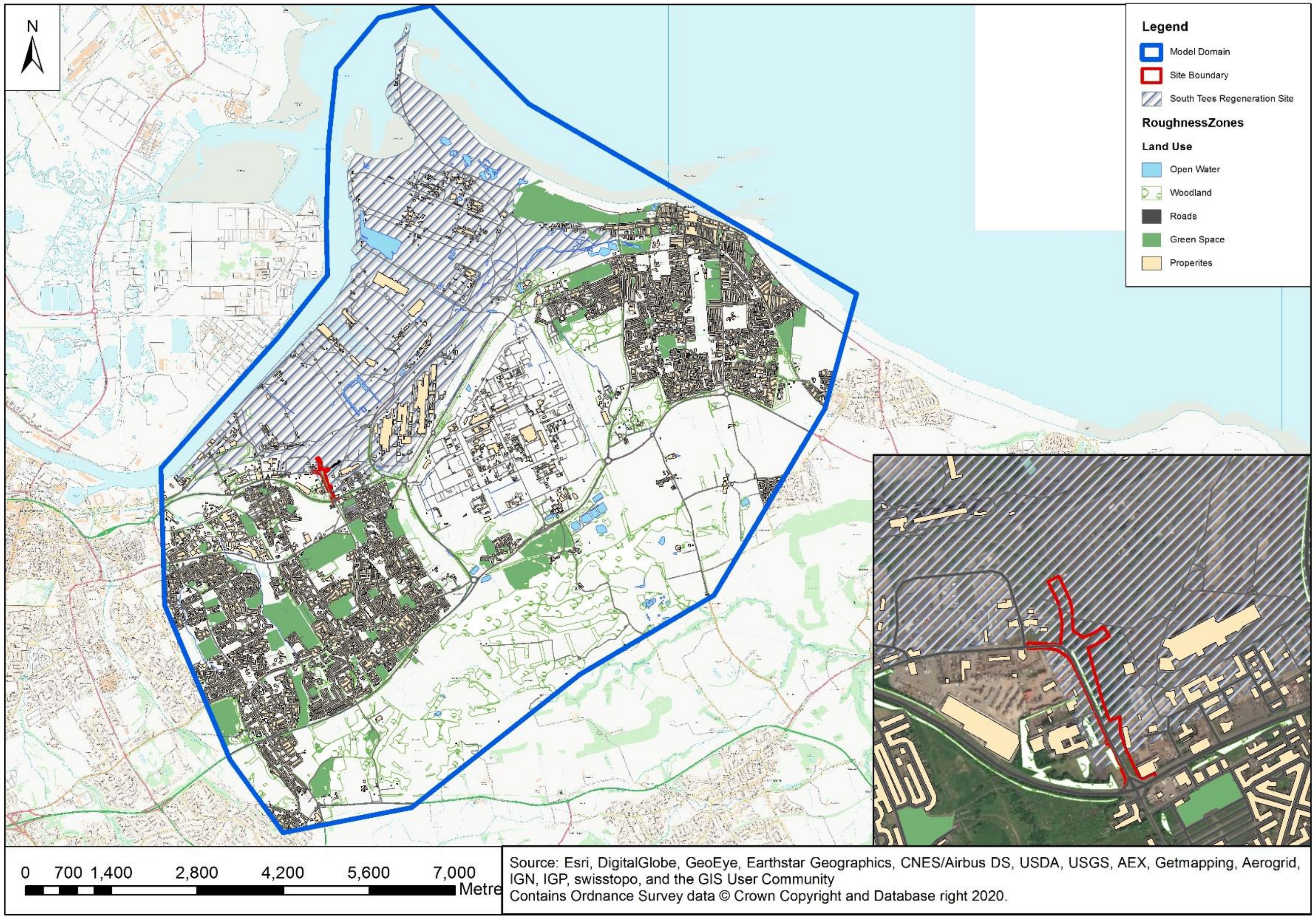


**Figure 3-1: Model Geometry**

**Model Results**

The hydraulic model was run for the 1 in 100 year flood event with and without an allowance for climate change. In accordance with guidance for climate change, a 40% uplift was applied to the rainfall intensity to simulate total anticipated change for the '2080s' (2070 to 2115) epoch. Anticipated surface water depths are shown in Figures 3-2 and Figures 3-3 for the modelled events. Under existing conditions there is isolated ponding in topographic low points however there is no evidence significant overland flow paths to the proposed development. It is considered that surface water flood risk to the development is low.

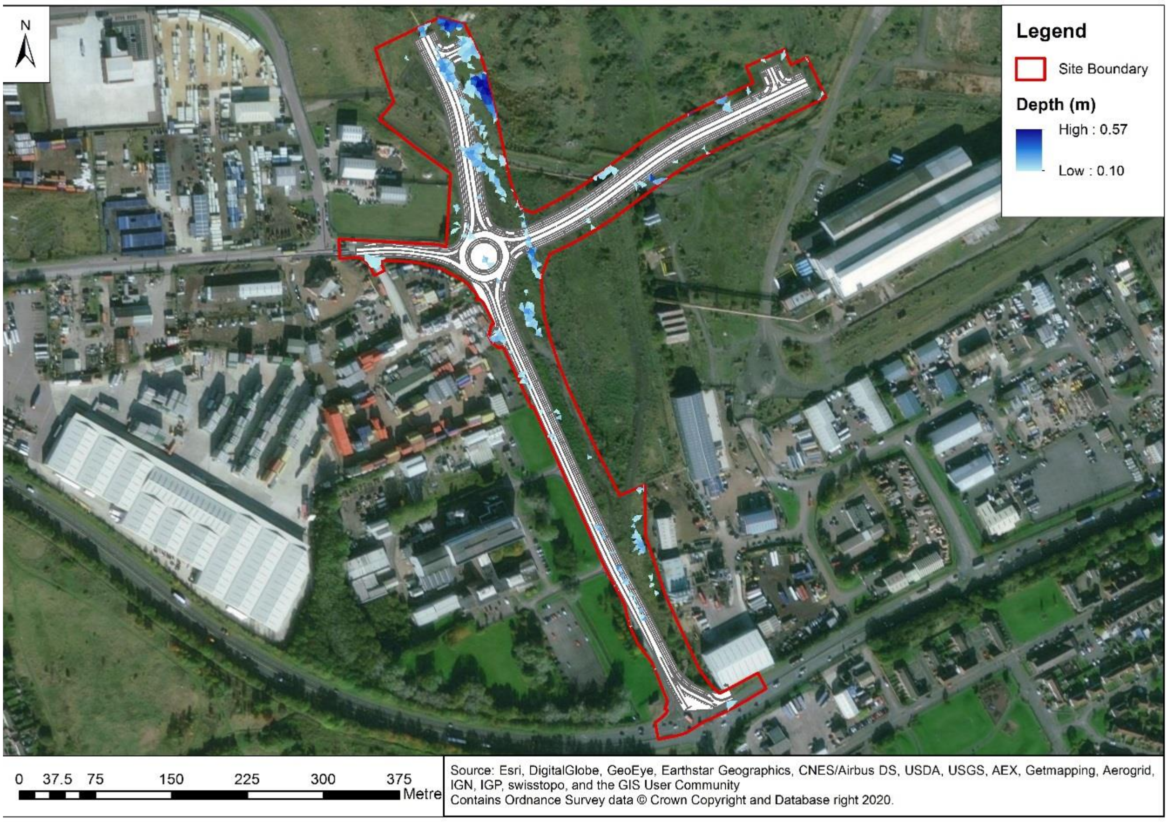


**Figure 3-2: Surface Water Depths (1 in 100 year plus 40%)**

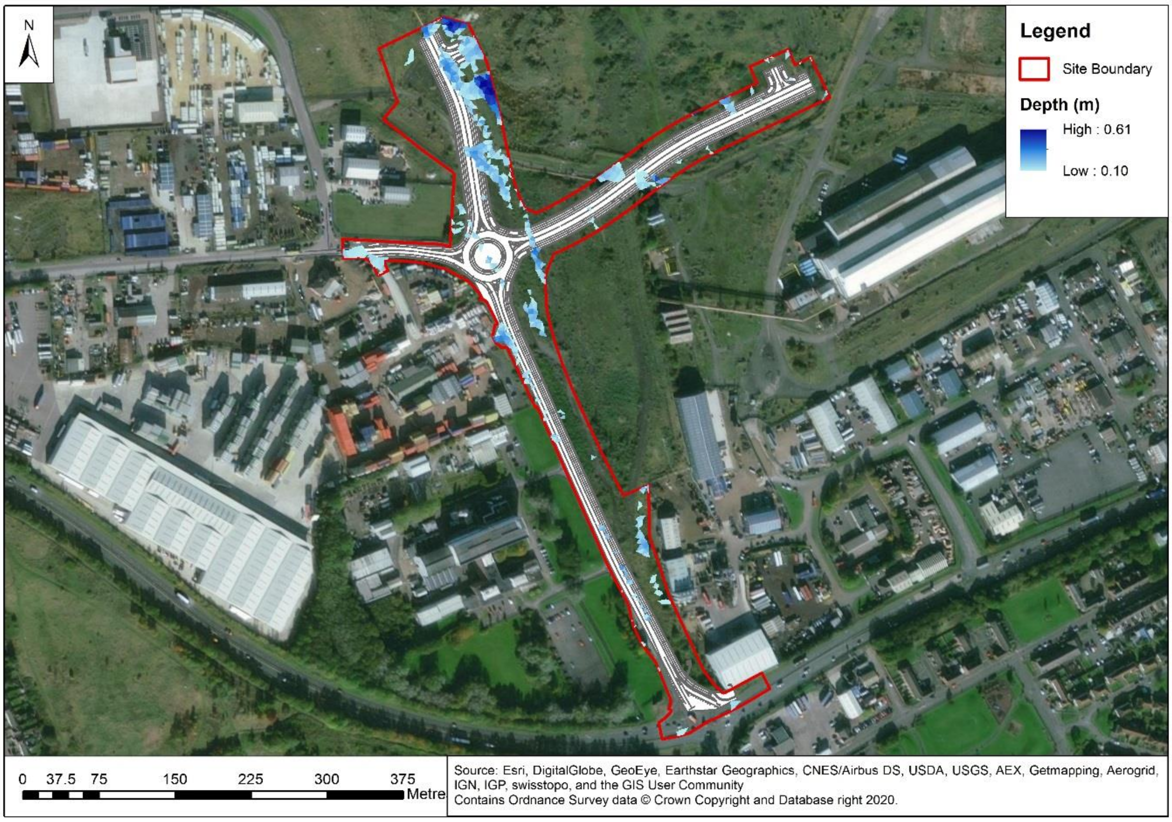


**Figure 3-3: Surface Water Depths (1 in 1000 year + 40%)**

## 3.3 Ground water

Based on the Redcar and Cleveland Strategic Flood Risk Assessment[1] (2016 update), the proposed development is located within an area defined as having a less than 25% risk of groundwater emergence, therefore, risk of flooding from groundwater is considered to be low.

## 3.4 Reservoir

Based on the Environment Agency defined long term flood risk map for England[2], the proposed development is located outside the predicted maximum extent of flood risk from reservoirs.

## 3.5 Canal

There are no canal systems located within the borough of Redcar and Cleveland

[1] https://www.redcar-cleveland.gov.uk/resident/planning-and-building/local-plan/Pages/Redcar-and-Cleveland-Strategic-Flood-Risk-Assessment.aspx
[2] Long term flood risk map for England – GOV.UK

# 4 Drainage Strategy

The proposed drainage strategy aims to manage the challenge of climate change and flooding outlined in national and local planning policy by incorporating green infrastructure. This will be achieved by de-culverting a reach of the Holme Beck to form a more natural open channel and incorporating a Sustainable Drainage System (SuDS) together making provision for biodiversity, landscapes, water quality and flood resilience.

## 4.1 Surface Water Runoff Management

The surface water drainage system has been developed to meet the Tees Valley Authorities Local Standards for Sustainable Drainage[3]. It is envisaged that surface water runoff from new impermeable surfaces will be intercepted and routed to a new site control SuDS detention basin. Runoff will receive passive treatment and attenuation to greenfield runoff rates on site prior to discharge to the Holme Beck.

## 4.2 Pre Development 'Greenfield' Runoff Rate and Volume

The proposed development will increase impermeable area by approximately 1.22 ha. The QBar (2 year) greenfield rate from this area has been estimated to be 5.26 l/s.

Disposal of surface water to ground is not feasible due to the prevailing low permeability of the underlying natural ground. It will not be possible to reduce the post development runoff volume to greenfield volumes.

The proposed surface water runoff rate and volume strategy is to intercept and attenuate surface water to 5.26 l/s for all storm events up to the 100 year plus allowance for climate change storm events.

Greenfield runoff rate calculations for the site are included in Appendix B.

## 4.3 Discharge Rate and Location

It is proposed to discharge surface water from the development to the Holm Beck at a rate of 5.26 l/s. This will be achieved using a hydrobrake or similar flow control device downstream of the detention basin. A plan showing the proposed discharge location is provided in Appendix E.

## 4.4 Attenuation Volumes

To provide assurance the drainage strategy is achievable within the proposed development, an assessment of surface water attenuation has been undertaken using the Quick Storage Estimation tool within WinDES Microdrainage, an industry standard package for drainage design.

The attenuation volume has been estimated for runoff from an impermeable area of 1.22 ha. A runoff coefficient of 1 has been applied for both winter and summer storm events with a return period of 100 years along with an uplift of 40% to rainfall to allow for the impact of climate change.

The estimation tool provides a range of storage volumes due to a high number of variables such as the flow control orifice used, geometry of the storage, design head parameters etc. The results indicate a volume of between 1124 and 1629 $m^3$ is required to achieve the strategy.

An efficient storage design using an optimised flow control unit will result in a design storage volume towards the lower range of the estimate.

