Englishcombe Lane, Bath

Sustainable Drainage Strategy

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Contacts

Bradley Allen
Graduate Civil Engineer

e bradley.allen@arcaids.com

Arcadis Consulting (UK) Limited

2 Glasswharf

Bristol

BS20FR

United Kingdom

Daniel Hadaway
Senior Civil Engineer

e daniel.hadaway@arcadis.com

Arcadis Consulting (UK) Limited

80 Fenchurch Street

London

ES3m 4BY

Sustainable Drainage Strategy

Author	Bradley Allen
Checker	Daniel Hadaway
Reviewer	-
Approver	Maddie Davies
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Contents

Tables

Figures

Appendices

Appendix A

Topographical Survey

Wessex Water Asset Records

Appendix B

Proposed Site Plan

Proposed Drainage Strategy

Proposed Catchment Plan

Overland Flows Plan

Standard Details

Appendix C

Soakaway Test Report

Soakaway Test Locations

Appendix D

Greenfield Runoff Rate Estimation

Hydrology Memo

Surface Water Microdrainage Calculations

Foul Drainage Calculations

Appendix E

SuDS Components Performance

Appendix F

Wessex Water Application

1 Introduction

1.1 Purpose of Report

1.1.1 This report has been prepared by Arcadis Consulting (UK) Ltd. (Arcadis) for Bath and North East Somerset Council (BANES). The purpose of this report is to set out a viable surface water and foul drainage strategy to support a proposed development on the land located to the south of Englishcombe Lane, Bath (herein referred to as the proposed site). The proposed development comprises 16 residential dwellings split into two ‘clusters. Cluster 1 located in the eastern portion of the site comprises of 9 dwellings and cluster 2, to the west of 7 dwellings. There is also the inclusion of two potential communal spaces and landscaping.

1.1.2 This Sustainable Drainage Strategy report forms part of the submission to the Local Authority in support of a Full Planning Application for the proposed development.

1.1.3 The following documents have been utilised to create site layouts and inform the drainage strategy.

1.2 Planning Layout Reference

1.2.1 This Sustainable Drainage Strategy is based on the Proposed Site Plan drawing prepared by Arcadis, numbered with drawing reference 30210292_ARC_XX_XX_M2_LA_0012, which has been submitted as part of this planning application and included within ***Appendix B.***

1.3 Topographical Survey Reference

1.3.1 Topographical Survey of the site was also used to inform the drainage strategy and has been provided by Solum Surveying Ltd. Their drawing number is 9975 This is included in ***Appendix A.***

2 Existing Site

2.1 Location

2.1.1 The proposed development site is on land to the South of Englishcombe Lane, Bloomfield, Bath, BA2 2EH as illustrated in ***Figure 2-1*** below. The majority of the exiting site is comprised mainly of greenfield space with an existing trench running from South to North through the centre of its extents.

2.1.2 The site is located approximately 1.8km to the South-west of Bath city centre. The approximate Ordnance Survey national grid reference for the centre of the site is 373531E, 163235N. The site is bounded by residential properties to the east, west, and north, and a woodland to the south.

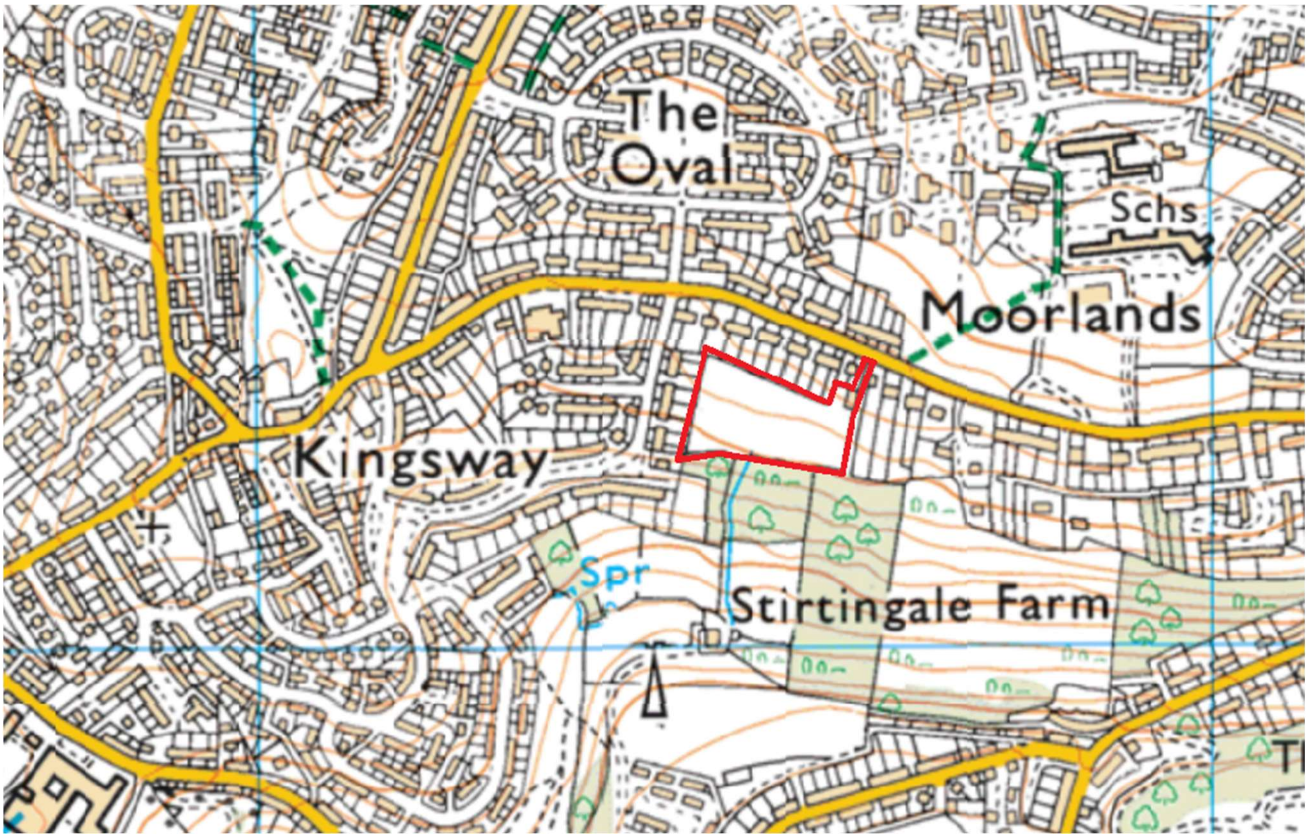

Figure 2-1 – Ordnance Survey Mapping Extract Showing Englishcombe Lane Site Location

2.2 Site Description

2.2.1 The current site make-up is as previously mentioned mainly greenfield space, with vegetation of a variety of grass and shrubs. The access to the development is in the North-east corner of the site off Englishcombe Lane.

2.3 Site Topography

2.3.1 From the topographical survey, contained in ***Appendix A*****,** the Englishcombe site undulates with Maximum levels at the Southern Boundary ranging from Approximately 97.00m to 100.00m AOD and reaching their minimum along the Northern Boundary with ground levels ranging from 90.00 to 92.00m AOD. The site forms part of a larger catchment that falls from approximately 168m AOD south of the site to the site boundary 100.00m AOD. North of the site, the existing properties and Englishcombe Lane to the sit at a lower level to the site.

2.4 Ground Conditions

2.4.1 From a review of the British Geological Survey (BGS) online Geological Viewer, the ground conditions comprise mainly of 'Fullers Earth Formation'-which is described as a *Silicate-mudstone, grey, bedded, variably calcareous, grading to lime-mudstone, fossiliferous, with units of thinly interbedded, more or less silici-muddy limestone*. To the North-east corner of the site there is an area of 'Inferior Oolite Group' - *Varied succession of bioclastic, peloidal, sandy, ferruginous, argillaceous, bioturbated limestones, with subordinate ooidal limestone, sandstone, limestone conglomerate, lime-mudstone and mudstone beds.* Within the BGS Geology viewer there is no information regarding superficial deposits within the site boundary. Extracts from the BGS mapping of bedrock shown below in ***Figure 2.2***.

