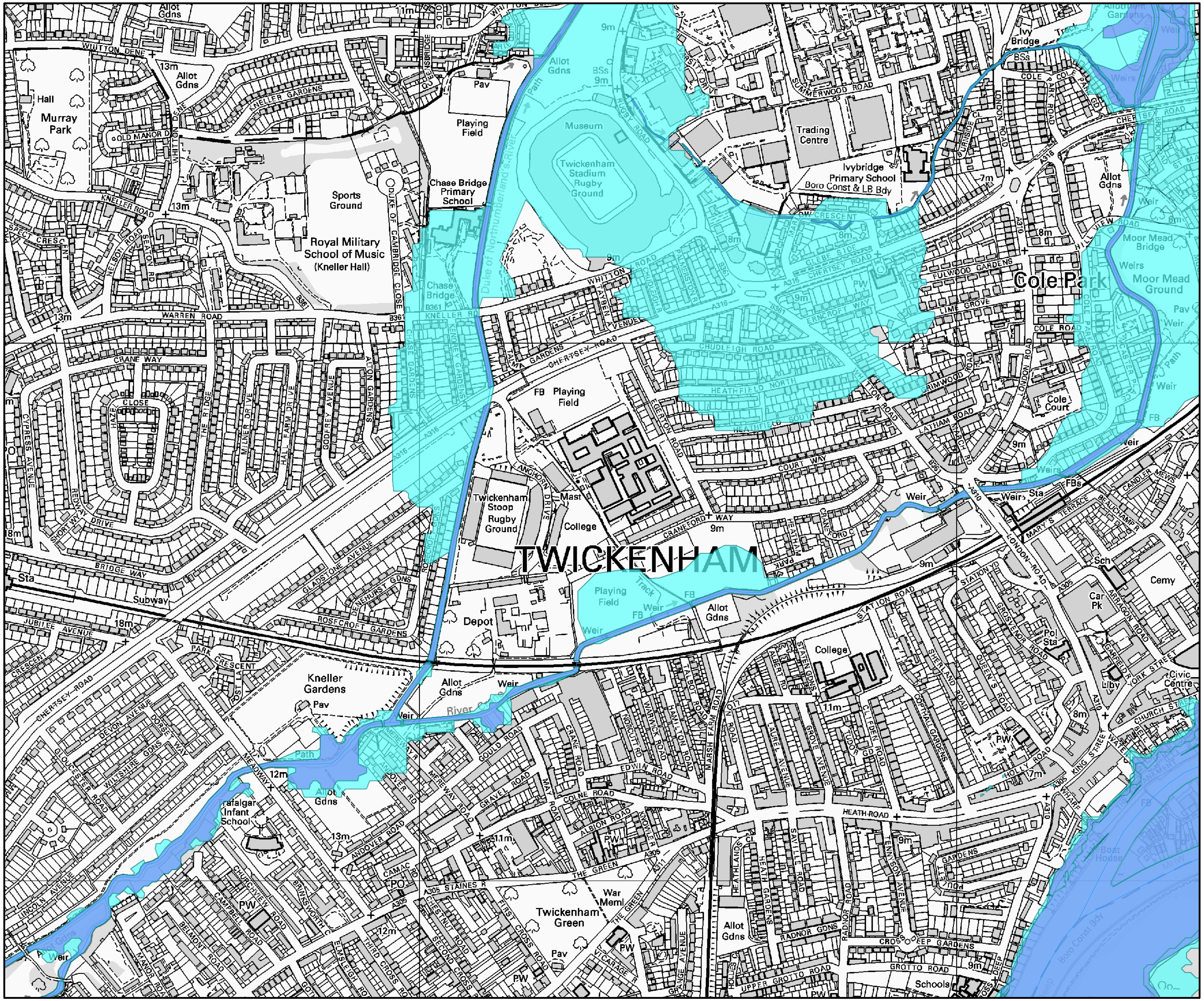
[Topographic Survey-
see Appendix 3.1]

APPENDIX C

Environment Agency modelled flood levels

Flood Map for Planning centred on Richmond College created 15/05/2014 - NET41816AS-2