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[3] Tees Valley Sustainable Draiange Systems (SuDS) Guidance, Design Guide and Local Standards, November 2019

It is proposed to provide the necessary attenuation in a detention basin utilising a Hydro-Brake flow control unit to minimise the required storage. Details for this are included in Appendix E.

### 4.5 Surface Water Treatment

Surface water treatment is a key element of the drainage strategy to mitigate the impact on the water environment. It is proposed to treat surface water in a detention basin designed in accordance with the SUDS Manual[4]. The detention basin will provide primary and secondary treatment to surface water through filtration and settlement. The proposed development is a high use road that will see use by industrial vehicles. Therefore, it is proposed to include a sediment forebay into the design.

Details of the proposed detention basin are included in Appendix E.

## 5 Holme Beck Deculvert Design

The proposed works will require the diversion of the Holme Beck. It is recognised that there is an opportunity to create a more natural open channel making provision for biodiversity, landscapes, and flood resilience through new green infrastructure. This will be achieved by de-culverting a reach of the Holme Beck to form a more natural channel that is safe within a heavily constrained corridor.

The proposed Holme Beck channel has been designed to provide flood resilience for up to and including the 1 in 100 year + CC flood event from an unconstrained catchment. Under existing conditions, flow into the watercourse at the site is restricted by the capacity of the upstream culvert and drainage network. However, the proposed channel has been designed under the philosophy that future development of the surrounding area will remove these restrictions over time and the new infrastructure will not be a future constraint to achieving this.

### 5.1 Design Flows

The high and low design flows of the Holme Beck have been estimated to inform the design of the channel geometry using current best practice.

#### 5.1.1 Drainage Catchment

The hydrological catchment draining to the Holme Beck to the East of Eston Road has been assessed using the FEH topographical catchment and refined using available NWL surface water drainage maps available, given the largely urbanised nature of the catchment. Additionally, the catchment has been checked against LiDAR and OS mapping. Adjustments were made to account for surface water drainage which differs slightly from the topographical catchment. The catchment is ungauged meaning there is no way to validate the design flow estimates using catchment specific data to this date.

The resulting catchment covers an area of 3.85 $km^2$ with ground elevations varying between 220 mAOD to 10 mAOD. Grassland, agricultural land and moorland are present mainly in the upper catchment areas while the lower reaches are mainly urbanised.

The downstream reaches of the catchment include significant areas of surface water drainage and culverted watercourses, ultimately flowing through a culvert under the A66 road to the site. Under existing conditions, flow to the Holme Beck is limited by the culvert and drainage network. However, for design purposes over the development lifetime, it is anticipated that future developments may allow the limitations of the catchment to be removed. At this stage, it is assumed that within the lifetime of the development, the full flows could be conveyed to the Holme Beck. The full estimated design flows have therefore been used for the channel and bridging structure design.

[4] Ciria C753 The SuDS Manual, CIRIA, 2015

### 5.1.2 Flood Estimation Methodology

Flow estimates were required for the Holme Beck in order to provide a comprehensive input for the preliminary design of the channel and hydraulic model inputs at a later stage. The design flows were calculated for a range of return periods from 2 to 1000 years, including the 100 year climate change event. As the catchment is less than 5km$^2$ and the proposed roads are considered sensitive infrastructure, the upper allowance of 40% for climate change has been used following UKCP18 guidance.

Flows were calculated using FEH Statistical and ReFH2 methodologies and compared. The ReFH2 methodology was taken forward in the analysis due to the small and relatively urbanised nature of the catchment. This method has been found to perform with less bias for small catchment design flow estimation. Additionally, the design flows obtained from the ReFH2 method produced higher peak flows. Table 5-1 below shows ReFH2 peak flows at the site of interest.

Full details of the flood flow estimation are included in Appendix C.

**Table 5-1: ReFH2 peak flows (m3/s)**

| Return Period (years) | Flow Rate ($m^3/s$) |
|---|---|
| 2 | 2.19 |
| 5 | 3.11 |
| 10 | 3.8 |
| 30 | 5.03 |
| 50 | 5.69 |
| 75 | 6.29 |
| 100 | 6.75 |
| 200 | 8.01 |
| 1000 | 11.77 |
| 100 + CC | 9.45 |

### 5.1.3 Low Flow Estimation

Low flows estimation was required in order to inform the hydromorphological design of the channel. This has been carried out using industry leading software LowFlows from HydroSolutions and the derived catchment boundary shapefile. The key parameters used in the software are detailed in Table 5-2 below while the principle Low Flow estimates are shown in Table 5-3.

**Table 5-2: Low Flows Calculations Inputs**

| Parameter | Value |
|---|---|
| Area | (25) Tees |
| Boundary source | Imported polygon |
| Catchment Area ($km^2$) | 3.854 |
| Grid-resolution used for derivation of catchment characteristics (m) | 20 |
| Runoff (mm) | 264.6 |
| BFI | 0.355 |
| Water Bodies | No significant lakes in catchment |

**Table 5-3: Low Flows Estimates**

| Frequency | Flow Rate ($m^3/s$) |
|---|---|
| Q95 | 0.003 |
| Q70 | 0.008 |
| Q50 | 0.015 |
| Q30 | 0.027 |
| Q10 | 0.071 |

## 5.2 Channel Geometry

Details of the alignment and geometry of the channel are included in Appendix E.

The new channel will run from the outlet of the existing culver under the A66 and is constrained by the invert level of the existing culvert. The new channel will flow north adjacent to Eston Road and will be conveyed under the eastern spur of the new roundabout in a bridging culvert before being conveyed further north in an open channel and into a terminating headwall and tie-in to the existing Holme Beck culvert at the norther site boundary. The precise location of the tie-in has yet to be confirmed and will depend on various site investigations.

At this outline design stage the channel lacks detail, but provides proof of concept whist allowing some flexibility in the detailed design stage. The design principle of the new channel will be to provide a two stage channel that allows for a more naturalised watercourse that is capable of sustaining a natural stream morphology under 'every-day' flows and able to convey flood flows of extreme events up to and including the 1 in 100 year + CC flood event. It is appropriate for this detailed element of design to be the subject of a planning condition attached to any planning permission granted.

Under low flow conditions the channel will convey water at a depth that can sustain a natural water environment (150 – 250mm deep) and velocity to prevent accretion of sediment. This will be contained within a low flow channel capable of conveying the Q10 flow rate of 0.071 $m^3/s$ (71 l/s). The low flow channel is represented as having a base width of 0.5 m and side slopes of 1:1. Channel velocities at the Q10 flow rate are anticipated to be approximately 0.5 m/s and to sustain a sand/gravel/cobble substrate.

Above the low flow channel, the second stage will provide a larger flow area that will allow the low flow channel to meander and convey higher flows. The full design capacity of the wider channel will be in excess of 9.45 $m^3/s$. The second stage will have a base width of 2 m with a side slope of 1:3; this will allow for easy egress from the channel and assumes that intensive maintenance will not be needed. The channel velocities for the 1 in 100 year + CC flow rate are anticipated to be approximately 1.2 m/s mitigating the risk of unexpected erosion or morphological change over time. Design calculations for the channel are included in Appendix D.

The design is such that the low flow channel can have sufficient sinuosity to allow for natural geomorphological process to exert themselves through the lifetime of the development. The second stage of the channel will be naturalised with vegetation that will promote stability of the channel and encourage biodiversity.

## 5.3 Proposed Structures

To facilitate access to the South Tees Regeneration Site it is necessary for the road to cross the Holme Beck at NGR 454366 521077 which will require a bridging structure. A second culvert is required where the road crosses the Holme Beck to provide access to a development site at NGR 454313 521270, but this is the anticipated location of the tie-in structure.

It is proposed to provide precast box culverts with dimensions circa 6 m x 1.8 m at the roundabout to facilitate the crossing. The culvert invert will be buried beneath 300 mm of bed material to allow a naturalised riverbed. The culvert has been sized to allow a freeboard of 300 mm above the peak design water level and the soffit of the culvert. The hydraulic performance of the culverts will be such that conveyance will be through laminar flow and that erosive forces will be minimised.

The upstream culvert will have an upstream invert of around 7.85 mAOD and downstream invert of around 7.70 mAOD. No security screen or special maintenance requirements are envisaged at this location.

The downstream culvert will have an upstream invert of around 6.34 mAOD and will tie into the existing Holme Beck Culvert. The existing culvert is estimated to be 1.2m diameter, at an invert level of 4.4m AOD, and 1200m long before discharging into the Cleveland Channel. The tie-in headwall structure will require a backdrop chamber and a security screen to prevent unauthorised/ accidental access to the culvert. This will require formal maintenance provision. It should be noted that it is the long-term aspiration of STDC to de-culvert the Holme Beck and this provision should not be required in perpetuity.

Details of the proposed crossing are included in Appendix E. Design calculations are included in Appendix D.

### 5.4 Maintenance

The channel has been designed as a self-sustaining semi-naturalised watercourse and will therefore require minimum maintenance. STDC will maintain control of the watercourse/SuDS and will perform routine inspections and maintenance. Typical maintenance schedules can be found in Appendix F.

## 6 Conclusions

It is proposed to create a new gateway hub to the South Tees Regeneration Area by widening and extending Eston Road. This will create approximately 1.22 ha of new road surface and associated drainage infrastructure.

The site has been assessed as being in flood zone 1 (low probability) and is suitable for all types of development. A detailed assessment of surface water flood risk, including the Holme Beck, has highlighted isolated areas of surface water ponding within the development area but no evidence of significant overland flow paths entering the site. Residual surface water flood risk can be managed within the development design.

The drainage strategy for the road is to provide new surface water drainage and discharge surface water to the Holme Beck. It is proposed to limit surface water flows to a predevelopment QBar rate equivalent to 5.26l/s for all storm events up to the 100 year + 40% allowance for climate change. A quick storage estimate indicates that between 1124 and 1629 $m^3$ of formal storage is needed to realise this strategy. The required storage volume will be provided in a detention basin that will also provide two stages of passive SuDS treatment prior to discharge into the Holme Beck.

The proposed works will require the diversion of the Holme Beck which is predominantly culverted through the site. It is recognised that there is an opportunity to create a more natural open channel making provision for biodiversity, landscapes, and flood resilience through new green infrastructure. This will be achieved by de-culverting the Holme Beck within the site to form a more natural channel that is safe within a heavily constrained corridor.

The new channel for the Holme Beck has been designed under the philosophy of avoiding constraints to future development. At this outline design stage, the channel lacks detail, but provides proof of concept whist allowing some flexibility in the detailed design stage. The design principle will be to provide a two stage channel that allows for a more naturalised watercourse that is capable of sustaining a natural stream morphology under ‘every-day’ flows and able to convey flood flows of extreme events up to and including the 1 in 100 year + climate change flood event of 9.45 $m^3$/s.

The new channel will run from the outlet of the existing culver under the A66 adjacent to Eston Road and will be conveyed under the eastern spur of the new roundabout in a bridging culvert approximately 6m wide by 1.8m high before being conveyed further north in an open channel and into a terminating headwall and tie-in to the existing Holme Beck culvert at the northern site boundary.

The future operation and maintenance of the Holme Beck and SuDS will be undertaken by the South Tees Development Corporation.

# Appendices

## A Site Details

DO NOT SCALE

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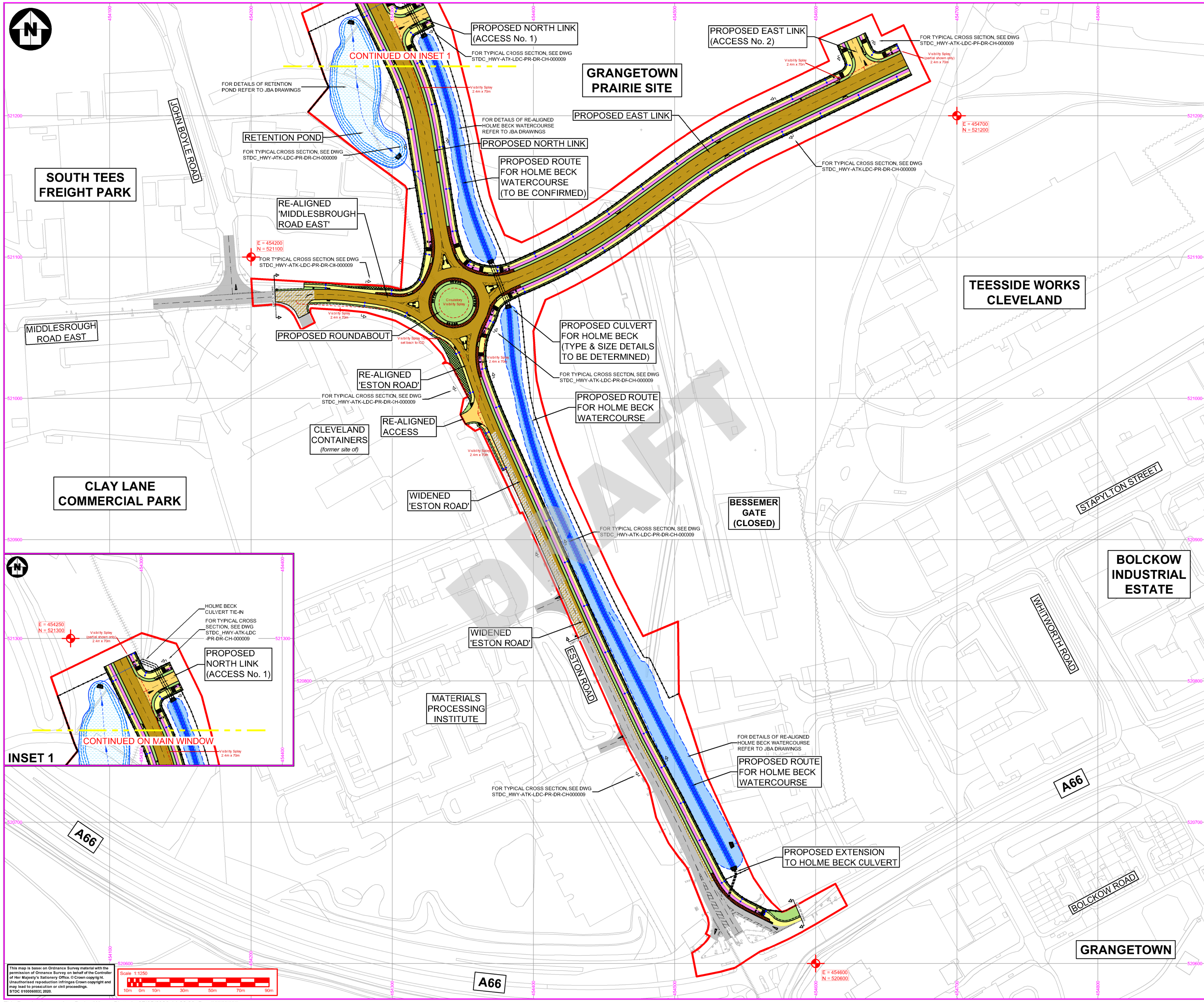