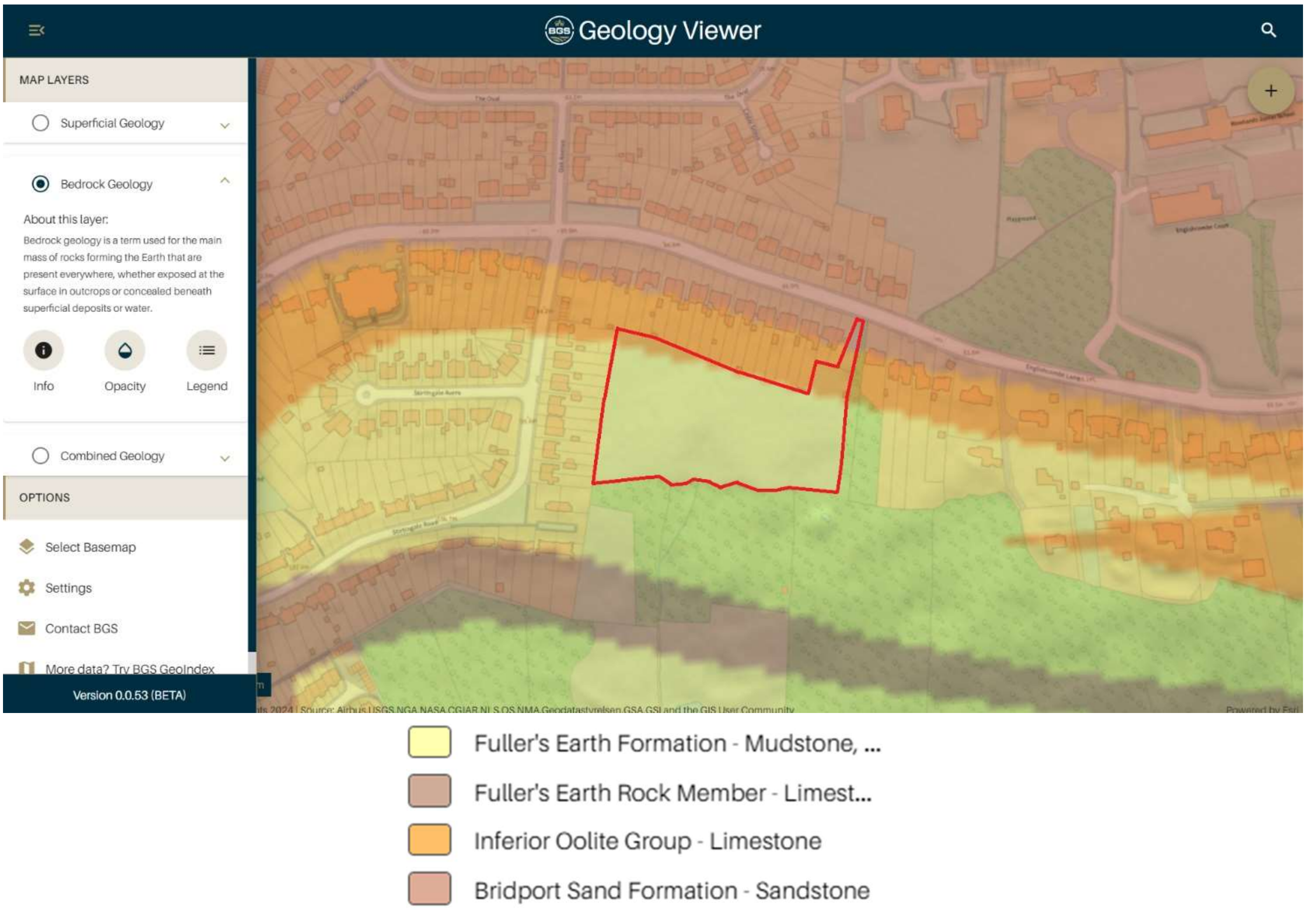

Figure 2-2 – British Geological Survey mapping (bedrock)

2.4.2 Although the presence of underlying clay may limit potential for infiltration, the presence of overlying sands and gravels may indicate some potential for the use of shallow infiltration features.

2.4.3 Sitewide Ground Investigations were carried out by CC Ground Investigation Limited (CCGI) under the instruction and supervision of Atkins between the dates 8th August to 6th September 2023. The extents of the ground investigations included 12 hand-dug trial pits (ATKTP01-TP12) to a maximum depth of 1.2m bgl or competent bedrock. There were also seven rotary boreholes (ATKBH01-BH07) drilling to depths of between 10.0 to 15.10m bgl. Within five of the seven rotary borehole locations Standpipes were installed. Ground investigation reported the following ground conditions:

Table 2-1 - Summary of Ground Conditions reported by 2023 CC Ground Investigation Limited

Soil Type	Depth Below Ground Level. (m)	Detailed Description
Topsoil	0.00 to 0.37	Soft dark brown loamy clay with frequent rootles
Fullers Earth Formation	0.15 to 3.30	Firm light greyish gravelly sandy clay. Sand is fine to medium. Gravel is fine to coarse sub-angular limestone.
Weathered Inferior Oolite Group	1.20 to 15.10	Light creamish brown limestone. Distinctly weathered to partially weathered. Medium to wide fractured.

2.4.4 As mentioned, the Boreholes extended to a depth of between 10 to 15.10m bgl. There was no encounter of groundwater or groundwater seepage encountered within the ground investigation works.

2.4.5 Five in-situ soakaway tests were undertaken in 2023 within two trial pits at a shallow depth of 0.8m (ATKSA1-SA2). The infiltration rates reported were between the values of 7.94×10^{-6} to 5.65×10^{-5}m/s. The results of the soakaway testing are summarised in ***Table 2.2*** below.

Table 2-2 – Atkins Soakaway Test results

Exploratory Hole	Test Number	Material	Soil Infiltration Rate (m/s)	Permeability
ATKSA1	1	Fullers Earth Formation	5.65×10^{-5}	Moderate Permeability
	2		2.78×10^{-5}	Moderate Permeability

	3		$2.78x10^{-5}$	Moderate Permeability
ATKSA2	1		$7.94x10^{-6}$	Moderate Permeability
	2		Unable to calculate due to insufficient drop in water level	Negligible Permeability

2.4.6 The soakaway tests undertaken within the Fullers Earth Formation indicate moderate permeability soils. As can be seen above one of the tests within trial pit ATKSA2 indicated negligible permeability. The GI report provided by Atkins states that 'The permeability results indicate that depending on the location, the proposed soakaway infiltration drainage may be practicable, although infiltration rates are only moderate and therefore the required size of soakaways may make infiltration drainage impractical.'

2.4.7 Intégrale conducted a number of soil infiltration tests on 15th June 2017 around the site ranging between depths 1.6 to 3.5m. The results can be found within the 'Geotechnical and Phase 2 Contamination Report section 5 Appendix G'. The summary of the infiltration rates and their respective hole reference are shown in ***Table 2.3*** below.

Table 2-3 – Integrale soil permeability test results

Exploratory Hole	Test Number	Test Depth (m)	Soil Infiltration Rate (m/s)
A	-	2.0	$1.48x10^{-3}$
B	-	2.4	$1.40x10^{-3}$
C	1	1.6	$6.07x10^{-3}$
	2	1.7	$4.1x10^{-4}$
	3	1.8	$2.48x10^{-4}$
F	-	3.5	$2.36x10^{-4}$
K	-	2.4	$4.38x10^{-4}$
N	-	2.8	$1.42x10^{-4}$

2.4.8 The results shown yield a far greater infiltration rate than the testing conducted by CC Ground Investigation on behalf of Atkins, this potentially due to the increased depth in which the infiltration testing was conducted, which extended into the underlying limestone. Therefore, there is potential for Soakaway SuDS features through the site, albeit these features would need to be provided at a depth where the infiltration rates are greater. A summary displaying the Hole references and their respective location within the site can be found within ***Appendix C.***

2.4.9 The Geology Mapping indicates the lower parts of the Englishcombe Lane site is underlain by Infeior Oolite over Midford Sand. The geological legend suggests these units are 14m and 12-20m thick, respectively. Both of these units are anticipated to be permeable. Below these permeable units, the Lower Lias Clay is present at depth; this is anticipated to be relatively impermeable. The contact between the Midford Sand and Lower Lias Clay ‘daylights’ in the slope >400m downslope to the north, at an elevation of ~50m AOD. Englishcombe Lane is at ~90m AOD.

2.4.10 At the contact between permeable and impermeable strata, springs often develop at ground surface. The Groundsure report included within Atkins’ desk study does not highlight any surface water feature within 500m downslope (north) of Englishcombe Lane. Ordnance Survey mapping shows a stream appearing at ~45m AOD, 500m north.

2.4.11 Therefore, it is considered that introduction of soakaway drainage into the Inferior Oolite (fractured limestone) within the proposed development is unlikely to cause a surface water flooding nuisance to residents on the downslope (northern) side of Englishcombe Lane.

2.5 Existing Watercourses

2.5.1 The topographical survey shows that the site generally falls from the south to north. There is an existing watercourse which crosses the site from South to North. These routes can be seen (in blue) on the above plan.

2.5.2 This existing watercourse conveys flows from natural springs located to the South of the site. The watercourse currently drains towards an existing 150mm diameter surface water sewer on the northern boundary. This can be seen on the Wessex Water Asset Plans ***Appendix A*** which shows the pipe exiting the site between plot 107 and 109 where it then crosses Englishcombe Lane and heads towards the northeast.

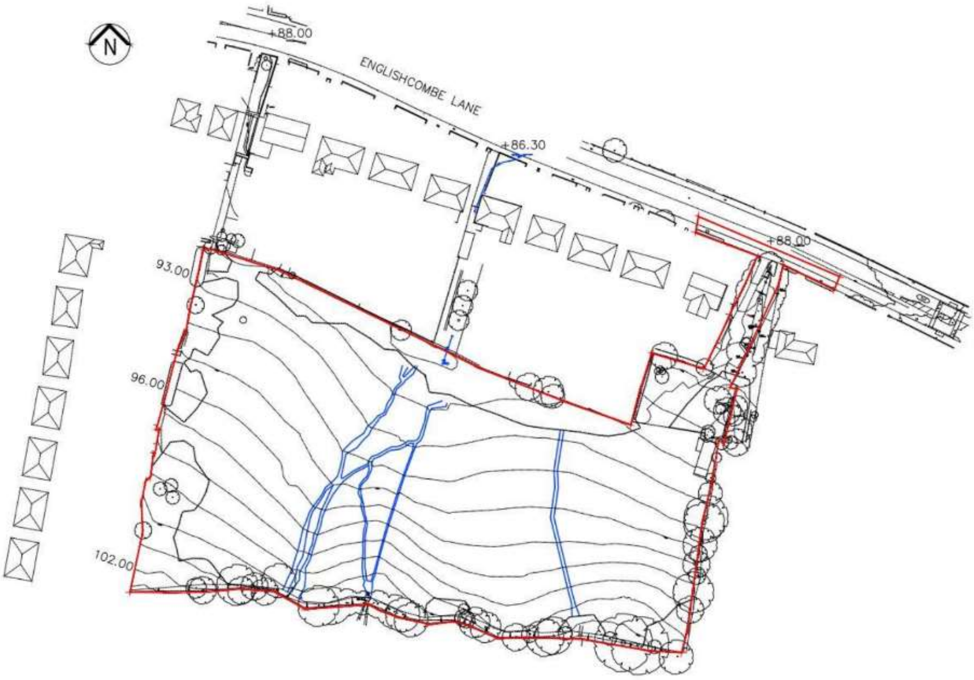

Figure 2-3 – Existing Watercourse Map

2.5.3 Historical map data provided by BANES Council indicates that there is a gulley on the northern and southern boundary of the site, these however have not been identified during site surveys. An extract of the mapping is below for reference.