Environment Agency

Environment Agency
2 Bishops Square Business Park
St Albans Road West
Hatfield
Hertfordshire
AL10 9EX

0 125 250 500
Metres

Legend

Main Rivers

Flood Map for Planning

Flood Zone 3

Flood Zone 2

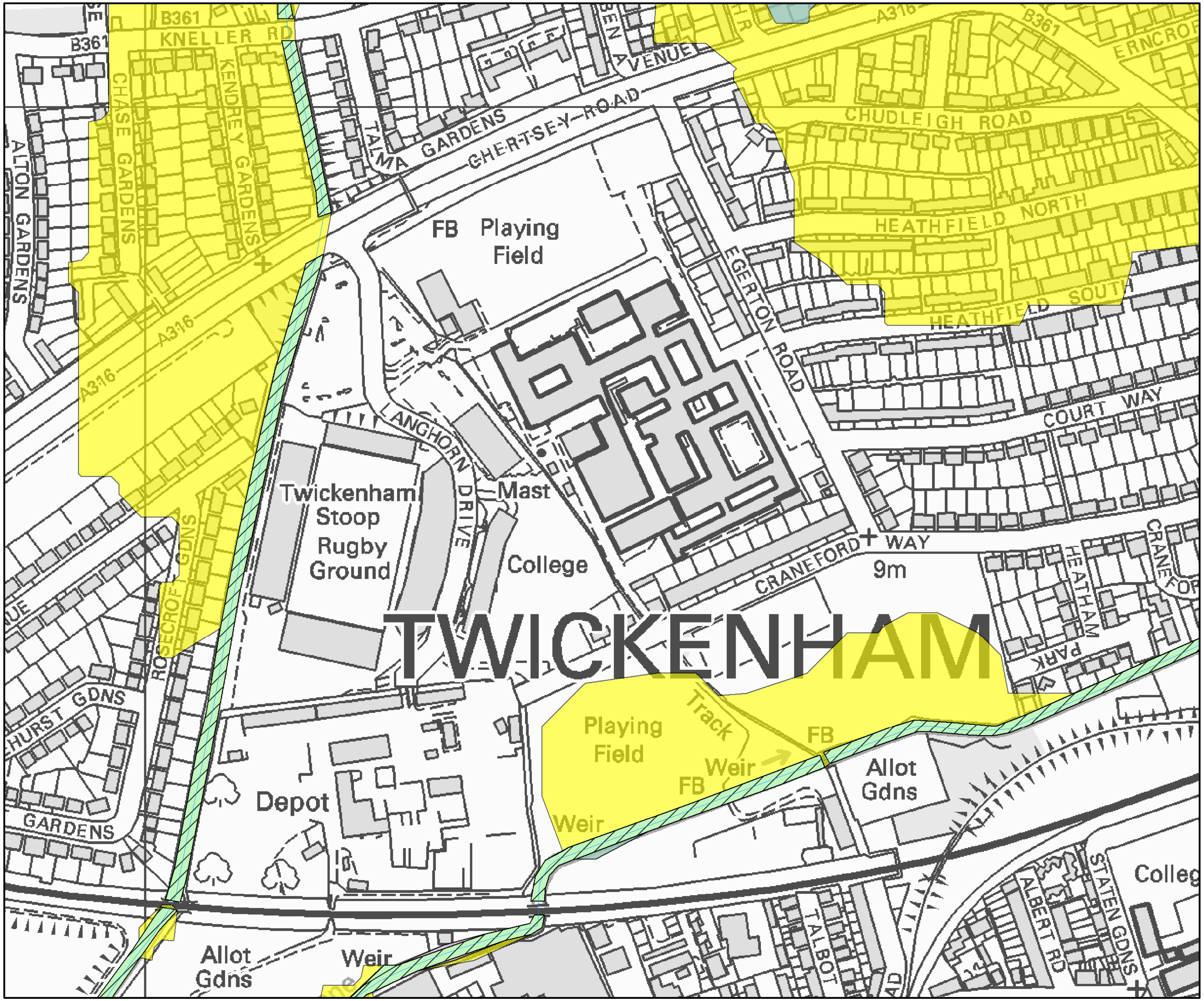
Flood Map for Planning (assuming no defences)

Flood Zone 3 shows the area that could be affected by flooding:
- from the sea with a 1 in 200 or greater chance of happening each year
- or from a river with a 1 in 100 or greater chance of happening each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to a 1 in 1000 chance of occurring each year.