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**KEY:**

EXISTING:
- Carriageway remains
- Carriageway removed
- Carriageway resurfaced

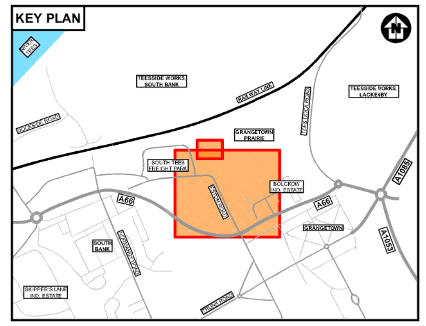
PROPOSED:
- Planning Application Boundary
- Limit of works
- Kerb edge
- Embankment / cuttings
- Road markings
- Selected visibility splay
- Traffic signs / bollards
- Lighting columns

PROPOSED cont.:
- Pedestrian guardrail
- Timber post & rail fence
- Metal palisade security fence
- Culvert / headwalls
- Carriageway (main links)
- Carriageway (accesses)
- Footway
- Cycleway
- Tactile paving
- Block paving
- Verge / berm
- Embankment / cutting
- Ditch / watercourse

**NOTES:**

1. For Typical Cross Section profiles refer to drawing: STDC_HWY-ATK-LDC-PR-DR-CH-000009.
2. Kerbing - Types and tactile paving arrangements to be determined in accordance with Tees Valley Design Guide (TVDG) and other relevant technical notes and DMRB standards.
3. Traffic Signs and Road Markings - Some road markings are shown for illustrative purposes only. An appropriate traffic signing and road marking layout will be developed during the detailed design to comply with current standards (TSRGD 2016, TVDG) and best practice. The signing provided will include appropriate directional, information, warning and regulation signs as well as any required NMU signs.
4. Street Lighting - Street lighting is shown for illustrative purposes only. All sections of new or widened highway and off carriageway NMU routes will be lit in accordance with the relevant standards for the route under consideration. The detailed design will consider the extents of street lighting required to provide safe highway and NMU routes.
5. Drainage - Due to the increase in paved areas there will be an increase in the volume of water entering the existing drainage systems. The existing drainage network is to be assessed to determine suitable outfall locations at detailed design.
6. See JBA drawings for details in relation to re-aligned Holme Beck watercourse and proposed retention pond adjacent to north link.
7. Pavement Design - The road construction and footway / cycleway construction will be constructed from flexible (bituminous) surfacing materials. They will be designed to the current TVDG standards or UK DMRB pavement standards. Existing pavement to be assessed for areas of resurfacing or full re-construction.

KEY PLAN



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SOUTH TEES DEVELOPMENT CORPORATION

Drawing Title
PRAIRIE SITE ENABLING WORKS
PLANNING APPLICATION
COLOUR GENERAL ARRANGEMENT
OVERVIEW

Drawing Number
Project: STDC_HWY - Originator: ATK - Volume: LDC - Location: PR - Type: DR - Role: CH - Number: 000004

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# B Greenfield Runoff Rates

# Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

| | |
|---|---|
| Calculated by: | Mark McMillan |
| Site name: | Eston Road |
| Site location: | South Tees |

This is an estimation of the greenfield runoff rates that are used to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013) , the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

## Site Details

| | |
|---|---|
| Latitude: | 54.58184° N |
| Longitude: | 1.16098° W |
| Reference: | 2473746779 |
| Date: | May 21 2020 09:41 |

## Runoff estimation approach

IH124

## Site characteristics

Total site area (ha): 1.22

## Methodology

| | |
|---|---|
| $Q_{BAR}$ estimation method: | Calculate from SPR and SAAR |
| SPR estimation method: | Calculate from SOIL type |

## Soil characteristics

| | Default | Edited |
|---|---|---|
| SOIL type: | 4 | 4 |
| HOST class: | N/A | N/A |
| SPR/SPRHOST: | 0.47 | 0.47 |

## Hydrological characteristics

| | Default | Edited |
|---|---|---|
| SAAR (mm): | 600 | 635 |
| Hydrological region: | 3 | 3 |
| Growth curve factor 1 year: | 0.86 | 0.86 |
| Growth curve factor 30 years: | 1.75 | 1.75 |
| Growth curve factor 100 years: | 2.08 | 2.08 |
| Growth curve factor 200 years: | 2.37 | 2.37 |

## Notes

### (1) Is $Q_{BAR}$ < 2.0 l/s/ha?

When $Q_{BAR}$ is < 2.0 l/s/ha then limiting discharge rates are set at 2.0 l/s/ha.

### (2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consent for discharge is usually set at 5.0 l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set where the blockage risk is addressed by using appropriate drainage elements.

### (3) Is SPR/SPRHOST ≤ 0.3?

Where groundwater levels are low enough the use of soakaways to avoid discharge offsite would normally be preferred for disposal of surface water runoff.

## Greenfield runoff rates

| | Default | Edited |
|---|---|---|
| $Q_{BAR}$ (l/s): | 4.92 | 5.26 |
| 1 in 1 year (l/s): | 4.23 | 4.52 |
| 1 in 30 years (l/s): | 8.61 | 9.2 |
| 1 in 100 year (l/s): | 10.23 | 10.93 |
| 1 in 200 years (l/s): | 11.66 | 12.45 |

# C Holme Beck Hydrology

# Flood estimation report

## Introduction

This report template is based on a supporting document to the Environment Agency's flood estimation guidelines (Version 5, 2015). It provides a record of the hydrological context, the method statement, the calculations and decisions made during flood estimation and the results.

## Contents



## Approval

| | Name and qualifications | Date |
|---|---|---|
| Method statement prepared by: | Nadeia Tourigny, BSc, MSc | 11/05/2020 |
| Method statement reviewed by: | Eva Kordomenidi BSc, MSc, MCIWEM CWEM, CSci | 20/05/2020 |
| Calculations prepared by: | Nadeia Tourigny, BSc, MSc | 11/05/2020 |
| Calculations reviewed by: | **Eva Kordomenidi BSc, MSc, MCIWEM CWEM, CSci** | 20/05/2020 |

# Abbreviations

AM.................................. Annual Maximum

AREA .............................. Catchment area (km$^2$)

BFI ................................. Base Flow Index

BFIHOST ......................... Base Flow Index derived using the HOST soil classification

CFMP.............................. Catchment Flood Management Plan

CPRE.............................. Council for the Protection of Rural England

FARL............................... FEH index of flood attenuation due to reservoirs and lakes

FEH................................. Flood Estimation Handbook

FSR................................. Flood Studies Report

HOST .............................. Hydrology of Soil Types

NRFA .............................. National River Flow Archive

POT................................. Peaks Over a Threshold

QMED ............................. Median Annual Flood (with return period 2 years)

ReFH .............................. Revitalised Flood Hydrograph method

SAAR .............................. Standard Average Annual Rainfall (mm)

SPR................................. Standard percentage runoff

SPRHOST ....................... Standard percentage runoff derived using the HOST soil classification

Tp(0) ............................... Time to peak of the instantaneous unit hydrograph

URBAN ........................... Flood Studies Report index of fractional urban extent

URBEXT1990 ................. FEH index of fractional urban extent

URBEXT2000 ................. Revised index of urban extent, measured differently from URBEXT1990

WINFAP-FEH ................. Windows Frequency Analysis Package – used for FEH statistical method

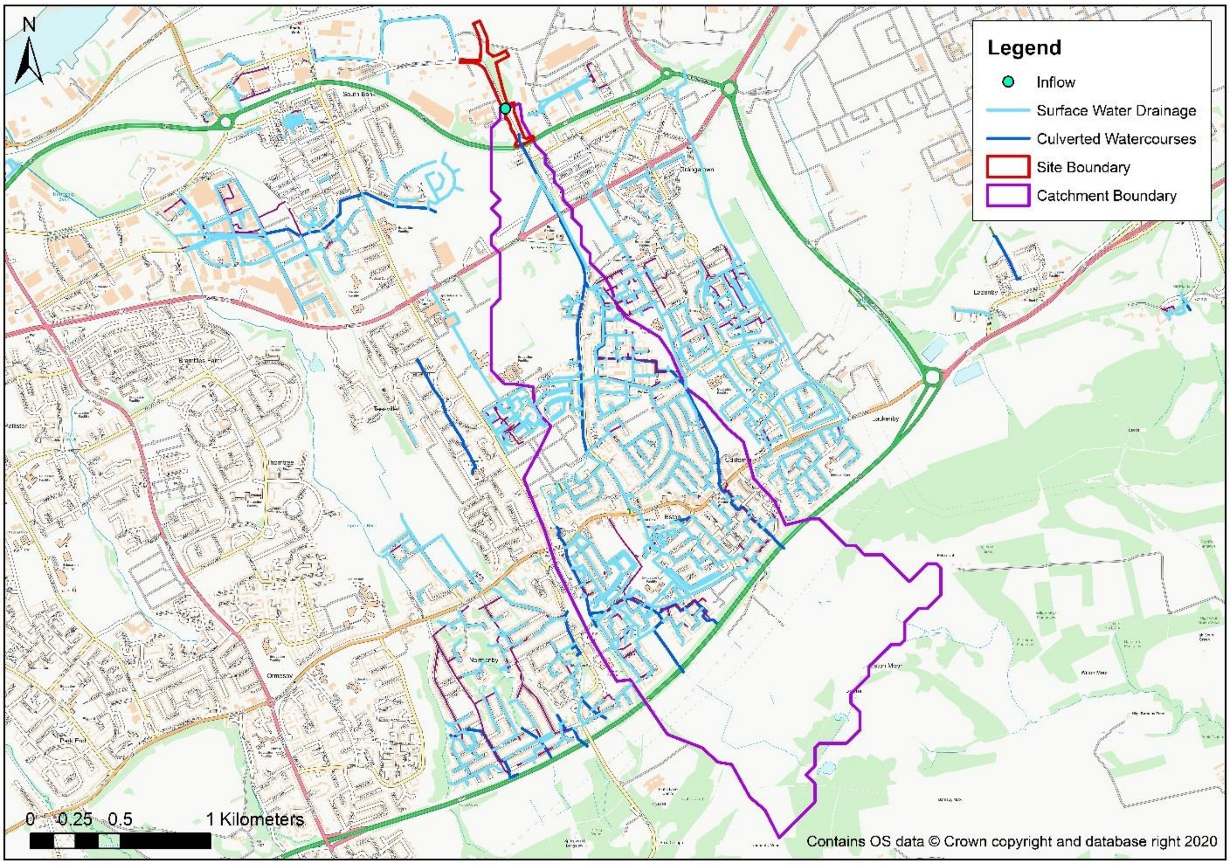
# 1 Method statement

## 1.1 Requirements for flood estimates

| Item | Comments |
|---|---|
| Overview<br>• Purpose of study<br>• Peak flows or hydrographs?<br>• Range of return periods and locations | The purpose of this study is to obtain peak flows and low flows for an unnamed watercourse along Eston road, Middlesbrough. These will be used to design an open channel to convey flows from an existing culvert to be day-lighted. The return periods calculated were 2year (50%AEP), 5year (20%AEP), 10year (10%AEP), 20year (5%AEP), 25year (4%AEP), 30year (3.33%AEP), 50year (2%AEP), 75year (1.33%AEP), 100year (1%AEP), 200% (0.5%AEP) and 1000year (0.1%AEP) and Q95 (5% exceedance). |

## 1.2 The catchment

| Item | Comments |
|---|---|
| Map (Include river network, catchment boundary and gauging stations) | |




| Item | Comments |
|---|---|
| Description<br>Include topography, climate, geology, soils, land use and any unusual features that may affect the flood hydrology. | **Area of interest:**<br>The open watercourse along Eston road, Middlesbrough, upstream of a culvert to be daylighted. Overall, the ground elevations vary between 220mAOD to 10mAOD and the unnamed watercourse flows in a south to north direction.<br><br>The catchment covers an area of 3.85km2 and is urbanised in the lower reaches and sewer data has been used to refine the catchment area. Grassland, agricultural land and moorland are present mainly in the upper catchment areas. |

## 1.3 Source of flood peak data

| | |
|---|---|
| Source<br>Record any changes made | NRFA peak flows dataset, Version 8, October 2019. This contains data up to water year 2017-18 for England, Wales, Northern Ireland and Scotland. |