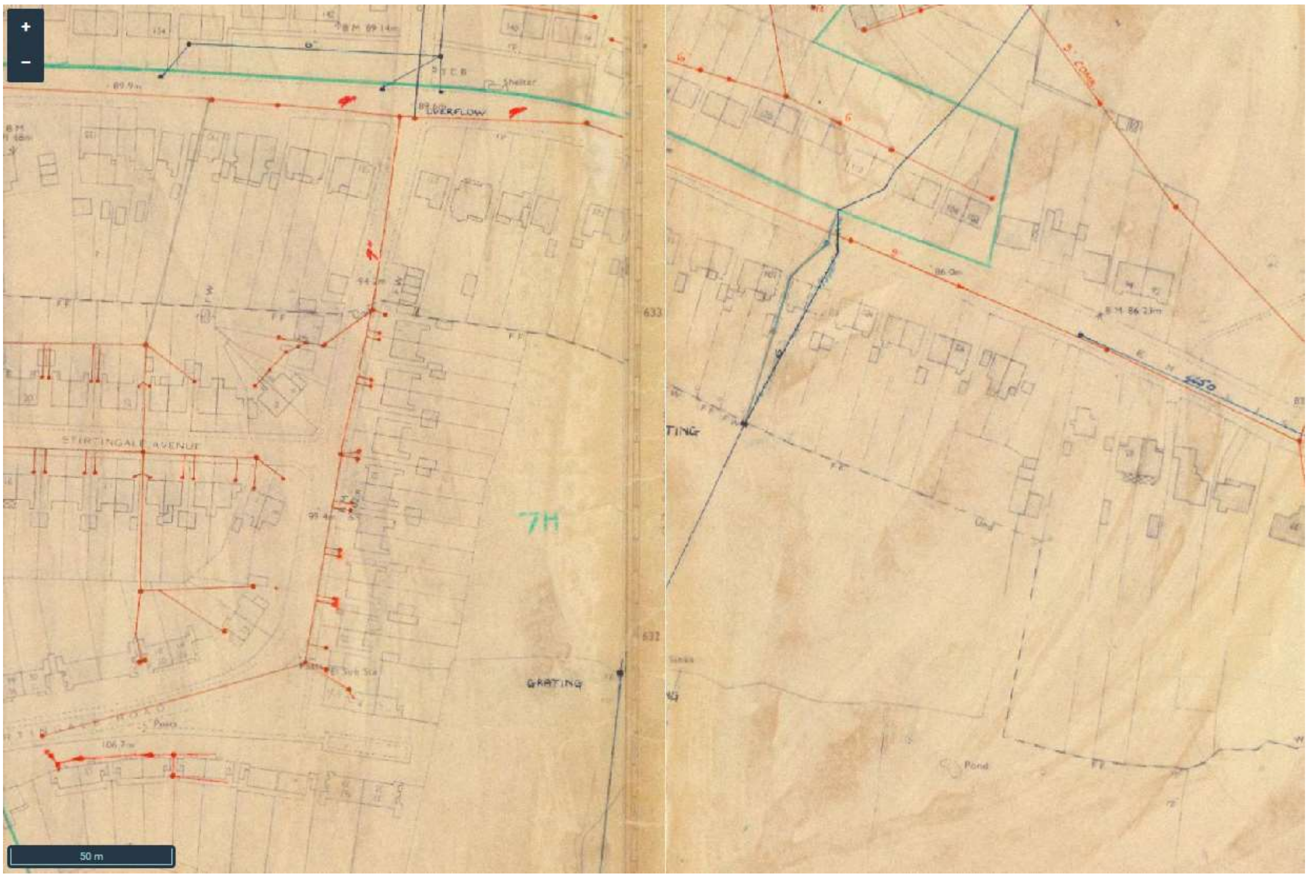

Figure 2-4: Historically drainage mapping provided by BANES Council.

2.6 Existing Sewers

2.6.1 Within Englishcombe Lane there is an existing 450mm surface water sewer and 225mm foul water sewer which fall east down Englishcombe Lane.

2.6.2 The foul and the surface water sewers described above are shown on the Wessex Water plans in **Appendix *A***.

2.7 Existing Site Runoff

2.7.1 As described in ***Section 2.2***, the site mainly consists of grassed areas, any surface water runoff from the site therefore appears to run overland towards the watercourse running down the centre of the site and northwards towards existing properties.

2.8 Existing Flood Risk

2.8.1 Arcadis have completed a Flood Risk Assessment (30210292-AUK-XX-XX-RP-CW-0001-03) which determined that the site has a low flood risk and sits within Flood Zone 1, and in accordance with the NPPF, the site is considered to be appropriate, on flood risk grounds, for the type of development proposed.

2.8.2 The EA Flood Map for Planning (Rivers and Sea) shows the site is located in Flood Zone 1, equivalent to an annual chance of flooding less than 1 in 1,000 (0.1%).

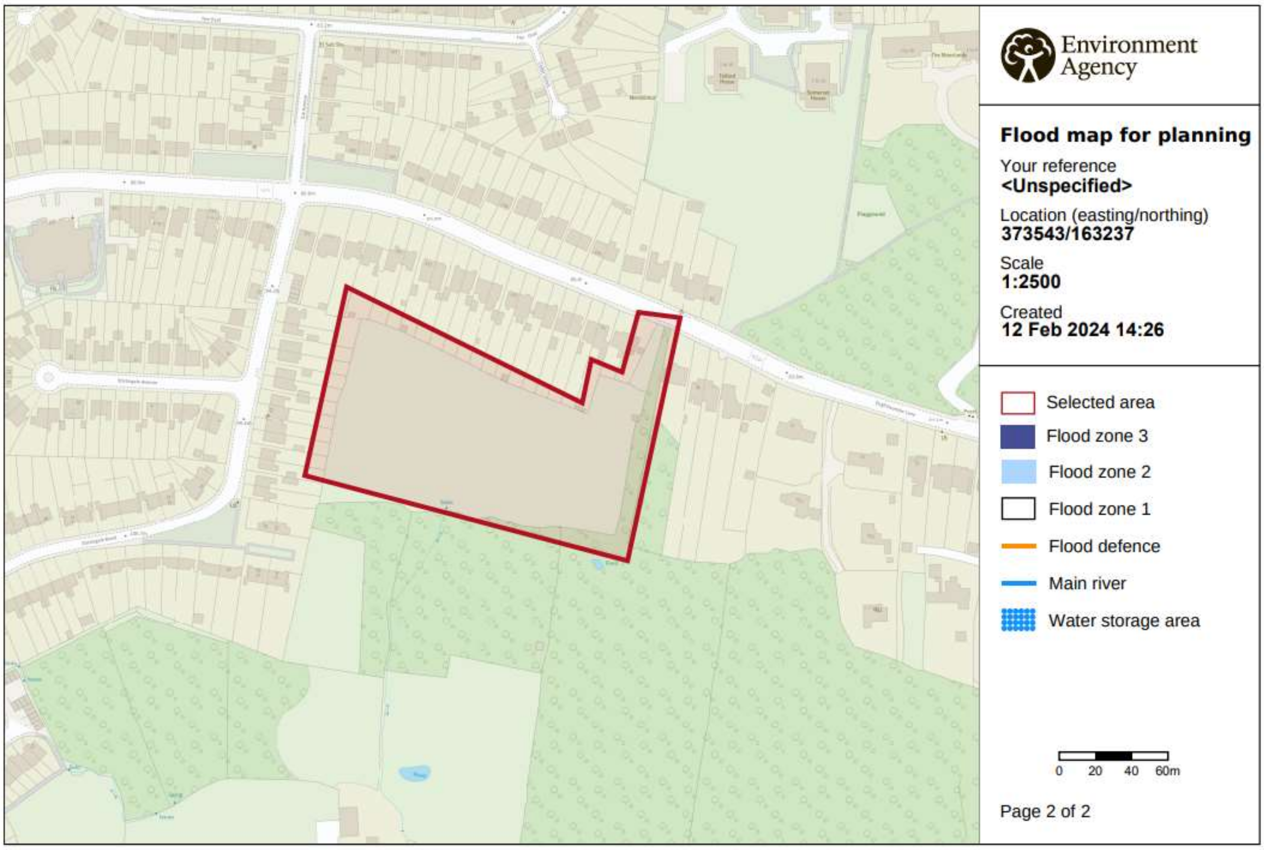

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Figure 2-5 - EA Flood map for planning.

3 Proposed Development

3.1.1 The development proposals include erection of 16 no. supported living units (Use Class C3(b)) with associated communal hub (to include ancillary carers' accommodation), access, landscaping and ancillary works' at Land To The Rear Of 89 To 123 Englishcombe Lane, Southdown, Bath, Bath And North East Somerset.

Figure 3-1 – Extract of Proposed Site Plan

3.1.2 The existing and proposed impermeable and permeable areas are shown in the table below:

Table 3-1 – Existing and proposed permeable and impermeable areas

		Permeable area	Impermeable area
Existing	Site Area	1.420-ha	-
	Total (1.42)	**1.420ha**	**0ha**
Proposed	Pedestrian Access	-	0.2574ha
	Roofs	-	0.1777ha
	Main Access Road	-	0.0531ha
	Clubhouse	-	0.008ha
	M&E and Bins	-	0.006ha
	Vehicular Access	0.0573ha	-
	Parking Bays	0.0201ha	-
	Proposed Bridge	0.0047ha	-
	Permeable Walkway	0.0095ha	
	Green Space	0.8262ha	-
	Total (1.42)	**0.9226**	**0.5022ha**

4 Planning Policy Requirements

4.1 NPPF & Local Planning Policy

4.1.1 The NPPF was first published on the 27th March 2012 and most recently updated on 19th December 2023. This sets out the governments planning policies for England and how these are expected to be applied. Along with its accompanying Planning Practice Guidance (PPG)[1], the NPPF sets out the government's planning policies for England and how these are expected to be applied. The principal aim of the NPPF is to achieve sustainable development. This includes ensuring that flood risk is taken into account at all stages of the planning process, avoiding inappropriate development in areas at risk of flooding and directing development away from those areas where risks are highest. Where development is necessary in areas of flooding, the NPPF aims to ensure that it is safe, without increasing flood risk elsewhere.