Produced by:
Partnerships & Strategic Overview,
Hertfordshire & North London

Detailed FRA centred on Richmond College created 15/05/2014 - NET41816AS-2



Environment Agency

Environment Agency
2 Bishops Square Business Park
St Albans Road West
Hatfield
Hertfordshire
AL10 9EX

0 50 100 200
Metres

Legend

Main Rivers

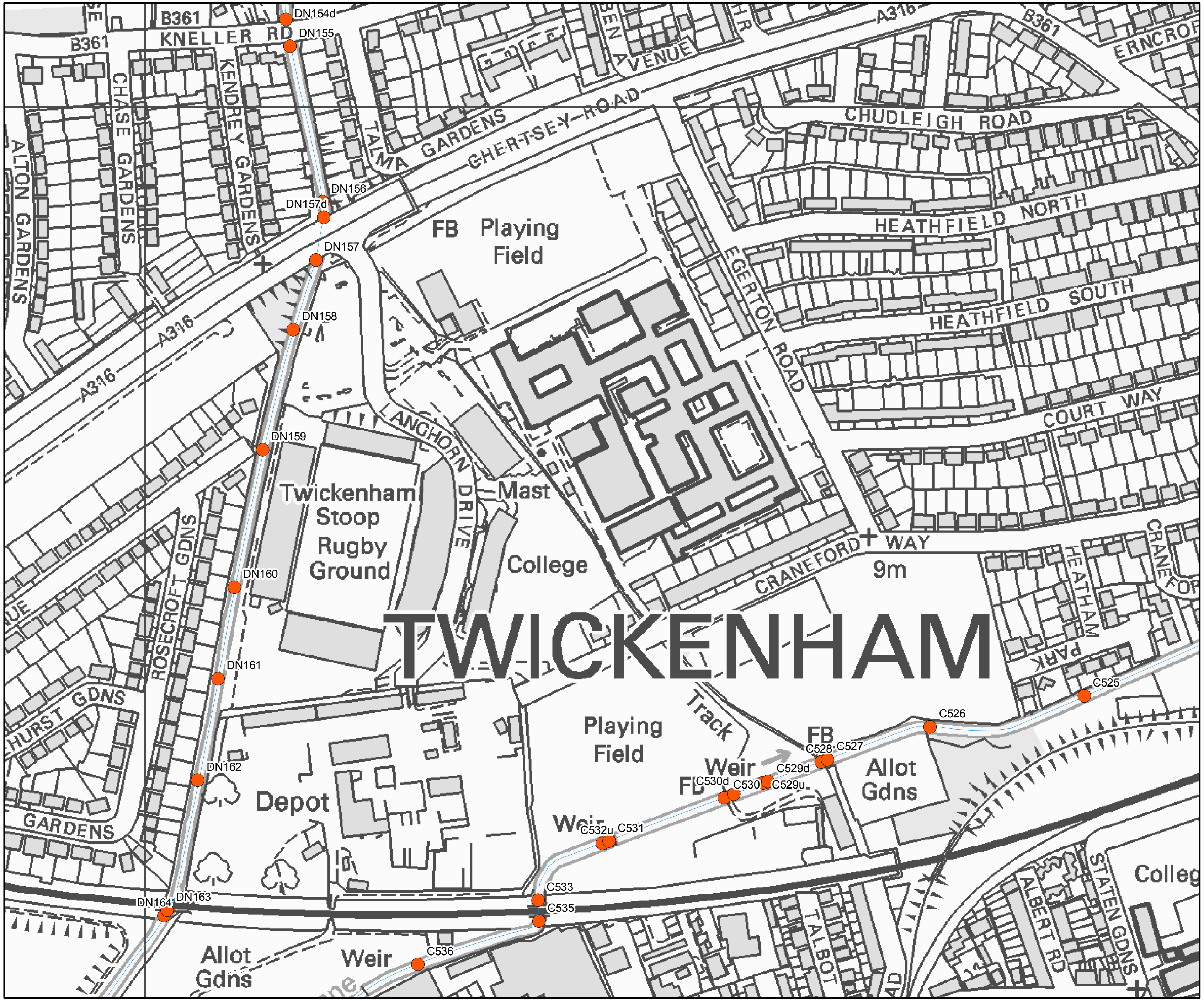
Defended Flood Outlines

- 1 in 5 (20%) Defended
- 1 in 10 (10%) Defended
- 1 in 20 (5%) Defended
- 1 in 50 (2%) Defended
- 1 in 100 (1%) Defended
- 1 in 100+20% (*CC) Defended
- 1 in 1000 (0.1%) Defended

The data in this map has been extracted from the River Crane Mapping Study (Halcrow 2008).
This model has been designed for catchment wide flood risk mapping. It should be noted that it was not created to produce flood levels for specific development sites within the catchment.
Modelled outlines take into account catchment wide defences.

Produced by:
Partnerships & Strategic Overview,
Hertfordshire & North London

Detailed FRA centred on Richmond College created 15/05/2014 - NET41816AS-2



Environment Agency

Environment Agency
2 Bishops Square Business Park
St Albans Road West
Hatfield
Hertfordshire
AL10 9EX

0 50 100 200
Metres

Legend

Main Rivers

1D Node Results

Node Results

The data in this map has been extracted from the River Crane Mapping Study (Halcrow 2008).
This model has been designed for catchment wide flood risk mapping. It should be noted that it was not created to produce flood levels for specific development sites within the catchment.
Modelled outlines take into account catchment wide defences.

Produced by:
Partnerships & Strategic Overview,
Hertfordshire & North London

Environment Agency ref: NET41816AS-2

The following information has been extracted from the River Crane Mapping Study (Halcrow 2008)

Caution:
The modelled flood levels and extents are appropriate for catchment wide strategic flood risk mapping. However, for more detailed flood risk assessment it is recommended that each of the underlying flood mapping, hydraulic modelling and hydrological assumptions are re-evaluated to determine the appropriateness in a more detailed analysis.

All flood levels are given in metres Above Ordnance Datum (mAOD)
All flows are given in cubic metres per second (cumecs)