## 1.4 Other data available and how it has been obtained

| Type of data | Data relevant to this study? | Data available ? | Source of data | Details |
|---|---|---|---|---|
| Check flow gaugings<br>(if planned to review ratings) | No | No | NRFA | |
| Historic flood data<br>Include chronology and interpretation of flood history in Annex or separate report. | Yes | Yes | Online research | Eston road flooded following heavy rainfall early April 2017 (https://www.gazettelive.co.uk/news/teesside-news/teesside-roads-businesses-hit-during-12832737) |
| | | | | |
| | | | | |
| Flow or river level data for events | Yes | No | NRFA | No gauges within proximity |
| Rainfall data for events | No | No | | No flood event analysis in scope |
| Potential evaporation data | No | No | | No flood event analysis in scope |
| Results from previous studies | Yes | No | | |
| | | | | |
| Other data or information<br>(e.g. groundwater, tides) | - | - | | |
| | | | | |

## 1.5 Hydrological understanding of catchment

| **All catchments** | |
|---|---|
| Outline the conceptual model, addressing questions such as:<br>• Where are the main sites of interest?<br>• What is likely to cause flooding at those locations? (peak flows, flood volumes, combinations of peaks, groundwater, snowmelt, tides…)<br>• Might those locations flood from runoff generated on part of the catchment only, e.g. downstream of a reservoir?<br>• Is there a need to consider temporary debris dams that could collapse? | The main site of interest is an open watercourse to the east of Eston Road. Flooding along the unnamed watercourse is likely to be caused by bank overtopping at peak flows. |
| Any unusual catchment features to take into account?<br>e.g.<br>• highly permeable – avoid ReFH if BFIHOST>0.65, consider permeable catchment adjustment for statistical method if SPRHOST<20%<br>• highly urbanised – seek local flow data; consider method that can account for differing sewer and topographic catchments<br>• pumped watercourse – consider lowland catchment version of rainfall-runoff method<br>• major reservoir influence (FARL<0.90) – consider flood routing, extensive floodplain storage – consider choice of method carefully | no |

## 1.6 Initial choice of approach

| | |
|---|---|
| Is FEH appropriate? (it may not be for extremely heavily urbanised or complex catchments) If not, describe other methods to be used. | Yes |
| Initial choice of method(s) and reasons<br>How will hydrograph shapes be derived if needed?<br>Will the catchment be split into sub-catchments? If so, how? | The FEH Statistical and ReFH2 will be both be used and flows will be compared. |
| Software to be used (with version numbers) | FEH Web Service / WINFAP-FEH v3.0.003[1] / WINFAP v4[2] / ReFH2 |

[1] WINFAP-FEH v3 © Wallingford HydroSolutions Limited and NERC (CEH) 2009.
[2] WINFAP-FEH v4 © Wallingford HydroSolutions Limited 2016.

# 2 Locations where flood estimates required

The table below lists the locations of subject sites. The site codes listed below are used in all subsequent tables to save space.

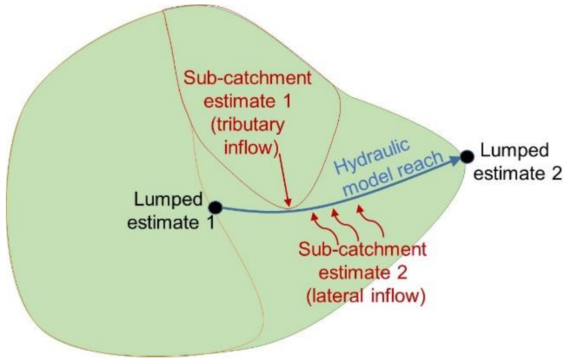
## 2.1 Summary of subject sites

| Site code | Type of estimate<br>L: lumped catchment<br>S: Sub-catchment | Watercourse | Name or description of site | Easting | Northing | AREA on FEH CD-ROM (km$^2$) | Revised AREA if altered |
|---|---|---|---|---|---|---|---|
| C_US | L | Unnamed | Culvert inlet | 454550 | 520650 | 4.34 | 3.85 |

Note: Lumped catchments (L) are complete catchments draining to points at which design flows are required.

Sub-catchments (S) are catchments or intervening areas that are being used as inputs to a semi-distributed model of the river system. There is no need to report any design flows for sub-catchments, as they are not relevant: the relevant result is the hydrograph that the sub-catchment is expected to contribute to a design flood event at a point further downstream in the river system. This will be recorded within the hydraulic model output files. However, catchment descriptors and ReFH model parameters should be recorded for sub-catchments so that the results can be reproduced.

The schematic diagram illustrates the distinction between lumped and sub-catchment estimates.




## 2.2 Important catchment descriptors at each subject site (incorporating any changes made)

| Site code | FARL | PROPWET | BFIHOST | DPLBAR (km) | DPSBAR (m/km) | SAAR (mm) | URBEXT 2000 | FPEXT |
|---|---|---|---|---|---|---|---|---|
| C_US | 0.997 | 0.32 | 0.385 | **2.09** | 67.9 | 635 | 0.397 | 0.238 |

## 2.3 Checking catchment descriptors

| | |
|---|---|
| Record how catchment boundary was checked and describe any changes<br>(add maps if needed) | The FEH catchment boundary has been checked against LiDAR 2m, OS mapping and sewer data. Some discrepancies were observed due to the sewer catchments slightly differing from the topographical catchment and amendments were made to account for surface water drainage. |
| Record how other catchment descriptors were checked and describe any changes.<br>Include before/after table if necessary. | BFIHOST values were checked against soil and geology maps and were found to be representative of the site. FARL and URBEXT values were also checked against OS mapping. |
| Source of URBEXT | URBEXT2000 |
| Method for updating of URBEXT | CPRE formula from 2006 CEH report on URBEXT2000 |

# 3 Statistical method

## 3.1 Overview of estimation of QMED at each subject site

| Site code | QMED from CDs ($m^3/s$) | Final method | Data transfer | | | | | | Final estimate of QMED ($m^3/s$) |
|---|---|---|---|---|---|---|---|---|---|
| | | | NRFA numbers for donor sites used (see 3.3) | Distance between centroids $d_{ij}$ (km) | Power term, a | Moderated QMED adjustment factor, $(A/B)^a$ | If more than one donor | | |
| | | | | | | | Weight | Weighted ave. adjustment | |
| C_US | 1.06 | DT | 25005 | 11.395 | 0.368 | 1.079 | | | 1.14 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| Are the values of QMED spatially consistent? | | | | | | Yes | | | |

**Notes**

Methods: AM – Annual maxima; POT – Peaks over threshold; DT – Data transfer (with urban adjustment); CD – Catchment descriptors alone (with urban adjustment); BCW – Catchment descriptors and bankfull channel width (add details); LF – Low flow statistics (add details).

When QMED is estimated from POT data, it should also be adjusted for climatic variation. Details should be added below.

The QMED adjustment factor A/B for each donor site is given in Table 3.2. This is moderated using the power term, a, which is a function of the distance between the centroids of the subject catchment and the donor catchment. The final estimate of QMED is $(A/B)^a$ times the initial estimate from catchment descriptors.

If more than one donor has been used, use multiple rows for the site and give the weights used in the averaging. Record the weighted average adjustment factor in the penultimate column.

**Important note on urban adjustment**

The method used to adjust QMED for urbanisation, for both subject sites and donor sites, is that published in Kjeldsen (2010)[3] in which PRUAF is calculated from BFIHOST. The result will differ from that of WINFAP-FEH v3.0.003 which does not correctly implement the urban adjustment of Kjeldsen (2010). Significant differences will occur only on urban catchments that are highly permeable.

## 3.2 Search for donor sites for QMED (if applicable)

| | |
|---|---|
| Comment on potential donor sites<br>Mention:<br>• Number of potential donor sites available<br>• Distances from subject site<br>• Similarity in terms of AREA, BFIHOST, FARL and other catchment descriptors<br>• Quality of flood peak data<br>Include a map if necessary. Note that donor catchments should usually be rural. | Two potential donor catchments for this study were identified using the 'Estimating QMED by data transfer' tool which is available in WINFAP-FEH3. The chosen donor site is within the same hydrometric area.<br><br>Catchment 25005 (Leven at Leven Bridge) was identified by WINFAP as the most suitable donor catchment available:<br><br>Donor \| 25005 \| 25019 |

[3] Kjeldsen, T. R. (2010). Modelling the impact of urbanization on flood frequency relationships in the UK. Hydrol. Res. **41**. 391-405.

| | | |
|---|---|---|
| Distance (km) | 11.395 | 10.761 |
| Area (km$^2$) | 194.15 | 15.09 |
| BFIHOST | 0.381 | 0.524 |
| FARL | 0.994 | 1 |
| SAAR | 726 | 830 |

The 25005 (Leven at Leven Bridge) catchment is located relatively close to the catchment but has a greater size than the target catchment. The SAAR values are slightly higher than the target catchment but more similar than the 25019 (Leven at Easby) catchment. BFIHOST is similar for the target and 25005 catchment. FARL values are equally similar.

## 3.3 Donor sites chosen and QMED adjustment factors

| NRFA no. | Reasons for choosing | Method (AM or POT) | Adjust-ment for climatic variation? | QMED from flow data (A) | QMED from catchment descriptors (B) | Adjust-ment ratio (A/B) |
|---|---|---|---|---|---|---|
| 25005 | BFIHOST and SAAR similarity | AM | No | 43.5 | 34.9 | 1.23 |

## 3.4 Derivation of pooling groups

Several subject sites may use the same pooling group.

| Name of group | Site code from whose descriptors group was derived | Subject site treated as gauged? (enhanced single site analysis) | Changes made to default pooling group, with reasons | Weighted average L-moments, L-CV and L-skew, (before urban adjustment) |
|---|---|---|---|---|
| 1 | C_US | No | Removed:<br>49005 Bolingey Stream @ Bolingey Cocks Bridge (only 8 years of data)<br>26802 Gypsey Race @ Kirby Grindalythe (chalk catchment)<br>36010 Bumpstead Brook @ Broad Green (chalk catchment)<br>44008 South Winterbourne @ Winterbourne Steepleton (chalk catchment)<br><br>Added to increase station years to 5T:<br>71003 Croasdale Beck @ Croasdale Flume<br>206006 Annalong @ Recorder | L-CV: 0.229<br>L-Skew: 0.250 |
| **Notes**<br>Pooling groups were derived using the procedures from Science Report SC050050 (2008). | | | | |

### 3.5 Derivation of flood growth curves at subject sites

| **Site code** | **Method** (SS, P, ESS, J) | **If P, ESS or J, name of pooling group (Error! Reference source not found.)** | **Distribution used and reason for choice[4]** | **Note any urban adjustment or permeable adjustment** | **Parameters of distribution** (location, scale and shape after adjustments) | **Growth factor for 100-year return period** |
|---|---|---|---|---|---|---|
| C_US | P | P_US | GL | Urban adjustment – Kjeldsen (2010) | Location: 1<br>Scale: 0.245<br>Shape: -0.218 | 1.76 |

**Notes**

Methods: SS – Single site; P – Pooled; ESS – Enhanced single site; J – Joint analysis

A pooling group (or ESS analysis) derived at one gauge can be applied to estimate growth curves at a number of ungauged sites. Each site may have a different urban adjustment, and therefore different growth curve parameters.

Urban adjustments are all carried out using the v3 method: Kjeldsen (2010).

Growth curves were derived using the procedures from Science Report SC050050 (2008).

### 3.6 Flood estimates from the statistical method

| **Site code** | **Flood peak ($m^3/s$) for the following return periods (in years)** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **2** | **5** | **10** | **30** | **50** | **75** | **100** | **200** | **1000** |
| C_US | 1.3 | 1.7 | 2.0 | 2.7 | 3.1 | 3.4 | 3.7 | 4.4 | 7.1 |
| | | | | | | | | | |

[4] *The selected distribution (GL) based on the best fit as measured by the z score in WINFAP.

# 4 Revitalised flood hydrograph 2 (ReFH2) method

## 4.1 Parameters for ReFH2 model (rural catchments)

| **Site code** | **Method**<br>OPT: Optimisation<br>BR: Baseflow recession fitting<br>CD: Catchment descriptors<br>DT: Data transfer (give details) | **Tp (hours)**<br>Time to peak | **$C_{max}$ (mm)**<br>Maximum storage capacity | **BL (hours)**<br>Baseflow lag | **BR**<br>Baseflow recharge |
|---|---|---|---|---|---|
| C_US | CD | 2.81 | 318.25 | 35.12 | 1.74 |
| | | | | | |
| Brief description of any flood event analysis carried out (further details should be given in the annex) | | | | | |
| * An additional catchment has been calculated here to account for the flows in the burn after the development as overland flows within the development will be directed to the drainage and attenuated on site rather than flowing towards the watercourse directly. This will be used to compare pre and post development flows in the model and assess the impact of developing the site on flows and flood risk. | | | | | |

## 4.2 Design events for ReFH2 method

| **Site code** | **Urban or rural** | **Season of design event (summer or winter)** | **Storm duration (hours)** | **Storm area for ARF (if not catchment area)** |
|---|---|---|---|---|
| C_US | Urban | Summer | 4.5 | |
| | | | | |
| Are the storm durations likely to be changed in the next stage of the study, e.g. by optimisation within a hydraulic model? | | | | |

## 4.3 Flood estimates from the ReFH2 method

Note: This table is for recording results for lumped catchments. There is no need to record peak flows from sub-catchments or intervening areas that are being used as inputs to a semi-distributed model of the river system.

| **Site code** | **Flood peak ($m^3/s$) for the following return periods (in years)** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **2** | **5** | **10** | **30** | **50** | **75** | **100** | **200** | **1000** |
| C_US | 2.2 | 3.1 | 3.8 | 5.0 | 5.7 | 6.3 | 6.8 | 8.0 | 11.8 |
| | | | | | | | | | |

# 5 Discussion and summary of results

## 5.1 Comparison of results from different methods

This table compares peak flows from various methods with those from the FEH Statistical method at example sites for two key return periods. Blank cells indicate that results for a particular site were not calculated using that method.