4.1.2 Early adoption of, and adherence to, the principles set out in the NPPF and its Technical Guidance, with respect to flood risk, should ensure that detailed designs and plans for developments take due account of flood risk and the need for appropriate mitigation, if required.

4.1.3 The NPPF specifies that surface water arising from a developed site should, as far as is practicable, be managed in a sustainable manner to mimic the surface water flows arising from the site prior to the proposed development. Opportunities to reduce the flood risk to the site itself and elsewhere, taking climate change into account, should be investigated.

4.2 Bath and North East Somerset Council Sustainable Drainage Guide

4.2.1 Bath and North East Somerset Council, as the Lead Local Flood Authority (LLFA), produced a document titled "West of England Sustainable Drainage Developer Guide" in March 2015. The document sets out the LLFA's local requirements for the design of surface water drainage, including the requirements for incorporating Sustainable Drainage Systems (SuDS). The document sets out a hierarchy by which surface water runoff not collected for re-use should be discharged, listed in the following order of priority:

- Discharge into the ground (infiltration)
- Discharge to a surface water body or watercourse
- Discharge to a surface water sewer, highway drain, or another drainage system
- Discharge to a combined sewer.

[1] Department for Levelling Up, Housing and Communities & Ministry of Housing, Communities and Local Government, 2022. Planning Practice Guidance. https://www.gov.uk/government/collections/planning-practice-guidance

5 General Drainage Design Principles

5.1 Design Guidance

5.1.1 The following design guidance will be adhered to for the proposed foul and surface water drainage system serving the proposed site.

- Building Regulations Part H
- National Planning Policy Framework (NPPF) & accompanying Planning Practice Guidance
- Sewer Sector Guidance (for adopted connections)
- BS EN 752:2008 Drainage & Sewer Systems Outside Buildings
- BS EN 12056:200 Gravity Drainage Inside Buildings
- SuDS Manual, CIRIA C753.
- West of England Sustainable Drainage Developer Guide

5.2 Climate Change

5.2.1 The NPPF and Sewers for Adoption require that surface water drainage systems provided for the new development site should be designed to retain all runoff for events up to the 1 in 100-year rainfall event, with an appropriate allowance for climate change. This is to prevent downstream flooding. An allowance of 45% has been made for climate change, acknowledging the lifespan of the development and the government guidance for climate change allowance sensitivity testing has been undertaken and there is appropriate space to accommodate this.

5.3 SuDS Treatment Train

5.3.1 SuDS are water sensitive drainage systems which mimic natural catchment processes to manage urban runoff. A 'treatment train' of various SuDS is required to capture, detain, convey and discharge water from an urban environment. The treatment train concept is fundamental to designing a successful SuDS strategy.

5.3.2 The treatment train philosophy uses drainage techniques to systematically control the three elements of runoff. A 'treatment train' of various SuDS is required to capture, detain, convey and discharge water form an urban environment. The treatment train concept is fundamental to designing a successful SuDS strategy.

5.3.3 The treatment train philosophy uses drainage techniques to systematically control the three elements of runoff: pollution, flow rates and volumes. This is achieved in three main steps: Source Control, Conveyance Control and Discharge Control (see ***Figure 5.1*** below). Source control is preferred to those further down the train as they lead to the retention of pollutants and control of water before it enters the proposed or existing drainage network or watercourse. All of the methods suggested are recommended controls considered for SuDS and will be utilised where practical.

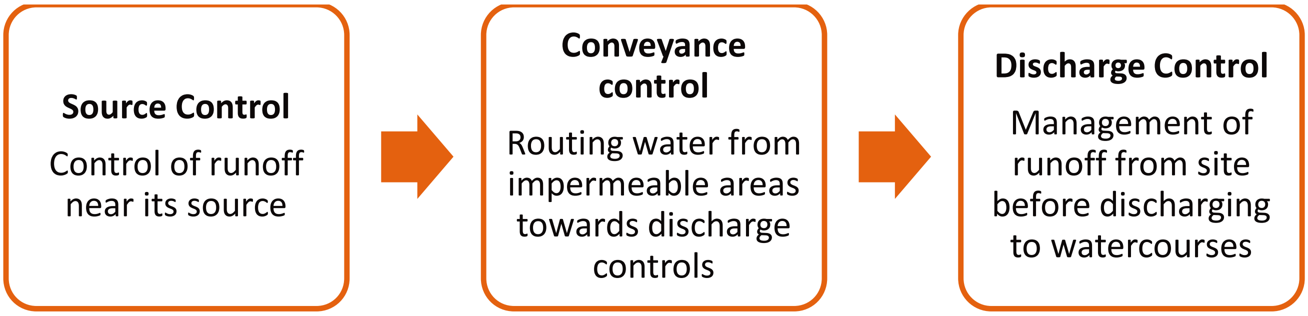


Figure 5-1 – SuDS Treatment Train

5.3.4 Individual SuDS components are not treated in isolation but work together as a suite of drainage features. The SuDS components integrated into the proposed drainage system will reflect the desirability to have a mix of SuDS components across the site, as different components have different capacities for treatment of individual pollutants.

6 Surface Water Drainage Strategy

6.1.1 The design of a surface water drainage system to serve the proposed development on Englishcombe Lane has been designed in accordance with the SuDS Manual (CIRIA C753). The proposed SuDS components aim to emulate the natural drainage of the site as closely as is practicably achievable.

6.2 Greenfield Runoff Rates

6.2.1 Both national and local planning policies state that for any development, peak rates of discharge to either a watercourse or a sewer should be restricted to as close as is reasonably practicable to the equivalent greenfield rates of runoff from the site especially if the existing site is a greenfield site.

6.2.2 Greenfield runoff rates for the site have been calculated using FEH data and the Wallingford Calculator greenfield runoff tool. Based on the location of the site and soil type, the Q_{MED} was calculated as 12.4l/s. This value was then multiplied by the Q_{BAR} to Q_{MED} conversion factor to achieve a Q_{BAR} (commonly known as mean annual peak flow rate) value of 13.3 l/s summarised in the table below:

Table 6-1 - Greenfield Runoff Rates

Flow Rate	Greenfield runoff rate (l/s) – 1.42ha site
Q_{MED}	12.4
Q_{BAR}	13.3

6.3 Proposed Surface Water Discharge Strategy

6.3.1 In accordance with the Hierarchy as set out within Bath and North East Somerset Council's "Local Standards and Guidance for Surface Water Drainage on Major Developments" document, surface water runoff not collected for re-use should be discharged in the following order of priority:

- Discharge into the ground (infiltration)
- Discharge to a surface water body or watercourse
- Discharge to a surface water sewer, highway drain, or another drainage system
- Discharge to a combined sewer.

6.3.2 A review has been undertaken of the suitability of various SuDS systems for the site conditions. Space constraints on the site, in particular open water features such as ponds and swales.

6.3.3 As noted in **Section 2.3**, ground investigations have indicated that the use of infiltration SuDS features are viable. Following the discharge hierarchy, it is therefore proposed that surface water runoff from the proposed development will be infiltrated to the ground.

6.3.4 The soluble ground strata requires the side of soakaways to be to be lined with discharge via infiltration through the base only.

6.4 Proposed Drainage & Infiltration Rates

6.4.1 Surface water runoff from a greenfield site is generally expected to be attenuated for all storm events up to and including the 1 in 100-year return period storm events, with a 45% allowance for climate change (see **Section 4**). This is to meet the policy requirement to mitigate and limit the increase in the overall volume of runoff from developments.

6.4.2 For the site, the existing greenfield runoff rates have been calculated. It is proposed that for all storm events up to and including the 1:100-year + CC event will be limited to Qbar at 13.3l/s (see table below).

Table 6-2 - Proposed Discharge Rates

Return Period Storm Event (n)	Greenfield Runoff Rate (l/s)	Proposed Discharge Rate (l/s)
1	10.4	13.3
30	25.99	13.3
100	32.39	13.3
100 + 45% CC	-	13.3

6.4.3 With proposed discharge rates for all storm events up to and including the 1 in 100-year return period storm events (with a 45% allowance for climate change) proposed to be controlled to a maximum of Qbar of 13.3l/s, the proposed development will mitigate the overall increase in discharge volumes compared to the greenfield scenario, in line with national and local policy requirements.

6.4.4 The result from the closest soakaway test available has been applied in the drainage design as outlined in ***section 2.4***,

6.4.5 As such the infiltration rates taken from the Intégrale tests in TPA 5.328m/hr and TPB 5.04m/hr have been applied to determined attenuation volumes and appropriate depths for infiltration features.

6.4.6 An additional sensitivity test has been completed for the proposed private drainage using the most conservative infiltration rate calculated for the Atkins soakaways test ATKSA02 0.0286m/hr.

6.5 Proposed Surface Water Drainage Strategy

6.5.1 The drainage system has been designed to mimic a greenfield situation as closely as practicably possible given the space constraints. A SuDS Treatment Train approach has been applied, following best practice for new impermeable areas through utilising.

- green roofs,
- rain gardens,
- permeable paving to capture overland flows.
- infiltration with attenuation

6.5.2 The existing above site overland flows will be intercepted by;

- filter drains
- the existing central channel
- Historical mapping indicated existing gulleys and pipe network, these are to be located and cleared out, although not included in calculations these will capture overland flows and provide betterment subject to existing condition.
- Infiltration blanket at base of central channel
- the permeable vehicle access connection from cluster 1 to cluster 2.
- a small bund is proposed on the north boundary to deflect any surface water overland flows as a further impediment to overland flows entering gardens to the north, retaining these on site where possible and improving on the existing situation .