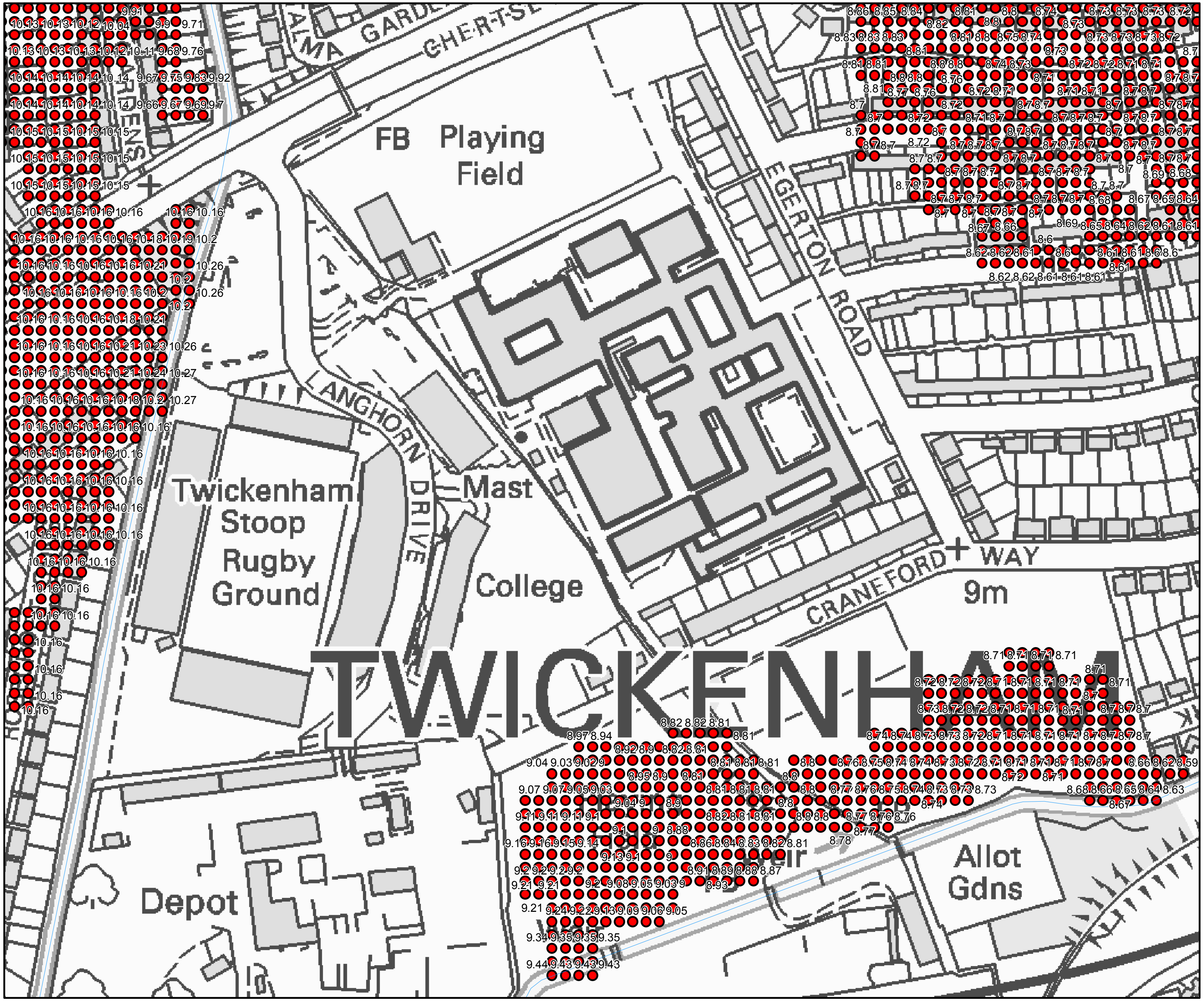
MODELLED FLOOD LEVEL

			Return Period					
Node Label	**Easting**	**Northing**	**5 yr**	**20 yr**	**50 yr**	**100 yr**	**100yr + 20%**	**1000yr**
C536	515203	173360	9.462	9.573	9.61	9.645	9.698	9.915
C535	515294	173393	9.383	9.497	9.536	9.573	9.628	9.854
C533	515293	173409	9.153	9.236	9.263	9.289	9.329	9.461
C532u	515341	173452	9.091	9.173	9.2	9.227	9.267	9.433
C531	515346	173453	8.982	9.061	9.086	9.112	9.151	9.317
C530	515432	173485	8.912	8.99	9.015	9.041	9.08	9.231
C530d	515432	173485	8.912	8.99	9.015	9.039	9.073	9.195
C529u	515460	173500	8.878	8.955	8.98	9.004	9.038	9.161
C529d	515460	173500	8.479	8.548	8.571	8.592	8.623	8.778
C528	515504	173513	8.425	8.494	8.516	8.537	8.568	8.729
C527	515506	173513	8.431	8.5	8.523	8.544	8.575	8.736
C526	515584	173537	8.27	8.339	8.362	8.383	8.413	8.601
C525	515698	173562	8.046	8.115	8.138	8.159	8.191	8.349
DN164	515016	173397	9.899	10.021	10.063	10.103	10.162	10.464
DN163	515016	173401	9.903	10.027	10.069	10.108	10.167	10.463
DN162	515040	173498	9.828	9.951	9.994	10.034	10.094	10.392
DN161	515056	173574	9.762	9.888	9.934	9.972	10.033	10.34
DN160	515067	173641	9.722	9.849	9.897	9.935	9.997	10.314
DN159	515088	173744	9.684	9.808	9.859	9.894	9.957	10.28
DN158	515110	173834	9.655	9.776	9.828	9.861	9.924	10.264
DN157	515126	173885	9.646	9.766	9.818	9.852	9.915	10.265
DN157d	515126	173885	9.646	9.766	9.818	9.851	9.914	10.264
DN156	515132	173929	9.632	9.749	9.801	9.832	9.895	10.256
DN155	515106	174044	9.611	9.726	9.779	9.809	9.871	10.246
DN154d	515104	174048	9.607	9.72	9.773	9.802	9.864	10.241