| Site code | Ratio of peak flow to FEH Statistical peak | | | | | |
|---|---|---|---|---|---|---|
| | Return period 2 years | | | Return period 100 years | | |
| | ReFH2 | Other method | Other method | ReFH2 | Other method | Other method |
| C_US | 1.68 | | | 1.82 | | |
| | | | | | | |

## 5.2 Final choice of method

| | |
|---|---|
| Choice of method and reasons<br>Include reference to type of study, nature of catchment and type of data available. | The catchment is ungauged and as such each method carries appreciable uncertainty. ReFH2 is recommended due to the small and relatively urbanised nature of the catchment.<br>The ReFH2 method has been found to perform will less bias for small catchment design flow estimation and the design flows obtained from the ReFH2 method produce higher peak flows. These will be used in the model to err on the side of caution. The catchment is ungauged and there is no way to validate the design flow estimates using catchment specific data. |

## 5.3 Assumptions, limitations and uncertainty

<table>
<tr><td>List the main assumptions made (specific to this study)</td><td>The main assumptions associated with this study are that:<ul><li>Tp (derived from catchment descriptors) is representative and therefore storm durations are representative of the typical catchment response</li><li>The characteristics and catchment descriptors of the donor catchment are representative of the of the study catchment (with the exception of the adjusted descriptors)</li><li>The pooling group is suitably representative of the study catchment</li></ul></td></tr>
<tr><td>Discuss any particular limitations, e.g. applying methods outside the range of catchment types or return periods for which they were developed.</td><td>The study catchment is ungauged; as such there is no catchment flow data to verify the peak flow estimates generated by the methods.<br>The study catchment is defined on the FEH web service, though the area was not fully accurate. The catchment boundary was adjusted manually using available information such as sewer maps. Confidence could be improved with further hydrometric data or flood history.</td></tr>
<tr><td>Give what information you can on uncertainty in the results, e.g. confidence limits from Kjeldsen (2014).</td><td>The uncertainty will depend on many factors, for example, how unusual the study catchment is relative to the pooling group and donor catchment, and the uncertainty in flow measurement at other gauges. However, a UK average measure of uncertainty has been produced by Kjeldsen (2014). The 95% confidence limits for a 1% AEP flood estimate are:<br>• Without donor adjustment of QMED: 0.42 – 2.37 times the best estimate<br>• With donor adjustment of QMED: 0.45 – 2.25 times the best estimate<br><br>A recently published R&D project into FEH, local data and uncertainty (Environment Agency funded consortium of JBA, CEH and others) established that the following range of a 95% confidence interval is to be expected per design flood for a rural site (numbers quoted are multipliers):<br><br><table><tr><td>AEP</td><td>No donor</td><td>1 donor</td></tr><tr><td>50%</td><td>0.48 – 2.10</td><td>0.50 – 2.02</td></tr><tr><td>1%</td><td>0.45 – 2.23</td><td>0.47 – 2.12</td></tr></table></td></tr>
<tr><td>Comment on the suitability of the results for future studies, e.g. at nearby locations or for different purposes.</td><td>Results are suitable for the purposes of the current study. If used in other studies, a review of the results is recommended as a minimum.</td></tr>
<tr><td>Give any other comments on the study, e.g. suggestions for additional work.</td><td>N/A</td></tr>
</table>

## 5.4 Checks

| | |
|---|---|
| Are the results consistent, for example at confluences? | Yes |
| What do the results imply regarding the return periods of floods during the period of record? | Given that there is no flow data in the catchment, it is not possible to check the flow estimates derived against gauge data.<br>Sensibility checks will be applied to the flood levels at channel design stage. |
| What is the range of 100-year growth factors? Is this realistic? | N/A |
| If 1000-year flows have been derived, what is the range of ratios for 1000-year flow over 100-year flow? | The 0.1%/1% AEP event growth factor range is 1.74 for the ReFH2 method.<br>The typical range for the ratio is 1.3 to 1.8. The value is therefore within the typical range. |
| How do the results compare with those of other studies? Explain any differences and conclude which results should be preferred. | No results from previous studies available. |
| Are the results compatible with the longer-term flood history? | No evidence of flow data in the site vicinity has been found. |
| Describe any other checks on the results | Flood levels will be sensitivity checked during the design phase. |

## 5.5 Final results

| Site code | Flood peak ($m^3$/s) for the following return periods (in years) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **2** | **5** | **10** | **30** | **50** | **75** | **100** | **200** | **1000** |
| C_US | 2.2 | 3.1 | 3.8 | 5.0 | 5.7 | 6.3 | 6.8 | 8.0 | 11.8 |
| | | | | | | | | | |

| | |
|---|---|
| If flood hydrographs are needed for the next stage of the study, where are they provided? (e.g. give filename of spreadsheet, name of ISIS model, or reference to table below) | |

# Annex 1 - Pooling Group

| Station name | Distance | Years of data | QMED AM | L-CV | L-SKEW | Discordancy |
|---|---|---|---|---|---|---|
| 27073 (Brompton Beck @ Snainton Ings) | 1.061 | 37 | 0.82 | 0.2 | 0.047 | 1.253 |
| 76011 (Coal Burn @ Coalburn) | 2.429 | 41 | 1.84 | 0.165 | 0.315 | 1.044 |
| 27051 (Crimple @ Burn Bridge) | 2.78 | 46 | 4.539 | 0.219 | 0.148 | 0.37 |
| 45816 (Haddeo @ Upton) | 2.926 | 25 | 3.456 | 0.306 | 0.399 | 0.957 |
| 28033 (Dove @ Hollinsclough) | 3.116 | 43 | 4.205 | 0.231 | 0.369 | 0.586 |
| 25019 (Leven @ Easby) | 3.141 | 40 | 5.384 | 0.343 | 0.378 | 2.065 |
| 47022 (Tory Brook @ Newnham Park) | 3.35 | 25 | 6.18 | 0.273 | 0.149 | 1.062 |
| 25003 (Trout Beck @ Moor House) | 3.399 | 45 | 15.12 | 0.167 | 0.302 | 0.905 |
| 25011 (Langdon Beck @ Langdon) | 3.422 | 32 | 15.533 | 0.235 | 0.334 | 1.6 |
| 27010 (Hodge Beck @ Bransdale Weir) | 3.486 | 41 | 9.42 | 0.224 | 0.293 | 0.092 |
| 72014 (Conder @ Galgate) | 3.524 | 50 | 16.465 | 0.233 | 0.162 | 0.235 |
| 71003 (Croasdale Beck @ Croasdale Flume) | 3.534 | 37 | 10.9 | 0.212 | 0.323 | 0.271 |
| 206006 (Annalong @ Recorder) | 3.571 | 48 | 15.33 | 0.189 | 0.052 | 2.561 |
| | | | | | | |
| Total | | 510 | | | | |
| Weighted means | | | | 0.229 | 0.25 | |

# Annex 2 – Low Flows

Low flows were estimated out using industry leading software LowFlows from HydroSolutions and the derived catchment boundary shapefile. The main parameters used in the software are detailed below

| | |
|---|---|
| **Region** | England: Northeast |
| **Area** | (25) Tees |
| **Boundary source** | Imported polygon |
| **Catchment Area (km²)** | 3.854 |
| **Grid-resolution used for derivation of catchment characteristics (m)** | 20 |
| **Runoff (mm)** | 264.6 |
| **BFI** | 0.355 |
| **Water Bodies** | No significant lakes in catchment |

| Flow | Annual Flow (m3/s) |
|---|---|
| **Qmean** | 0.032 |
| **Q(0.1)** | 0.766 |
| **Q(1)** | 0.290 |
| **Q(5)** | 0.115 |
| **Q(10)** | 0.071 |
| **Q(15)** | 0.052 |
| **Q(20)** | 0.040 |
| **Q(25)** | 0.032 |
| **Q(30)** | 0.027 |
| **Q(35)** | 0.023 |
| **Q(40)** | 0.020 |
| **Q(45)** | 0.017 |
| **Q(50)** | 0.015 |
| **Q(55)** | 0.012 |
| **Q(60)** | 0.011 |
| **Q(65)** | 0.009 |
| **Q(70)** | 0.008 |
| **Q(75)** | 0.006 |
| **Q(80)** | 0.005 |
| **Q(85)** | 0.005 |
| **Q(90)** | 0.004 |
| **Q(95)** | 0.003 |
| **Q(99)** | 0.002 |
| **Q(99.9)** | 0.001 |

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# D Design Calculations

# CALCULATION RECORD

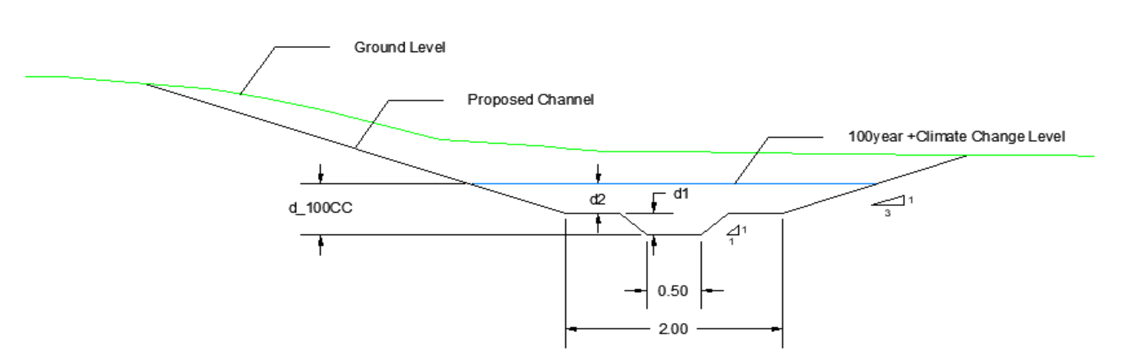
| | | | | | | |
|---|---|---|---|---|---|---|
| **Project Code:** | 2020s0655 | **Page** | **1** | **of** | **1** | |
| **Project Title:** | Eston Road Highway Works | | | | | |
| **Subject:** | **Channel Design Calculations** | | | | | |

| | *Initials* | *Date* |
|---|---|---|
| **Designer:** | NT | **21/05/2020** |
| **Checker:** | MM | **27/05/2020** |
| **Approver:** | RD | **27/05/2020** |
| **Office:** | **Glasgow** | |

JBA consulting

| **Channel Design Parameters** | |
|---|---|
| Lower Channel Capacity | Up to Q10 |
| Upper Channel Capacity | Q10 to Q100+CC |
| Lower Channel Width (m) | 0.5 |
| Upper Channel Width (m) | 2 |
| Lower Channel Side Slopes | 1 |
| Upper Channel Side Slopes | 3 |
| Freeboard Allowance (mm) | 300 |
| Channel Roughness (Manning's n) | 0.035 |

**Typical Cross Section**




**Flow Calculation - Manning's Equation**

$$Q = VA = \left(\frac{1.00}{n}\right) A R^{\frac{2}{3}} \sqrt{S}$$

| | |
|---|---|
| V | Velocity (m/s) |
| A | Flow Area (m2) |
| R | Hydraulic Radius (m) |
| S | Slope (m/m) |
| n | Manning's Roughness Coefficient |

| Section | Chainage (m) | IL (mAOD) | GL (mAOD) | Gradient (1 in) | d1 (m) | d2 (m) | d_100CC (m) | Q10 Velocity (m/s) | Q100+40%CC Velocity (m/s) |
|---|---|---|---|---|---|---|---|---|---|
| XS 1 | 0 | 10.50 | 13.30 | 471 | 0.25 | 1.36 | 1.61 | 0.38 | 1.12 |
| XS 2 | 200 | 10.08 | 12.00 | 140 | 0.25 | 1.36 | 1.61 | 0.38 | 1.12 |
| XS 3 | 350 | 9.00 | 10.60 | 72 | 0.18 | 1.03 | 1.21 | 0.59 | 1.76 |
| XS 4 | 433 | 7.85 | 10.00 | 200 | 0.20 | 1.12 | 1.32 | 0.52 | 1.54 |
| XS 5 | 463 | 7.70 | 9.50 | 123 | 0.20 | 1.12 | 1.32 | 0.52 | 1.54 |
| XS 6 | 500 | 7.40 | 8.90 | 111 | 0.17 | 1.00 | 1.17 | 0.62 | 1.84 |
| XS 7 | 600 | 6.50 | 8.15 | 207 | 0.20 | 1.13 | 1.33 | 0.51 | 1.52 |
| XS 8 | 662 | 6.20 | 8.20 | - | 0.20 | 1.13 | 1.33 | 0.51 | 1.52 |

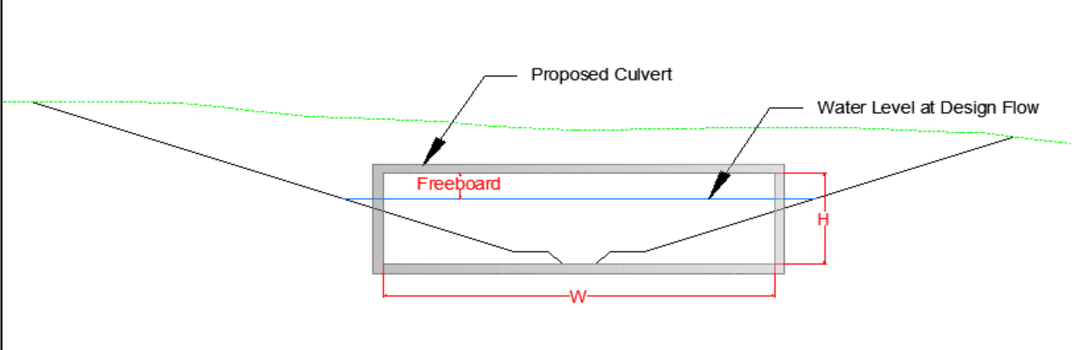
# CALCULATION RECORD

| | | | | | | |
|---|---|---|---|---|---|---|
| **Project Code:** | 2020s0655 | **Page** | **1** | **of** | **1** | |
| **Project Title:** | Eston Road Highway Works | | | | | |
| **Subject:** | **Culvert Design Calculations (East of Eston Road Roundabout)** | | | | | |

| | *Initials* | *Date* |
|---|---|---|
| **Designer:** | NT | **21/05/2020** |
| **Checker:** | MM | **27/05/2020** |
| **Approver:** | RD | **27/05/2020** |
| **Office:** | **Glasgow** | |

| Channel Design Parameters | |
|---|---|
| Culvert Upstream Invert Level $IL_{US}$ (mAOD) | 7.85 |
| Culvert Downstream Invert Level (mAOD) | 7.70 |
| Ground Level (mAOD) | 10.30 |
| Culvert Length (m) | 30 |
| Culvert Thickness (m) | 0.2 |
| Services Gap (m) | 0.15 |
| Minimum Cover (m) | 0.6 |
| Total Cover Requirement (m) | 0.95 |
| Minimum Freeboard Allowance (mm) | 300 |
| Culvert Roughness (Mannings'n) | 0.035 |