6.5.3 Further detail on these treatment trains is provided below.

On-site Surface water strategy

6.5.4 For the purposed of the surface water modelling there have been two separate hydraulic models produced. The first, utilising infiltration rates which are found within the closest vicinity and elevation of each soakaway and the second using the lowest infiltration rates encountered across the development. This resulted in a difference in attenuation requirements for SuDS features between each. In sizing the SuDS features to for on-site surface water, the lower infiltration values have been used, however there is also a printout with the modelling results for the higher infiltration rates contained within ***Appendix D.***

6.5.5 As mentioned within ***Section 3*** there is the introduction of multiple impermeable areas. The development itself has been split into separate networks, to best use elevations and deal with Surface Water runoff without interrupting the natural forms and aesthetics of the site.

6.5.6 Geocellular crates to the Northwest of the vehicle access route are proposed to attenuate and discharge Surface Water falling upon the roof areas, bin storage and pedestrian access within cluster 2. The surface water attenuation requirements for the geocellular crates is 346m^3 with infiltration rate 7.94x10^{-6} (ATKSA02) which is provided by 173m^2 of geocellular crates which are 2m deep.

6.5.7 The geocellular crates to attenuate the Surface Water falling upon cluster 1 are beneath the Parking area and occupy the entire footprint of this space. Similar to the crates for cluster 2 these are to attenuate surface water falling upon the roof areas, bin storage and pedestrian access of the cluster. However, in this case there is the introduction of the main access road. The Surface Water attenuation required is 380.8m^3 with infiltration rate 7.94x10^{-6} (ATKSA02) and is provided by crated storage with area 238.0m^2 and depth 1.6m Due to the natural elevation of the site the crates are only to take the surface water falling upon the area of access from the south to the space adjacent. The additional areas of the main site access north of the crated storage will be unable to discharge to the crates via gravity. Therefore, this space is to discharge north to either a soakaway or positively drain to the Wessex Water sewer located within Englishcombe Lane, infiltration is subject to space and tree constraints, alternatively Wessex Water have indicated their system has capacity available.

6.5.8 A printout of the High and Low infiltration rate microdrainage results can be found within **Appendix D.** A safety factor of 5 has been applied to the low infiltration rates inline with LLFA consultation comments.

6.5.9 The space requirements shown on the drainage strategy drawing for both geocellular storage structures are the worst-case scenarios and may be value engineered subject to further review.

6.5.10 It is proposed that the Southernmost plots of each will be built into the embankment and retaining features will be utilised to stabilise the mud slides, filter trenches will be required upslope behind these retaining features to capture overland surface water runoff from the catchment above the proposed development and positively managed and routed away from the proposed development, towards the central drainage channel to mimic existing overland flow routing across the site.

6.5.11 The vehicular access across the development has been proposed as a permeable, where Surface Water falling upon it will simply infiltrate through the surface into the ground, this can also act as an overflow for excess overland flows running within the central channel of the site.

6.5.12 Across the site there is potential for the inclusion of water butts and greenroofs to accept water falling across the site, which overall will increase the time for Surface Water to enter the system, details of both are to be confirmed.

Above site drainage Strategy

6.5.13 Surface water falling upon the catchment area south of the site as shown in ***Figure 6-1*** currently routes though the site and towards a low point where an existing 150mm diameter pipe is located at the southern edge of the site. Therefore, care has been taken to ensure the existing discharge arrangement is followed as closely as possible while providing a betterment. Hydrographs and a hydrology technical note '30210292-AUK-XX-XX-RP-CW-0002-01' **Appendix D** were prepared to aid the quantification of upstream runoff and how this could be managed within the site.

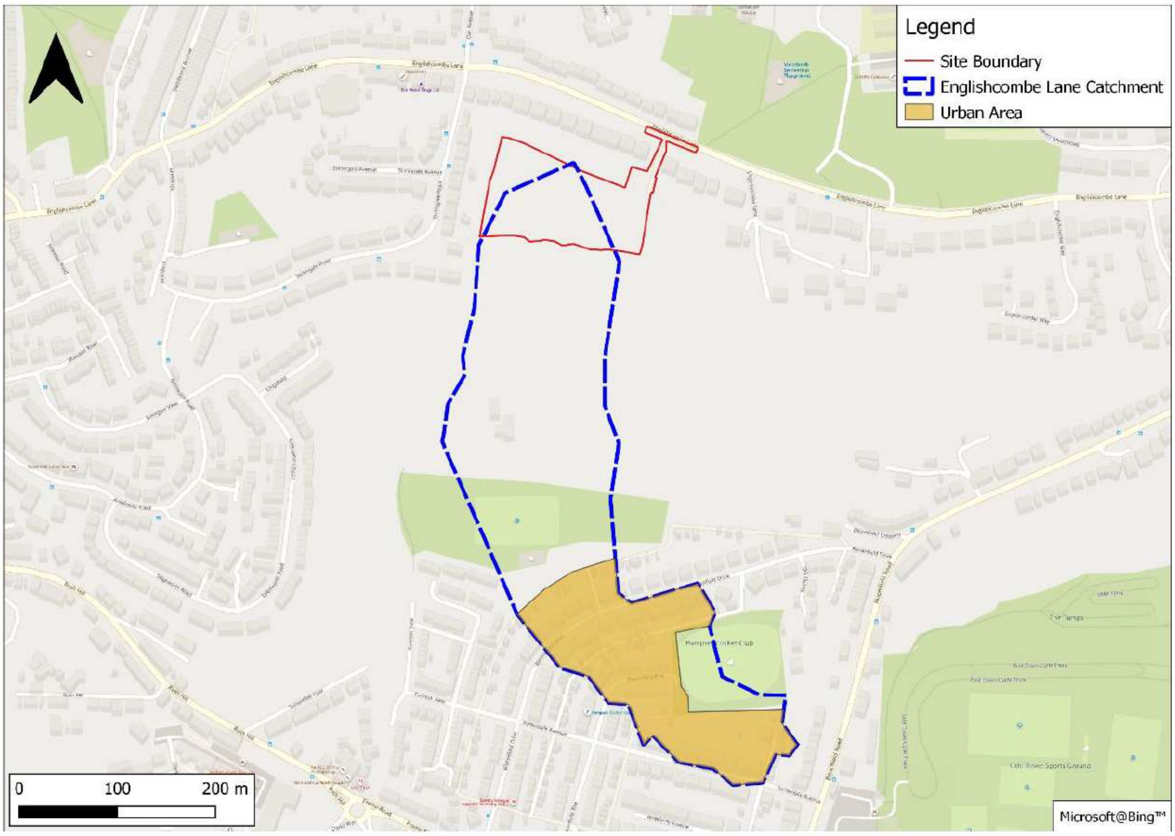


Figure 6-1: Catchment Overview

6.5.14 The flows from the existing catchment follow the existing ground low points through the site to the southern boundary. The overland flow routing corridor has been retained within the development proposals as a central channel that is not proposed for development, with capacity to convey upstream overland flows in extreme rainfall events.

6.5.15 Microdrainage's cascade module has been utilised in the design of SuDS features attenuating and discharging surface water falling within the external catchment. Printouts of the cascade results for these features can be found within **Appendix D** of this report.

6.5.16 On the northern boundary of the site, where overland flows may sometimes runoff into existing gardens, it is proposed to raise the elevation of the access road to create a batter slope suitable for retaining overland flows within a dished area such that infiltration into a $40m^2$ x 2.4m infiltration blanket can take place. This will be designed to connect the surface to the more permeable geology below, to allow for higher infiltration rates of $1.40x10^{-3}m/s$ (Integral Trial Pit B). This feature will be designed to attenuate and discharge rainfall events up to and including a 1 in 1 year storm.

6.5.17 Events exceeding the 1 in 1 year storm are proposed, would exceed the capacity of the infiltration blanket, and therefore it is proposed that a 450mm diameter overflow (1.85m above the base of the blanket) . into further geocellular storage is provided.

6.5.18 This geocellular storage with dimensions $236m^2$ x 2.4m and infiltration rate $1.40x10^{-3}m/s$ (Integral Trial Pit B), has been designed to have sufficient storage to attenuate the 1 in 100-year rainfall event (including an allowance for 45% Climate change) with a safety factor of 5 applied. Similar to the infiltration blanket the crates storage is designed to access the more permeable material found within the previous infiltration testing conducted by integral.

6.5.19 The geocellular crates may be prone to calcification due to the mineral content of the water discharging into the site. Due to the incorporation of the infiltration banket these crates will not be used regularly, reducing the potential mineral buildup within the crated storage and further maintenance requirements.

6.5.20 An additional overflow pipe from the crated storage has been included as a final measure for preventing flows overtopping in more extreme events into existing gardens. This pipe would be a new connection to the Wessex Water sewer, removing the existing 150mm connection within gardens to the north of the site that currently conveys overland flow routing in all rainfall events. The discharge through the pipe would be only in extreme events over and above the designed capacity of the system proposed.

6.5.21 In summary the proposed SuDS strategy has incorporated:

- Each dwelling and community hub are to incorporate green roofing in construction. It is understood these features will increase the time for the surface water from falling on these areas to entering the proposed drainage system, reducing the total attenuation required. However, for the purpose of design, this increase in time has not been included within drainage calculations.
- The use of small-scale rain gardens in the landscaped areas in front of the residential. The storage achievable in these features will likely be minimal and has discounted from any further assessment regarding attenuation.
- Surface water falling on southern green areas (i.e not being developed) is to be directed to the central drainage channel via land drains to discharge as existing.
- Attenuation will be provided in both Geocellular attenuation tanks.