MODELLED FLOWS

			Return Period					
Node Label	Easting	Northing	5 yr	20 yr	50 yr	100 yr	100yr + 20%	1000yr
C536	515203	173360	24.112	26.036	26.678	27.274	28.149	32.517
C535	515294	173393	24.113	26.035	26.677	27.274	28.149	32.503
C533	515293	173409	24.113	26.036	26.677	27.274	28.149	32.504
C532u	515341	173452	24.113	26.035	26.677	27.274	28.149	31.412
C531	515346	173453	24.113	26.035	26.677	27.274	28.149	31.411
C530	515432	173485	24.112	26.035	26.677	27.274	28.149	31.394
C530d	515432	173485	24.112	26.035	26.677	27.274	28.149	31.394
C529u	515460	173500	24.112	26.035	26.677	27.274	28.149	31.39
C529d	515460	173500	24.112	26.035	26.677	27.274	28.149	31.39
C528	515504	173513	24.112	26.035	26.677	27.274	28.149	31.384
C527	515506	173513	24.112	26.035	26.677	27.274	28.149	31.384
C526	515584	173537	24.112	26.035	26.678	27.274	28.149	31.391
C525	515698	173562	24.112	26.035	26.677	27.273	28.149	32.46
DN164	515016	173397	2.735	3.562	3.852	4.123	4.555	6.6
DN163	515016	173401	2.735	3.562	3.852	4.123	4.555	6.6
DN162	515040	173498	2.734	3.563	3.852	4.124	4.556	6.7
DN161	515056	173574	2.734	3.563	3.853	4.125	4.558	6.7
DN160	515067	173641	2.734	3.563	3.854	4.126	4.558	6.80
DN159	515088	173744	2.735	3.565	3.855	4.127	4.561	6.8
DN158	515110	173834	2.737	3.566	3.857	4.128	4.564	6.3
DN157	515126	173885	2.738	3.567	3.858	4.13	4.565	6.2
DN157d	515126	173885	2.738	3.567	3.858	4.13	4.565	6.2
DN156	515132	173929	2.739	3.567	3.859	4.13	4.566	6.2
DN155	515106	174044	2.743	3.569	3.861	4.133	4.571	6.20
DN154d	515104	174048	2.894	3.649	3.993	4.211	4.745	9.90

Detailed FRA centred on Richmond College created 15/05/2014 - NET41816AS-2



Environment Agency

Environment Agency
2 Bishops Square Business Park
St Albans Road West
Hatfield
Hertfordshire
AL10 9EX

0 37.5 75 150
Metres

Legend

Main Rivers

2D Node Results

1 in 1000 (0.1%) Defended

The data in this map has been extracted from the River Crane Mapping Study (Halcrow 2008).
This model has been designed for catchment wide flood risk mapping. It should be noted that it was not created to produce flood levels for specific development sites within the catchment.
Modelled outlines take into account catchment wide defences.

Produced by:
Partnerships & Strategic Overview,
Hertfordshire & North London

Environment Agency ref: NET41816AS-2

The following information on defences has been extracted from the Asset Information Management System (AIMS)