**Typical Cross Section**




**Flow Calculation - Manning's Equation**

$$Q = VA = \left(\frac{1.00}{n}\right) AR^{\frac{2}{3}} \sqrt{S}$$

| | |
|---|---|
| V | Velocity (m/s) |
| A | Flow Area (m2) |
| R | Hydraulic Radius (m) |
| S | Slope (m/m) |
| n | Manning's Roughness Coefficient |

| Cuvert Dimensions | |
|---|---|
| Culvert Height H (m) | 1.5 |
| Culvert Width W (m) | 6 |
| Upstream Soffit Level (mAOD) | 9.35 |
| Slope (m/m) | 0.005 |
| **Flow Calculations at Q=100yr+CC** | |
| Design Flow $Q_{100CC}$ (m3/s) | 9.45 |
| Water Depth (m) | 0.96 |
| Flow Area (m) | 5.78 |
| Wet perimeter (m) | 7.93 |
| Hydraulic Radius (m) | 0.73 |
| Velocity (m/s) | 1.64 |
| Calculated Freeboard $F_{CAL}$ (m) | 0.54 |
| Calculated Flow $Q_{CAL}$ (m3/s) | 9.46 |

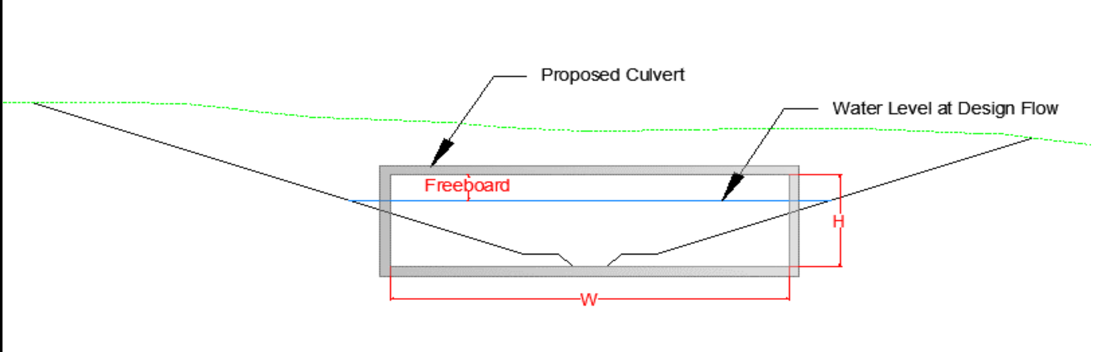
| Checks | | ✓ / ✕ | Changes required? |
|---|---|---|---|
| Flow | $Q_{CAL} \geq Q_{100CC}$ | ✓ | No |
| Freeboard | $F_{CAL} \geq$ Design Freeboard | ✓ | No |
| Culvert cover | GL - ($IL_{US}$ + H) $\geq$ Required Cover | ✓ | No |

# CALCULATION RECORD

| | | | | | | |
|---|---|---|---|---|---|---|
| **Project Code:** | 2020s0655 | **Page** | 1 of 1 | | ***Initials*** | ***Date*** |
| **Project Title:** | Eston Road Highway Works | | | **Designer:** | NT | **21/05/2020** |
| **Subject:** | **Culvert Design Calculations (North of Eston Road Roundabout)** | | | **Checker:** | MM | **27/05/2020** |
| | | | | **Approver:** | RD | **27/05/2020** |
| | | | | **Office:** | **Glasgow** | |

| **Channel Design Parameters** | |
|---|---|
| Culvert Upstream Invert Level $IL_{US}$ (mAOD) | 6.34 |
| Culvert Downstream Invert Level (mAOD) | 6.22 |
| Ground Level (mAOD) | 8.80 |
| Culvert Length (m) | 24 |
| Culvert Thickness (m) | 0.2 |
| Services Gap (m) | 0.15 |
| Minimum Cover (m) | 0.6 |
| Total Cover Requirement (m) | 0.95 |
| Minimum Freeboard Allowance (mm) | 300 |
| Culvert Roughness (Manning's'n) | 0.035 |

**Typical Cross Section**




**Flow Calculation - Manning's Equation**

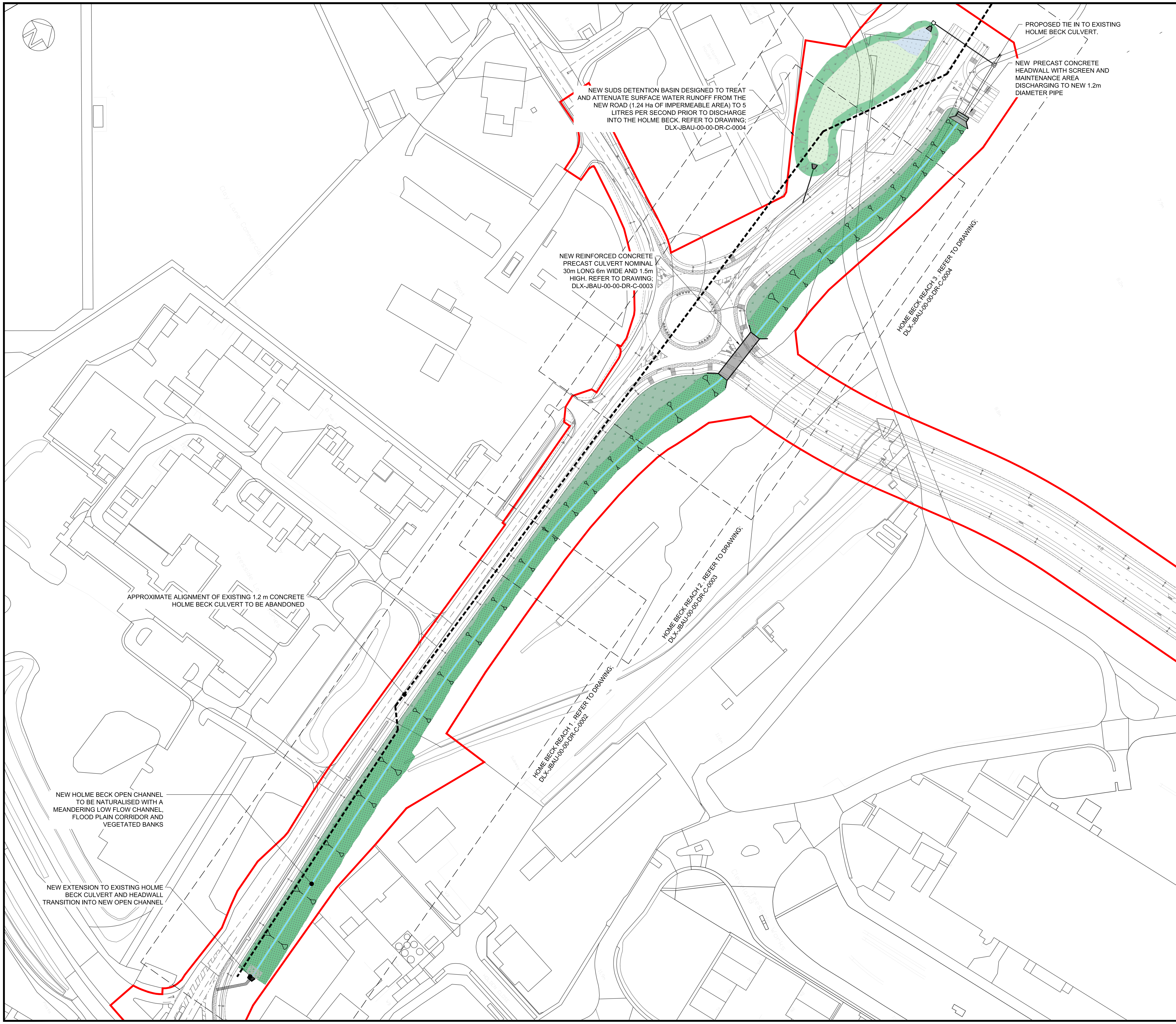
$$Q = VA = \left(\frac{1.00}{n}\right) AR^{\frac{2}{3}} \sqrt{S}$$

| | |
|---|---|
| V | Velocity (m/s) |
| A | Flow Area (m2) |
| R | Hydraulic Radius (m) |
| S | Slope (m/m) |
| n | Manning's Roughness Coefficient |

| **Cuvert Dimensions** | |
|---|---|
| Culvert Height H (m) | 1.5 |
| Culvert Width W (m) | 6 |
| Upstream Soffit Level (mAOD) | 7.84 |
| Slope (m/m) | 0.005 |
| **Flow Calculations at Q=100yr+CC** | |
| Design Flow $Q_{100CC}$ (m3/s) | 9.45 |
| Water Depth (m) | 0.96 |
| Flow Area (m) | 5.78 |
| Wet perimeter (m) | 7.93 |
| Hydraulic Radius (m) | 0.73 |
| Velocity (m/s) | 1.64 |
| Calculated Freeboard $F_{CAL}$ (m) | 0.54 |
| Calculated Flow $Q_{CAL}$ (m3/s) | 9.46 |

| **Checks** | | ✓ / ✗ | **Changes required?** |
|---|---|---|---|
| Flow | $Q_{CAL} \geq Q_{100CC}$ | ✓ | No |
| Freeboard | $F_{CAL} \geq$ Design Freeboard | ✓ | No |
| Culvert cover | GL - ($IL_{US}$ + H) ≥ Required Cover | ✓ | No |

# E Design Drawings




| No. | Construction Risk | Maintenance Risk | Demolition Risk |
|---|---|---|---|
| 1 | | | |
| 2 | | | |

In addition to the hazards/risks normally associated with the types of work detailed on this drawing take note of the above.

## SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION BOX

General Notes

A. All dimensions shown are in metres unless otherwise stated and levels in metres to Ordnance Datum.
B. Do not scale from this drawing. All dimensions must be checked/verified on site.
C. This drawing is to be read in conjunction with;
DLX-JBAU-00-00-DR-C-0001
DLX-JBAU-00-00-DR-C-0002
DLX-JBAU-00-00-DR-C-0003
DLX-JBAU-00-00-DR-C-0004
DLX-JBAU-00-00-DR-C-0005
D. Refer to Flood Risk Assessment and Design Justification report DXL-JBAU-00-00-C-RP-0001 for hydraulic calculations.

LEGEND

- HIGH FLOW CHANNEL EXTENT (DESIGNED TO CONTAIN THE 1 IN 100 YEAR FLOW PLUS 40% ALLOWANCE FOR CLIMATE CHANGE)
- LOW FLOW CHANNEL EXTENT
- RENATURALISATION CORRIDOR
- SuDS BASIN INVERT
- SuDS BASIN CUT SLOPE
- LOW FLOW Q10 CHANNEL
- CONCRETE STRUCTURE
- EXISTING HOLME BECK CULVERT TO BE REMOVED
- DEVELOPMENT BOUNDARY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DRAFT

Project
# Eston Road Highway Works

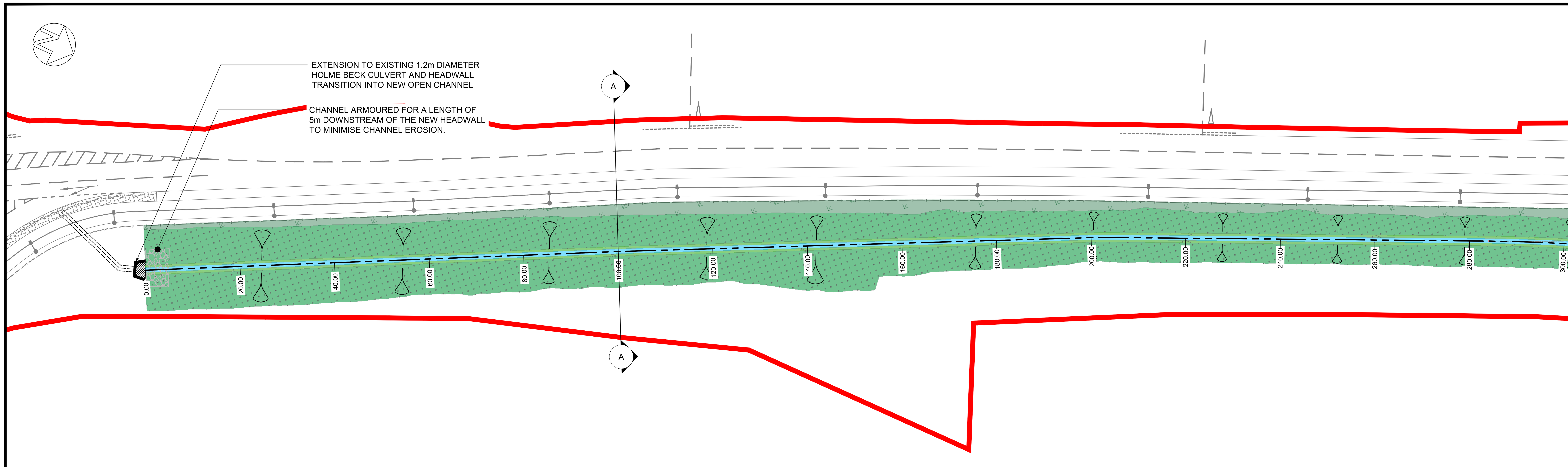
Title
SuDS & River Restoration Proposal
Holme Beck
Plan
for