- Excess overland flows from upstream within the central low point of the site will infiltrate through the infiltration blanket upstream of the vehicular access and further attenuation provided within geocellular storage for more extreme rainfall event and a high level overflow proposed to the Wessex Water network (Replacing the exiting 150mm diameter pipe).
- Surface water runoff from the main access, north of the parking, is to be positively drained northwards towards Englishcombe Lane and discharged either by soakaway (subject to root protection requirements) or positively drained to the existing public surface water sewer.

6.5.22 The proposed Drainage Strategy layout utilising SuDS techniques is included in **Appendix B**. A summary of each of the proposed SuDS techniques is shown in ***Figure 6-1*** on the following pages, with more detail regarding the performance of each treatment device contained within **Appendix E**.

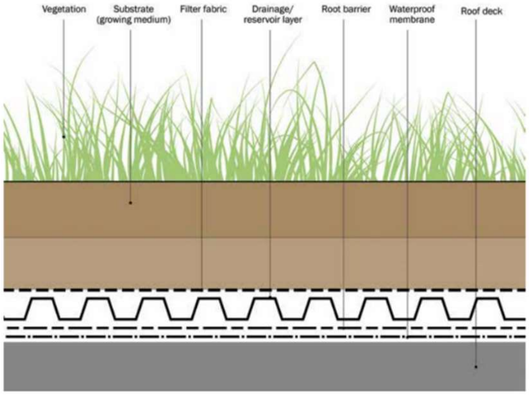
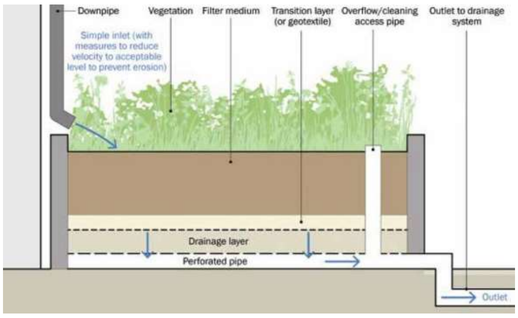
Item	Description
GREEN ROOFS  Image Ref: CIRIA Report C753 – The SuDS Manual v6	Green roofs are areas of living vegetation, installed on the top of buildings for a range of reasons, including visual benefit, ecological value, enhanced building performance and the reduction of surface water runoff.
RAIN GARDENS / RAISED PLANTERS  Image Ref: CIRIA Report C753 – The SuDS Manual v6	Rain gardens are a type of bio-retention system, that typically comprise either shallow landscaped depressions or raised planters. Runoff conveyed to such systems temporarily ponds on the surface, and then filters through the vegetation and underlying soils, with excess water infiltrating to ground or discharging to a wider site drainage system. Volumes of attenuation provided are typically small, and so are often not considered in attenuation calculations. Location and use on site: Incorporated into the landscaping of the front gardens of each residential dwelling.
GEO-CELLULAR ATTENUATION TANKS	Attenuation tanks are used to create a below-ground void space for the temporary storage of surface water prior to infiltration, controlled release, or use. Different forms of storage structure are available, but the most common solution comprises the use of geo-cellular crates, modular plastic units with a

Image Ref: CIRIA Report C753 – The SuDS Manual v6

high porosity (typically 95%). A tank is formed by assembling the required number of individual units (sometimes in several layers) and wrapping them in a geomembrane.

Location and use on site: Geo-cellular tanks proposed within the rear gardens of several residential dwellings towards the centre of the site.

PERMEABLE PAVING

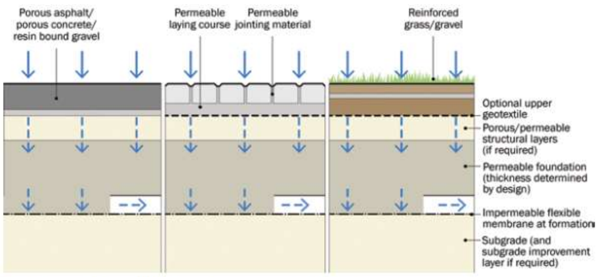


Figure 20.14 Pervious pavement system types: Type C – no infiltration

Image Ref: CIRIA Report C753 – The SuDS Manual v6

Pervious pavements provide a pavement suitable for pedestrian and/or vehicular traffic, while allowing rainwater to infiltrate through the surface and into the underlying structural layers. The water is temporarily stored beneath the overlying surface, before use, infiltration to the ground or controlled discharge downstream. Permeable paving is one of two types of pervious pavement, where the surface is formed of a material that itself is impervious to water. The materials are laid to provide void space through the surface to the sub-base.

Location and use on site: Permeable paving is proposed on the proposed access road and on the multi-use games area.

VORTEX FLOW CONTROLS

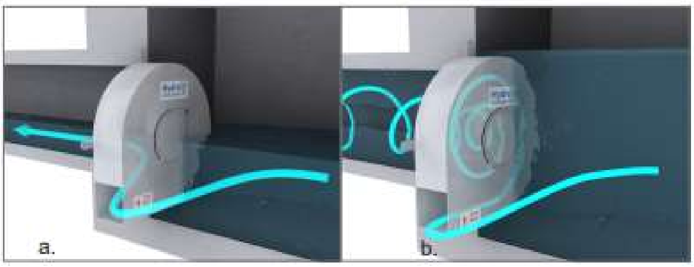


Image Ref: Hydro International – Hydro-brake ® Optimum Brochure

The design of passive (vortex) type devices is generally undertaken by manufacturers to suit the particular application. As head increases, the inlet and outlet become submerged, and a vortex will begin to form. As head levels then continue to increase the unit becomes entirely submerged and sufficient hydrostatic pressure is generated a stable vortex is formed with a central air-filled core. This air-filled core acts as a pseudo-physical restriction by reducing the cross-sectional area of the device for passage of water.

Location and use on site: Two separate vortex flow control devices are proposed upstream of the proposed outfalls to the adjacent watercourse.

LAND DRAIN/DRY SWALE

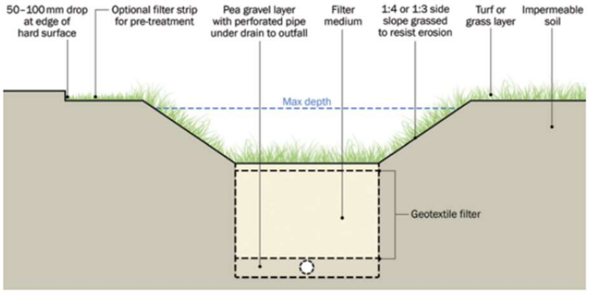


Image Ref: CIRIA Report C753 – The SuDS Manual v6

The land drain/dry swale is a vegetated conveyance channel, designed to include a filter bed of prepared soil that overlays an underdrain system. This undertrain provides additional treatment and conveyance capacity beneath the base of the swale and prevents waterlogging. To prevent infiltration or where groundwater levels are high, a liner could be introduced at the base.

Figure 6-2 – SuDS Components Incorporated into Proposed Design

Green Roofs

6.5.23 Green roofs are proposed to be utilised within the site. For this stage the entirety of each green roof has not been utilised in the drainage design, these areas are subject to change during detailed design and therefore have been excluded from all hydraulic calculations.

Raingardens

6.5.24 Raingardens are proposed to be utilised within the site. For this stage the entirety of each garden has not been utilised in the drainage design, these areas are subject to change during detailed design and therefore have been excluded from all hydraulic calculations.

Attenuation Tanks

6.5.25 The proposed housing roof areas will drain into a proposed piped surface water system via rainwater downpipes. This piped network will discharge through a series of underground geo-cellular attenuation tanks. The attenuation tanks have been designed to infiltrate.

Permeable Paving and Rainwater Diffusers

6.5.26 All the proposed road areas (including parking areas) are to be permeable, with surfacing comprising either permeable concrete block paving, or porous asphalts. The sub-base to these permeable paved areas will be continuous, therefore providing conveyance for surface water runoff to move laterally through the sub-base material.

Permeable Paving and Rainwater Diffusers

6.5.27 The land drain/dry swale is proposed to intercept surface water overland flows across site. The infiltration through the granular sub-base will provide a form of treatment and it will convey surface water to the central channel.

6.6 Proposed Surface Water Strategy Modelling Results

6.6.1 The surface water drainage system has been designed to prevent flooding in any part of the site and contain surface water during a 100yr storm event plus 45% climate change.

6.6.2 It is anticipated that all surface water flows would infiltrate into the ground and conservative infiltration rates have been sued to calculate the required attenuation to be provided.

6.6.3 The proposed site attenuation requirements are set out in the table below, summarises the microdrainage calculations contained within ***Appendix D***. A conservative infiltration rate which was achieved in a test at shallow depth has been used, although testing has indicated that a high infiltration can be achieved onsite at the designed depth of the infiltration features, the positions of the proposed infiltration feature varies slightly from where the proposed test was completed, as such using the lower infiltration rate allows for sensitivity testing for the proposed site drainage design (both referred to within ***Section 6.4*** of this report).

Table 6-3 - Provisional Attenuation Requirements

Network	Impermeable Area	Worst Case Storm Event	Attenuation Provided (m^3)
Cluster 1	0.272ha	480 min Winter	380.8
Cluster 2	0.24ha	1,440min Winter	346
Site Access Road	0.028ha	60 min Summer	7.2
Access Road Between Clusters	0.0573	960 min Winter	60.2

6.6.4 The existing overland flows attenuation requirements set out in the table below, summarises the microdrainage calculations contained within ***Appendix D***. The infiltration feature is designed to infiltrate at the same depth at which the nearest test was undertaken, a (refer to ***Section 6.4*** of this report).

6.6.5 The infiltration blanket is designed for up to 1in1yr storm events, any larger storm events and the gravel blanket will overflow into the attenuation crates.

6.6.6 The attenuation crates are designed for up to a 100yr storm event plus 45% climate change, however for more extreme events an overflow into the Wessex Water sewer in Englishcombe Lane has been proposed. In addition to allow further robustness in the design a safety factor of 5 has also been applied to this feature.

Table 6-4 - Provisional Overland Flow Interception Requirements

Network	Impermeable Area	Worst Case Storm Event	Attenuation Provided (m^3)
Overland Flows Infiltration Blanket (1in1yr)	8.8ha	100,800 min Winter	28.8
Overland Flows Attenuation Crates (100yr plus 45%CC)	8.8ha	30 min Winter	538.1

6.6.7 The proposed attenuation arrangement is illustrated on the accompanying drainage strategy plan in **Appendix B**.

6.7 Overland Flows

6.7.1 The NPPF requires that surface water drainage systems should cope with events that exceed the design capacity of the system. Any rainfall event with intensity in excess of that of the design capacity of the development surface water drainage network may result in temporary above ground flooding, potentially giving rise to overland flows. This excess water should be safely stored or conveyed from the site without adverse impacts to the development proposals, adjacent existing development or downstream.

6.7.2 The existing site naturally falls from south to north, and the proposed site falls in the same direction. Should an exceedance storm event occur, and surface flooding start to occur within the development site, flows will therefore generally be collected and controlled within the proposed attenuation features. Finished floor levels to new residential dwellings will require elevation above exceedance routes. Open space design will ensure natural flow paths are not intercepted by new development infrastructure, with fences, walls and other potential obstructions designed to make provision to allow exceedance flows to continue above ground unhindered during extreme rainfall events.An Overland Flows Plan ***Appendix B*** has been produced for the proposed site indicating direction of surface water movement and how is contained within the site.

6.8 Water Quality

6.8.1 Pollution control measures have been included to minimise the risk of contamination or pollution emanating from surface water runoff from the development entering the receiving watercourse. The onsite surface water drainage system has been designed to comply with the requirements of the SuDS treatment train as laid out by CIRIA SuDS Manual.

6.8.2 Table 26.2 of the CIRIA SuDS Manual provides the pollution hazard indices for different land use classifications. Residential Roofs exhibit low pollution hazard level for surface water runoff as shown in the table below:

Table 6-4: Pollution Hazard Indices

Land Use	Pollution Hazard Level	Total Suspended Solids (TSS)	Metals	Hydro-carbons
Residential roofs	Very Low	0.2	0.2	0.05
Individual property driveways, low traffic roads (e.g. cul de sacs, home zones and general access roads)	Low	0.5	0.4	0.04

6.8.3 The proposed permeable paving build-up to the access road will provide high levels of pollutant removal. Whilst the proposed geo-cellular attenuation tanks will not provide any meaningful removal of pollutants, a proprietary treatment device such as a Downstream Defender could be provided upstream of the tanks, which would provide some pollutant removal during most storm events.

6.8.4 The table below summarises the treatment efficiency of different SuDS components discharging to surface waters as detailed in Chapter 26 of the SuDS Manual.

Table 6-5: SuDs Treatment Efficency

Type of SuDS component	Mitigation Indices		
	Total Suspended Solids (TSS)	**Metals**	**Hydro-carbons**
Permeable Paving	0.7	0.6	0.7
Proprietary treatment systems	These must demonstrate that they can address each of the contaminant types to acceptable levels for frequent events up to approximately the 1 in 1 year return period event, for inflow concentrations relevant to the contributing drainage area		

7 Adoption and Maintenance

7.1 SuDS Maintenance Schedule

7.1.1 The proposed surface water drainage system comprises different components, the long-term management and maintenance for which may fall to different parties. The access road has been designed as a permeable paved road, into which no other surface water runoff is discharged (i.e. no plot drainage is connected into it). This will be privately maintained by a private estates management company.

7.1.2 The rest of the drainage network is conveying runoff from individual residential plots. The piped drainage network is unlikely to be considered for adoption by Thames Water, as Thames Water will not currently consider adoption of the proposed geo-cellular attenuation tanks. The majority of the surface water drainage network, including the tanks, will therefore need to be maintained by a private estates management company.

Attenuation Tanks

7.1.3 The following table outlines typical maintenance requirements for attenuation tanks. This will be privately maintained by a private estates management company.

Table 7-1 - Typical Operation & Maintenance Requirements, Attenuation tanks

Attenuation storage tanks – Operation and maintenance requirements in accordance with CIRIA C753 – The SuDS Manual

Maintenance Schedule	Required Action	Frequency
Regular Maintenance	Inspect and identify any areas that are not operating correctly. If required, take remedial action	Monthly for 3 months, then annually
	Remove debris from the catchment surface (where it may cause risks to performance)	Monthly
	For systems where rainfall infiltrates into the tank from above, check surface of filter for blockage by sediment, algae, or other matter; remove and replace surface infiltration medium as necessary	Annually
	Remove sediment from pre-treatment structures and/ or internal forebays	Annually, or as required
Remedial actions	Repair/rehabilitate inlets, outlet, overflows, and vents	As required
Monitoring	Inspect/ check all inlets, outlets, vents, and overflows to ensure that they are in good condition and operating as designed	Annually
	Survey inside of tank for sediment build-up and remove if necessary	Every 5 years or as required
Refer to manufacturer's requirements for detailed specification and frequencies for the required maintenance		
Attenuation storage tanks will be maintained by the owner / occupier appointed management company		

Permeable Paving

7.1.4 The following table outlines typical maintenance requirements for permeable paving. This will be privately maintained by a private estates management company.

Table 7-2 -Typical Operation & Maintenance Requirements, Permeable Paving

Permeable Paving – Operation and maintenance requirements is accordance with CIRIA C753 – The

Maintenance Schedule	Required Action	Frequency
Regular Maintenance	Brushing and vacuuming (standard cosmetic sweep over whole surface).	Once a year, after autumn leaf fall, or reduced frequency as required, based on site-specific observations of clogging or manufacturer's recommendations – pay particular attention to areas where water runs onto pervious surfaces from adjacent impermeable areas as this area is most likely to collect the most Sediment.
Occasional Maintenance	Stabilise and mow contributing and adjacent areas.	As required.
	Removal of weeds or management using glyphosate applied directly into the weeds by an applicator rather than spraying.	As required – once per year on less frequently used pavements.
Remedial Actions	Remediate any landscaping which, through vegetation maintenance or soil slip, has been raised to within 50 mm of the level of the paving.	As required.
	Remedial work to any depressions, rutting and cracked or broken blocks considered detrimental to the structural performance or a hazard to users, and replace lost jointing material.	As required.
	Rehabilitation of surface and upper substructure by remedial sweeping.	Every 10 to 15 years or as required (if infiltration performance is reduced due to significant clogging).
Monitoring	Initial inspection.	Monthly for three months after installation.
	Inspect for evidence of poor operation and/or weed growth – if required, take remedial action.	Three-monthly, 48 h after large storms in first six months.
	Inspect silt accumulation rates and establish appropriate brushing frequencies.	Annually.
	Monitor inspection chambers.	Annually.

Permeable Paving – Operation and maintenance requirements is accordance with CIRIA C753 – The

Permeable Paving will be maintained by the highway authority (if the road will be adopted as public highway, a response has been received where adoption would be considered), or else by the owner appointed management company.

Raingardens/ Land drains/ Dry Swales (Bioretention Systems)

7.1.5 The following table outlines typical maintenance requirements for Bioretention Systems in the form of raingardens and water butts. This will be privately maintained by a private estates management company.

Table 7-3 – Typical Operation & Maintenance Requirements, Bioretention Systems (Rain Gardens)

Bioretention systems – Operation and maintenance requirements in accordance with CIRIA C753 – The SuDS Manual

Maintenance Schedule	Required Action	Frequency
Regular inspections	Inspect infiltration surfaces for silting and ponding, record de-watering time of the facility and asses standing water levels in underdrain (if appropriate) to determine if maintenance is necessary	Quarterly
	Check operation of underdrains by inspection of flows after rain	Annually
	Assess plants for disease infection, poor growth, invasive species etc and replace as necessary	Quarterly
	Inspect inlets and outlets for blockage	Quarterly
Regular maintenance	Remove litter and surface debris and weeds	Quarterly (or more frequently for tidiness or aesthetic reasons)
	Replace any plants, to maintain planting density	As required
	Remove sediment, litter, and debris build-up from around inlets or from forebays	Quarterly to biannually
Occasional maintenance	Infill any holes or scour in the filter medium, improve erosion protection if required	As required

	Repair minor accumulations of silt by raking away surface mulch, scarifying surface of medium and replacing mulch	As required
Remedial actions	Remove and replace filter medium and vegetation above	As required but likely to be > 20 years
Bioretention systems will be maintained by the owner / occupier appointed management company		

Gravel Blanket

7.1.6 The following table outlines typical maintenance requirements for a Gravel Blanket. This will be privately maintained by a private estates management company.

Table 7-4 – Typical Operation & Maintenance Requirements, Gravel Blanket

Gravel Blanket – Operation and maintenance requirements is accordance with CIRIA C753 – The SuDS Manual

Maintenance Schedule	**Required Action**	**Frequency**
Regular Maintenance	Remove litter and debris	Monthly (or as required)
	Manage other vegetation and remove nuisance plants	Monthly (at start, then as required)
	Inspect filter strip surface to identify evidence of erosion, poor vegetation growth, compaction, ponding, sedimentation and contamination (eg oils)	Monthly (at start, then half yearly)
	Inspect slit accumulation rates and establish appropriate removal frequencies	Monthly (at start, then half yearly)
Remedial actions	Repair erosion or other damage	As required
	Relevel uneven surfaces and reinstate design levels	As required
	Remove build-up of sediment	As required
	Remove and dispose of oils and petrol residues using safe standard practices	As required

Gravel Blanket will be maintained by the owner / occupier appointed management company

Other Drainage Features

7.1.7 The following table outlines typical maintenance requirements of the Owner / Occupier Appointed Management Company for other drainage features, such as pipes, chambers, and flow control devices.