Client
South Tees Development Corporation



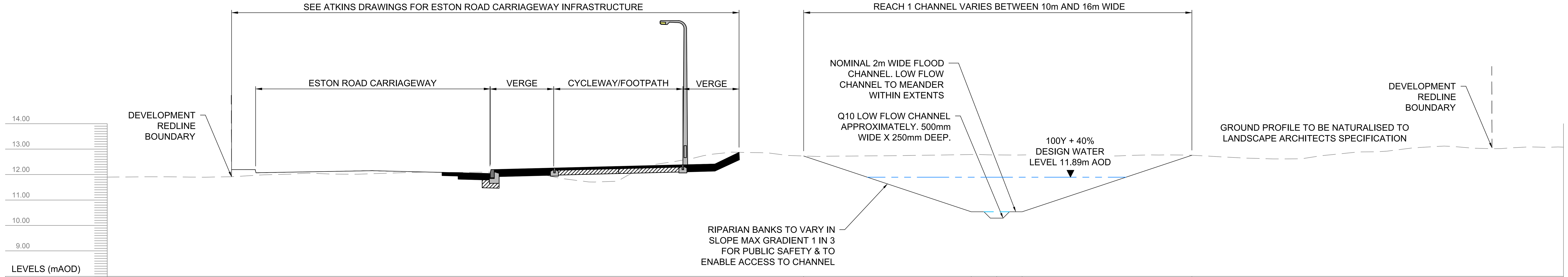
| | | | | | |
|---|---|---|---|---|---|
| Drawn: | S Thomson | 20/05/2020 | Designed: | S Thomson | 20/05/2020 |
| Checked: | S Thomson | 20/05/2020 | Approved: | R Dobson | 21/05/2020 |
| Project Reference: | 2020s0655 | | Scale: | 1:1000 @ A1 | |

| Drawing Number: | Status: | Revision: | Sheet Size: |
|---|---|---|---|
| DLX-JBAU-00-00-DR-C-0001 | S3 | P01 | A1 |




## HOLME BECK CHANNEL CH 0 - 280m

**SCALE 1:500**




| | | | | | |
|---|---|---|---|---|---|
| CHAINAGE (m) | 7.58 | 1.00 | 0.00 | 1.00 | 7.66 |
| EXISTING GROUND LEVEL (mAOD) | 12.73 | 12.79 | 12.77 | 12.77 | 12.76 |
| FINISHED GROUND LEVEL (mAOD) | 12.73 | 10.54 | 10.29 | 10.54 | 12.76 |

## TYPICAL SECTION A-A
## CH: 100.00

**SCALE 1:100**

| No. | Construction Risk | Maintenance Risk | Demolition Risk |
|---|---|---|---|
| 1 | | | |
| 2 | | | |

In addition to the hazards/risks normally associated with the types of work detailed on this drawing take note of the above.

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION BOX

General Notes

A. All dimensions shown are in metres unless otherwise stated and levels in metres to Ordnance Datum.
B. Do not scale from this drawing. All dimensions must be checked/verified on site.
C. This drawing is to be read in conjunction with;
DLX-JBAU-00-00-DR-C-0001
DLX-JBAU-00-00-DR-C-0002
DLX-JBAU-00-00-DR-C-0003
DLX-JBAU-00-00-DR-C-0004
DLX-JBAU-00-00-DR-C-0005
D. Refer to Flood Risk Assessment and Design Justification report DXL-JBAU-00-00-C-RP-0001 for hydraulic calculations.

**LEGEND**

- HIGH FLOW CHANNEL EXTENT (DESIGNED TO CONTAIN THE 1 IN 100 YEAR FLOW PLUS 40% ALLOWANCE FOR CLIMATE CHANGE)
- LOW FLOW CHANNEL EXTENT
- RENATURALISATION CORRIDOR
- LOW FLOW WETTED AREA
- CONCRETE STRUCTURE
- EXISTING GROUND LEVEL
- FINISHED GROUND LEVEL
- DEVELOPMENT BOUNDARY
- Q10 WATER LEVEL
- 1:100 YR + 40% CC WATER LEVEL

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Twitter @JBAConsulting

DRAFT

JBA consulting

Project
Eston Road Highway Works

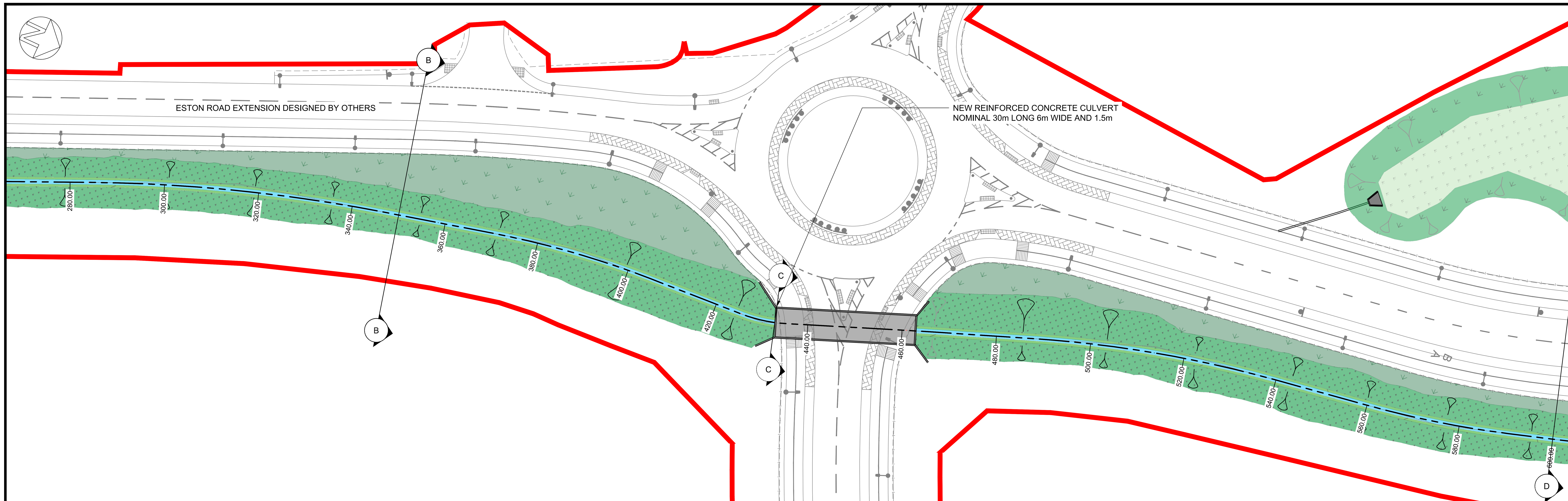
Title
SuDS & River Restoration Proposal
Holme Beck
Plan & Section 1 of 3
for

Client
South Tees Development Corporation



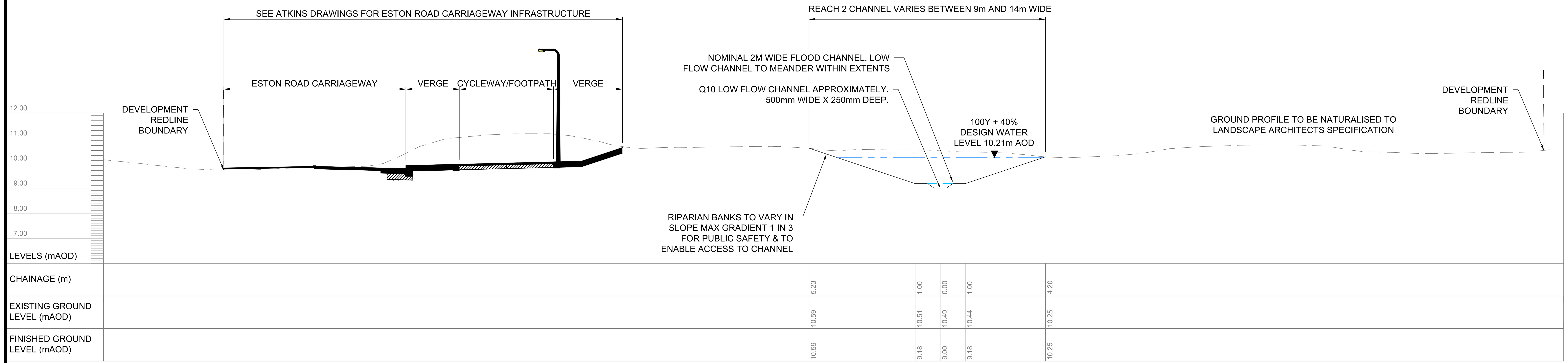
| | | | | | |
|---|---|---|---|---|---|
| Drawn: | S Thomson | 20/05/2020 | Designed: | S Thomson | 20/05/2020 |
| Checked: | S Thomson | 20/05/2020 | Approved: | R Dobson | 21/05/2020 |
| Project Reference: | 2020s0655 | | Scale: | As Shown @ A1 | |

| Drawing Number: | Status: | Revision: | Sheet Size: |
|---|---|---|---|
| DLX-JBAU-00-00-DR-C-0002 | S3 | P01 | A1 |




## HOLME BECK CHANNEL REACH 2 CH 280 - 463m

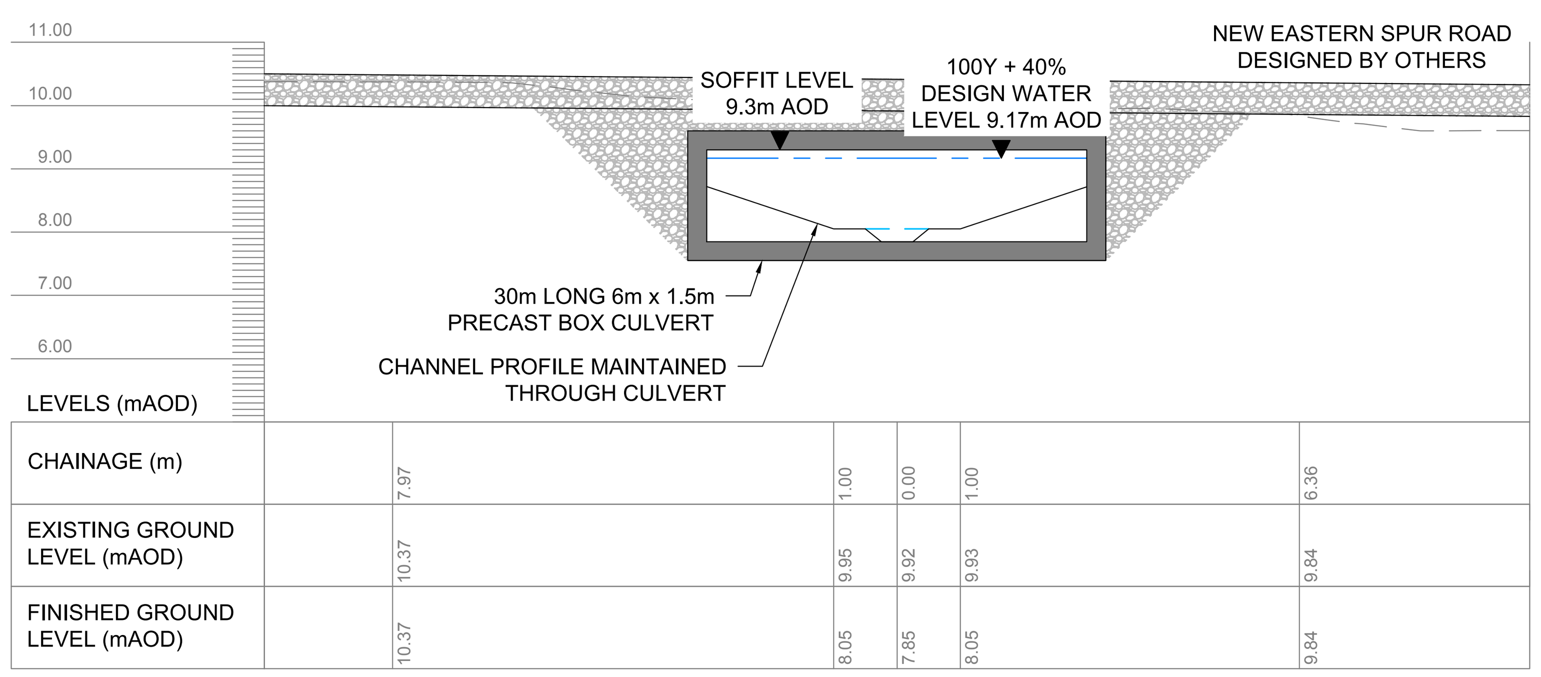
**SCALE 1:500**




## TYPICAL SECTION B-B

CH: 350.00

**SCALE 1:100**




## TYPICAL SECTION C-C

CH: 433.00

**SCALE 1:100**

| No. | Construction Risk | Maintenance Risk | Demolition Risk |
|---|---|---|---|
| 1 | | | |
| 2 | | | |

In addition to the hazards/risks normally associated with the types of work detailed on this drawing take note of the above.

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION BOX

General Notes

A. All dimensions shown are in metres unless otherwise stated and levels in metres to Ordnance Datum.
B. Do not scale from this drawing. All dimensions must be checked/verified on site.
C. This drawing is to be read in conjunction with;
DLX-JBAU-00-00-DR-C-0001
DLX-JBAU-00-00-DR-C-0002
DLX-JBAU-00-00-DR-C-0003
DLX-JBAU-00-00-DR-C-0004
DLX-JBAU-00-00-DR-C-0005
D. Refer to Flood Risk Assessment and Design Justification report DXL-JBAU-00-00-C-RP-0001 for hydraulic calculations.

LEGEND

- HIGH FLOW CHANNEL EXTENT (DESIGNED TO CONTAIN THE 1 IN 100 YEAR FLOW PLUS 40% ALLOWANCE FOR CLIMATE CHANGE)
- LOW FLOW CHANNEL EXTENT
- RENATURALISATION CORRIDOR
- SuDS BASIN INVERT
- SuDS BASIN CUT SLOPE
- LOW FLOW WETTED AREA
- CONCRETE STRUCTURE
- EXISTING GROUND LEVEL
- FINISHED GROUND LEVEL
- DEVELOPMENT BOUNDARY
- Q10 WATER LEVEL
- 1:100 YR + 40% CC WATER LEVEL

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DRAFT

Project: Eston Road Highway Works

Title: SuDS & River Restoration Proposal
Holme Beck
Plan & Section 2 of 3
for

Client: South Tees Development Corporation



| | | | | | |
|---|---|---|---|---|---|
| Drawn: | S Thomson | 20/05/2020 | Designed: | S Thomson | 20/05/2020 |
| Checked: | S Thomson | 20/05/2020 | Approved: | R Dobson | 21/05/2020 |
| Project Reference: | 2020s0655 | | Scale: | As Shown @ A1 | |

| Drawing Number: | Status: | Revision: | Sheet Size: |
|---|---|---|---|
| DLX-JBAU-00-00-DR-C-0003 | S3 | P01 | A1 |

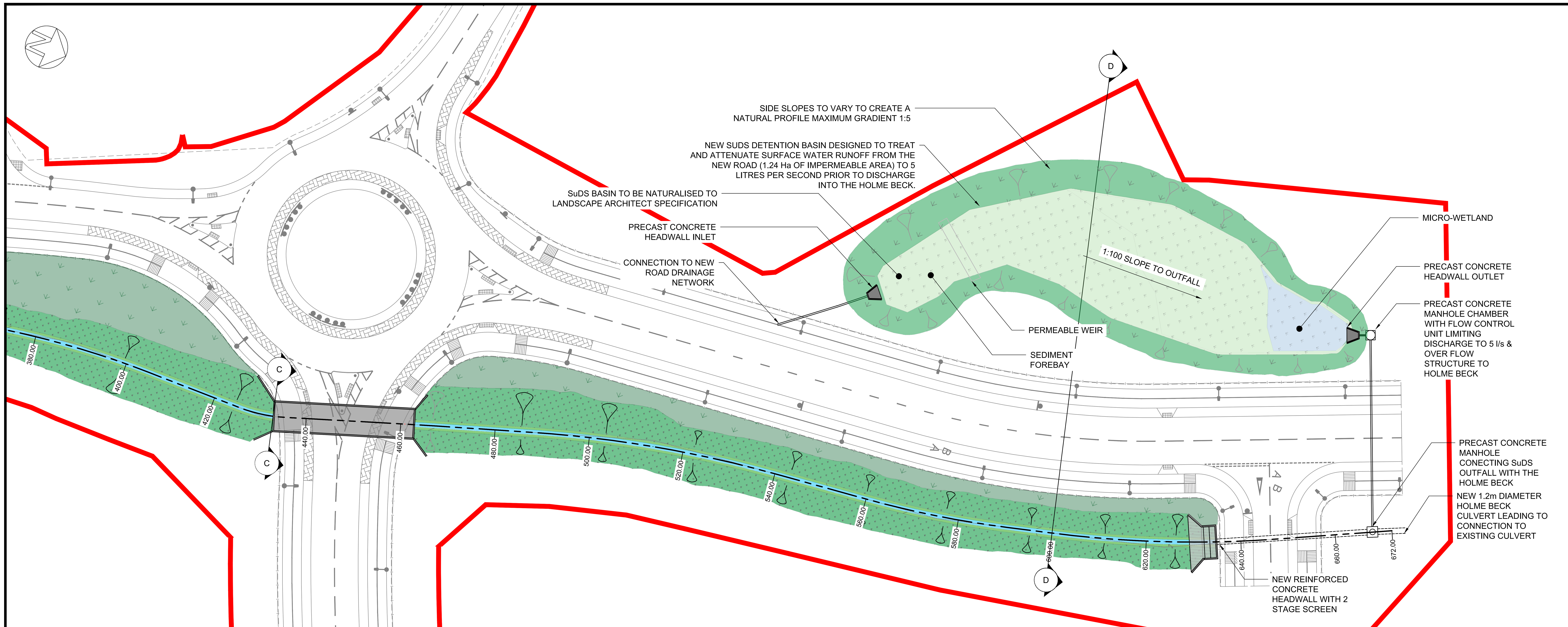
| No. | Construction Risk | Maintenance Risk | Demolition Risk |
|---|---|---|---|
| 1 | | | |
| 2 | | | |

In addition to the hazards/risks normally associated with the types of work detailed on this drawing take note of the above.

## SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION BOX

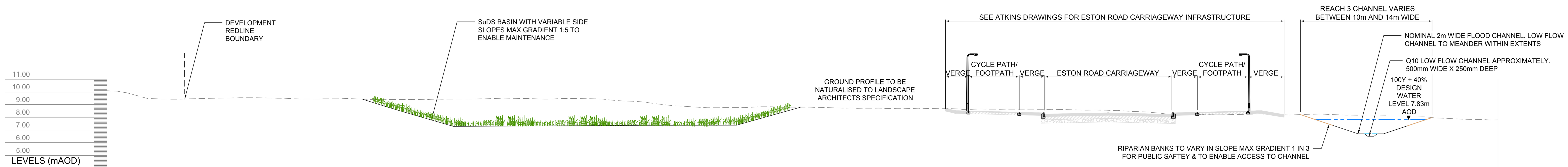
General Notes

A. All dimensions shown are in metres unless otherwise stated and levels in metres to Ordnance Datum.
B. Do not scale from this drawing. All dimensions must be checked/verified on site.
C. This drawing is to be read in conjunction with;
DLX-JBAU-00-00-DR-C-0001
DLX-JBAU-00-00-DR-C-0002
DLX-JBAU-00-00-DR-C-0003
DLX-JBAU-00-00-DR-C-0004
DLX-JBAU-00-00-DR-C-0005
D. Refer to Flood Risk Assessment and Design Justification report DXL-JBAU-00-00-C-RP-0001 for hydraulic calculations.
E. SuDS and new channel to be operated and maintained by STDC.




## HOLME BECK CHANNEL REACH 3 CH 463 - 672m

**SCALE 1:500**




| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| CHAINAGE (m) | 79.33 | 72.16 | 49.89 | 44.91 | 5.54 | 1.00 | 0.00 | 1.00 | 4.82 |
| EXISTING GROUND LEVEL (mAOD) | 9.43 | 9.57 | 8.76 | 8.69 | 8.21 | 8.16 | 8.18 | 8.17 | 7.97 |
| FINISHED GROUND LEVEL (mAOD) | 9.43 | 7.34 | 7.38 | 8.69 | 8.21 | 6.70 | 6.50 | 6.70 | 7.97 |

## TYPICAL SECTION D-D
## CH: 600.00

**SCALE 1:200**

LEGEND

- HIGH FLOW CHANNEL EXTENT (DESIGNED TO CONTAIN THE 1 IN 100 YEAR FLOW PLUS 40% ALLOWANCE FOR CLIMATE CHANGE)
- LOW FLOW CHANNEL EXTENT
- RENATURALISATION CORRIDOR
- SuDS BASIN INVERT
- SuDS BASIN CUT SLOPE
- LOW FLOW WETTED AREA
- CONCRETE STRUCTURE
- EXISTING GROUND LEVEL
- FINISHED GROUND LEVEL
- DEVELOPMENT BOUNDARY
- Q10 WATER LEVEL
- 1:100 YR + 40% CC WATER LEVEL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JBA consulting

Project
Eston Road Highway Works

Title
SuDS & River Restoration Proposal
Holme Beck
Plan & Section 3 of 3

for

Client
South Tees Development Corporation



| | | | | | |
|---|---|---|---|---|---|
| Drawn: | S Thomson | 20/05/2020 | Designed: | S Thomson | 20/05/2020 |
| Checked: | S Thomson | 20/05/2020 | Approved: | R Dobson | 21/05/2020 |
| Project Reference: | 2020s0655 | | Scale: | As Shown @ A1 | |

| Drawing Number: | Status: | Revision: | Sheet Size: |
|---|---|---|---|
| DLX-JBAU-00-00-DR-C-0004 | S3 | P01 | A1 |

# F Maintenance Schedule

# NOTE TO FILE

| | |
|---|---|
| JBA Project Code | 2020s0655 |
| Contract | Eston Road Highway Works |
| Client | South Tees Site Company |
| Day, Date and Time | 26 May 2020 |
| Author | Nadeia Tourigny |
| Reviewer / Sign-off | |
| Subject | Eston Road Highway Works - Maintenance Schedule |

## 1 Maintenance Schedule

The drainage strategy for the proposed Eston Road works includes a naturalised channel adjacent to Eston two culvert under the proposed roundabout and a proposed spur off Eston Road, a detention basin with an inlet and outlet in the north-east of the site and an outlet from the channel to the existing Holme Beck culvert to the north of the site.

Each drainage element should be regularly inspected and maintained to maintain the required design standard.

### 1.1 Channel

The channel is designed as a two-stage channel, allowing everyday flow from the Holme Beck to be conveyed within the lower part of the channel and exceedance flows to be conveyed in the upper part of the channel. The lower part of the channel has side slopes of 1 in 1 a base width of 0.5m and a depth of approximately 0.25m. There is a bench at the junction of the upper and lower parts of the channel as the upper part of the channel has a base width of 2m and side slopes of 1 in 3. Areas of wildlife enhancement are present within the site, adjacent to the channel. A fence is located to the eastern boundary of the site.

| Maintenance Activity | Description | Frequency (times/year) |
|---|---|---|
| Regular maintenance | | |
| Visual Inspection | Visual inspection of channel,<br>Report on requirement to remove debris from channel, channel vegetation state, pollution signs (eg. oil), areas of erosion or siltation, presence of vermin or invasive species, etc<br>Check if public safety measures are in place | 4 - 12 |
| Litter & Debris Removal | Removal of debris from channel and channel banks,<br>Environmental management (off-site disposal of removed debris) | 4 - 12 |
| Grass Cutting | Mowing of the second stage channel<br>Allow grass to grow to 100mm or to full height annually in the second stage channel<br>Allow vegetation around the channel to develop as a meadow and cut at suitable height September - November<br>Environmental management (off-site disposal of cleared vegetation) | 1 - 4 |
| Occasional tasks | | |

| | |
|---|---|
| JBA Project Code | 2020s0655 |
| Contract | Eston Road Highway Works |
| Client | South Tees Site Company |
| Day, Date and Time | 26 May 2020 |
| Author | Nadeia Tourigny |
| Reviewer / Sign-off | |
| Subject | Eston Road Highway Works - Maintenance Schedule |

| Maintenance Activity | Description | Frequency (times/year) |
|---|---|---|
| Weed and Invasive Plant Control | Removal of weeds and invasive plants<br>Environmental management (off-site disposal of cleared vegetation) | 0 - 1 |
| Vermin | Vermin control | 0 - 1 |
| Sediment Management | Desilting of channel | 0 - 1 |

### 1.2 Detention Basin

| Maintenance Activity | Description | Frequency (times/year) |
|---|---|---|
| Visual Inspection | Visual inspection of the basin,<br>Report on requirement to remove debris, vegetation state, pollution signs (eg. oil), areas of erosion or siltation, presence of vermin or invasive species, etc<br>Check basin inlet and outlet including flow control unit are free from obstructions<br>Check if public safety measures are in place | 4 - 12 |
| Grass Cutting | Mowing of the basin<br>Allow grass to grow to 100mm or to full height annually in the basin<br>Allow vegetation around the basin to develop as a meadow and cut at 100mm September - November<br>Environmental management (off-site disposal of cleared vegetation) | 1 - 2 |
| Weed and Invasive Plant Control | Occasionally remove pond vegetation, if it spreads across the pond by hand cleaning, raking or machine clearance using a 1-3 tonne tracked vehicle<br>Environmental management (off-site disposal of cleared vegetation) | 0 - 1 |
| Vermin | Vermin control | 0 - 1 |
| Litter & Debris Removal | Removal of debris from the basin and its banks, | 4 - 12 |

| Maintenance Activity | Description | Frequency (times/year) |
|---|---|---|
| | Environmental management (off-site disposal of removed debris) | |
| Sediment Management | Desilting of basin | 0 - 1 |

### 1.3 Culverts

| Maintenance Activity | Description | Frequency (times/year) |
|---|---|---|
| Visual Inspection | Visual inspection of culvert,<br>Report on any evidence of structural damage, requirement to remove debris from culverts and safety screens | 4 - 12 |
| Litter & Debris Removal | Removal of debris from culverts and safety screens,<br>Environmental management (off-site disposal of removed debris) | 4 - 12 |
| Sediment Management | Sediment removal within the culverts | 1 |

### 1.4 Outlet

| Maintenance Activity | Description | Frequency (times/year) |
|---|---|---|
| Visual Inspection | Visual inspection of outlet,<br>Report on any evidence of structural damage, requirement to remove debris from outlet and safety screens | 4 - 12 |
| Litter & Debris Removal | Removal of debris from from outlet and safety screens,<br>Environmental management (off-site disposal of removed debris) | 4 - 12 |
| Sediment Management | Sediment removal within the outlet, culverts and safety screens | 1 |

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