Table 7-5 - Typical Operation & Maintenance Requirements, Other Drainage Features

Other Drainage Items – Operation and maintenance requirements is accordance with CIRIA C753 – The SuDS Manual

Maintenance Schedule	**Required Action**	**Frequency**
Private Drains.	Inspection.	CCTV survey every 5-10 years.
	Regular Maintenance.	Jet clean system fully every 5-10 years. (Recommend prior to CCTV drainage survey).
	Remedial / Occasional Maintenance.	Carry out remedial works as identified in CCTV survey.
Discharge orifice manholes/flow control devices.	Inspection	Quarterly.
	Regular Maintenance.	Remove silt and debris as necessary to prevent build up.

7.2 SuDS Construction

7.2.1 The construction of SuDS usually only requires the use of standard civil engineering construction and landscaping operations, such as excavation, filling, grading, top soiling, seeding, planting etc. These operations are specified in various standard construction documents, such as the Civil Engineering Specification for the Water Industry (CESWI).

7.2.2 Construction of permeable paving is regulated by the Building Regulations Part H (Drainage and Waste Disposal) which sets out the requirements for drainage of rainwater from the roofs of buildings.

7.2.3 During construction, any surfaces which are intended to enable infiltration must be protected from compaction. This includes protecting from heavy traffic or storage of materials.

7.2.4 Water contaminated with silt must not be allowed to enter drains as it may cause pollution. All parts of the drainage system must be protected from construction runoff to prevent silt clogging the system and causing pollution downstream. Measures to prevent this include soil stabilisation, early construction of sediment management basins, channelling runoff away from surface water drains, and erosion prevention measures.

7.2.5 After the end of the construction period and prior to handover to the site owner/operator:

- Subsoil that has been compacted during construction activities should be broken up prior to the re-application of topsoil to garden areas and other areas of public open space to reinstate the natural infiltration performance of the ground.
- Any areas of the SuDS that have been compacted during construction but are intended to permit infiltration must be completely refurbished.
- Checks must be made for blockages or partial blockages of orifices or pipe systems.
- Any silt deposited during the construction must be completely removed.
- Soils must be stabilised and protected from erosion whilst planting becomes established.

7.2.6 Detailed guidance on the construction related issues for SuDS is available in the SuDS Manual (CIRIA C753 2015).

7.3 Biodiversity

7.3.1 Within the site careful measures have been put in place to retain or improve (if possible) existing habitats. Notably, to the Northwest corner of the site there is a grassland restoration region with the potential opportunity to restore the species rich grassland.

7.3.2 Within the central drainage trench, there has been the addition of planting and wet woodland to increase the biodiversity within the site. There is also the incorporation of scrapes and swales within the central trench, these features provide a species rich environment within the site while also providing a betterment to the overland flows as existing.

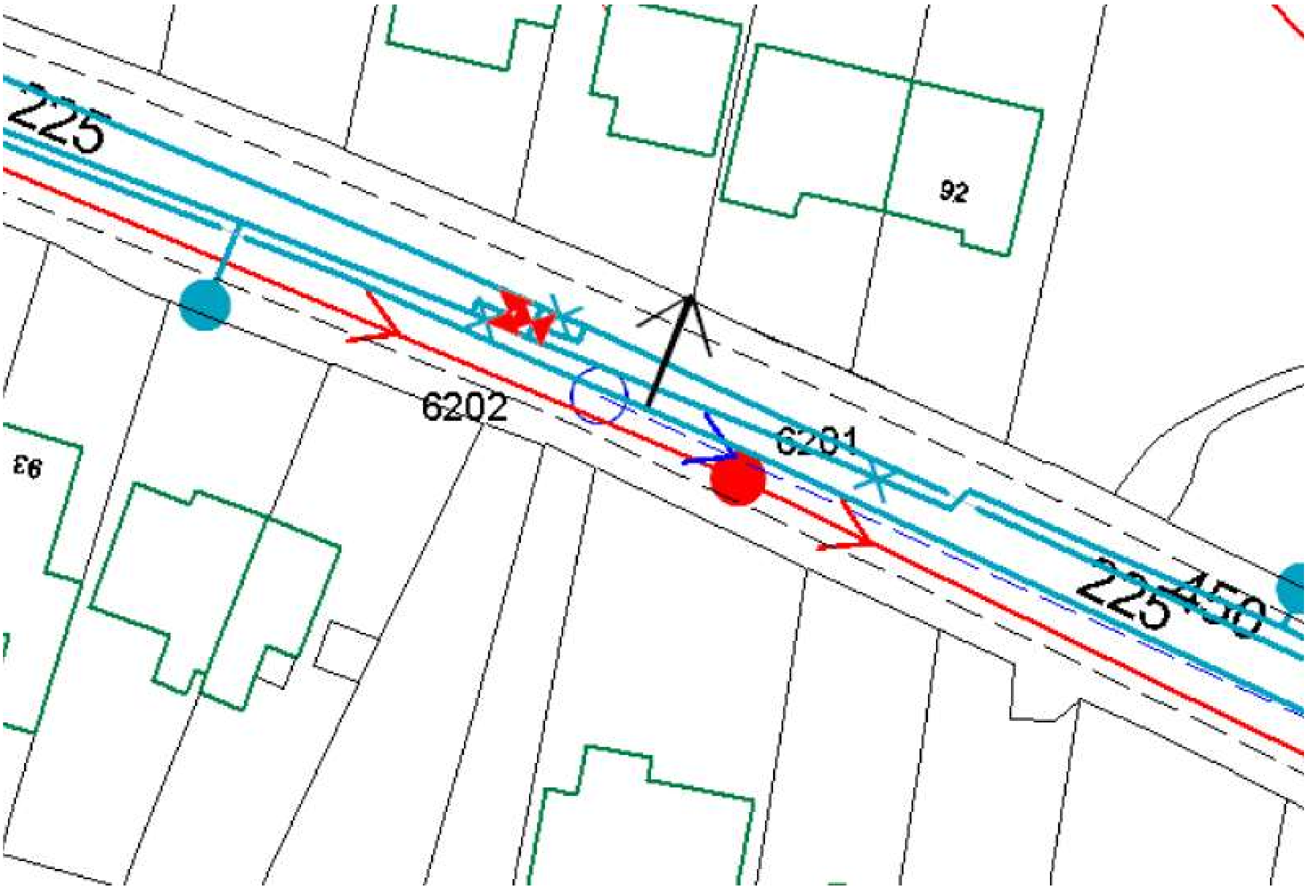
7.3.3 Where possible the overland flows have intentionally been designed to behave as existing, while also, where possible providing a betterment by the incorporation of SuDS features. Flows into the central drainage trench are expected to be reduced with the introduction of drainage in cluster 1 & 2, reducing the catchment area draining into this area.

7.3.4 Though yet to be confirmed, rain gardens and green rooves can be incorporated through the site, to provide ecological benefits, water treatment and also increase the time for Surface Water to reach the proposed network.

8 Foul Water

8.1.1 Wessex Water's sewer asset records are contained within **Appendix A** of this report and have been used to inform this drainage strategy.

8.1.2 Foul flows from the site are to drain via a conventional piped gravity network into the existing 225mm diameter foul sewer, with manhole reference 6201, discharging away from the site located adjacent the site access within Englishcombe Lane.



8.1.3 Foul sewerage flows from the development have been estimated using Sewer Sector Guidance of 4,000 litres per dwelling per day (note this figure is based on an assumed peaking factor of 6). Based on the proposed total of 16 dwellings, the peak foul flow rate is estimated as **0.75l/s.**

8.1.4 A pre-planning capacity enquiry has been submitted to Wessex Water detailing the number of dwellings and their type within the proposed development. The proposed foul drainage connection into manhole reference 6201 and the proposed peak foul discharge rate have been confirmed by Wessex Water. A copy of this correspondence can be found in **Appendix F**.

9 Conclusion

9.1.1 This report has set out the principles for a viable drainage strategy for the disposal of both surface water and foul flows from the development.

9.1.2 The conclusions are:

- An assessment of the surface water catchment has been made and the Greenfield runoff rate (Qbar) for the site has been determined at 13.3 litres/second. This rate has therefore been used as the maximum allowable discharge rate from the site.
- The greenfield runoff from the development has been calculated using the FEH 2013 rainfall model. All positive flows to discharge from the site (if any) are to be limited to the value of 13.3l/s.
- An assessment has been undertaken to establish the required surface water attenuation for the site using conservative infiltration rates. Approximately 794.2m^3 of storage is required using the conservative infiltration rate (to be provided in geo-cellular attenuation tanks and permeable paving sub-bases) to cater for all storm events up to and including the 1 in 100 year storm plus 45% climate change.
- The proposed surface water drainage system can effectively control all runoff generated within the site to Greenfield runoff rates off-site without increasing flood risk elsewhere.
- Pollution control measures will also be included to minimise the risk of contamination or pollution entering the receiving water body from surface water runoff from the development.
- Regular maintenance of the drainage features will be required to ensure they work efficiently for the lifetime of the development.
- Through the use of green roofs, permeable paving, geocellular attenuation tanks, raingardens, the proposed development will discharge surface water flows safely through infiltration into the ground, preventing flooding within the site and downstream, and providing water quality treatment. The proposed strategy therefore achieves the aims and objectives of both local and national planning policies.
- The existing watercourse overland flows will be captured and conveyed using land drains to the central channel, an infiltration blanket at the base of the central channel will be used to attenuate and infiltrate for storm periods up to 1in1yr. The infiltration blanket will have an overflow to attenuation crates which will attenuate and infiltrate surface water for larger storm events up to 100yrs plus 45% climate change.
- The proposed development comprises 16 residential dwellings, leading to a peak foul flow rate of 0.7/s. A point of connection to the Wessex Water public sewer network within Englishcombe Lane has been applied for.