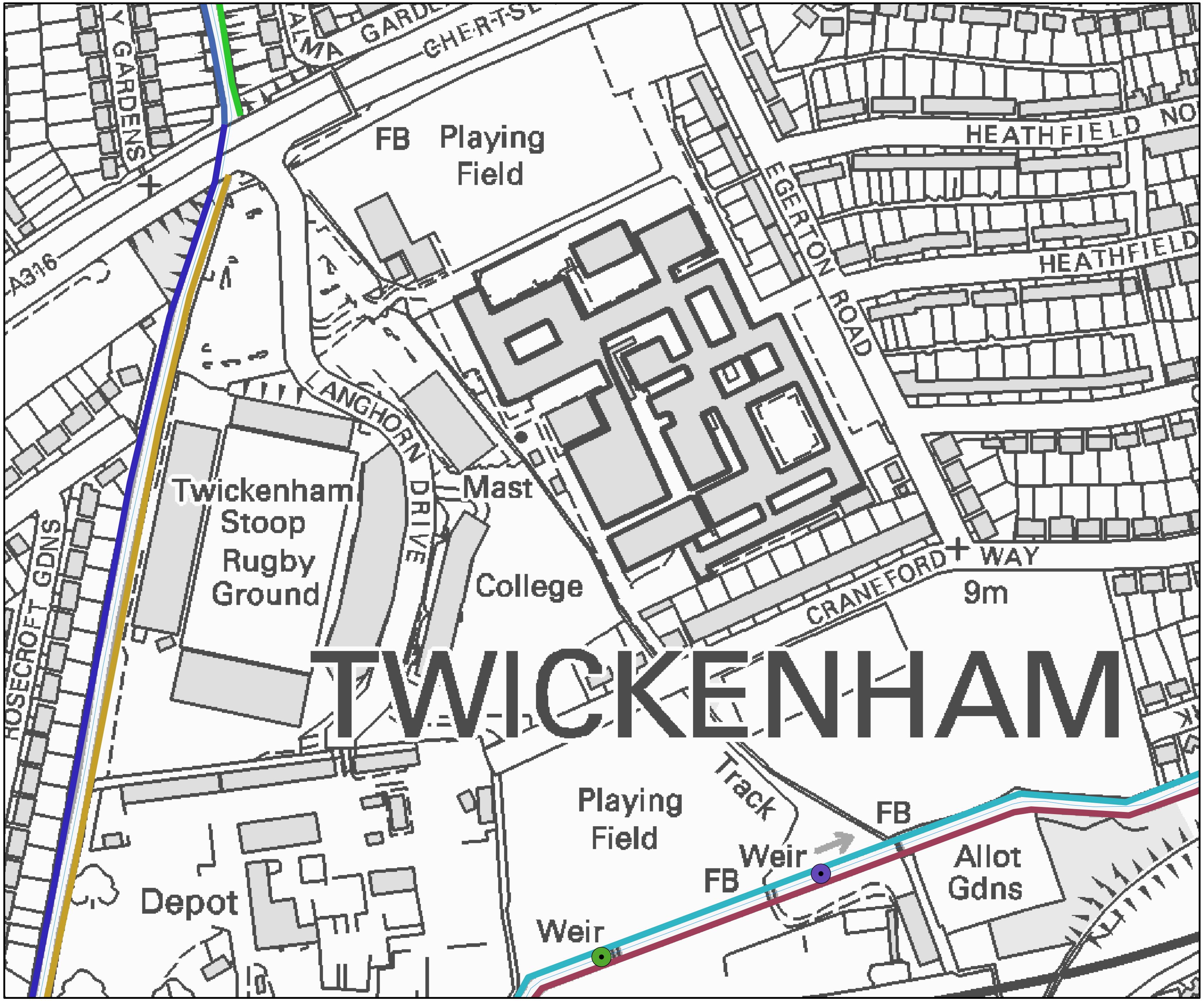
Defences

Map ID	Asset Reference	Asset Type	Asset Protection	Asset Comment	Asset Description	Asset Location	Design Standard of protection (years)	Grid Reference
126260	0623636DH0114L02	defence	Fluvial	Combination of poured concrete and timber bank protection	Bank protection.	D/S from Chertsey Road	200	TQ1512973916
126461	0623636DH0114R03	defence	Fluvial	Concrete bank protection with section of timber lining	Bank protection.	D/S from Chertsey Road	200	TQ1513273888
126257	0623636DH0113L02	defence	Fluvial	Cast insitu concrete channel lining	Lined Channel	Kneller Road, Twickenham	200	TQ1509974064
126259	0623636DH0113R03	defence	Fluvial	Cast insitu concrete channel lining.	Lined Channel	Kneller Road, Twickenham.	200	TQ1511174048
143354	0623636CR0104L02	defence	Fluvial	Cast insitu concrete lined channel with 1.5m high walls and lined channel bed.	Lined channel.	Twickenham	10	TQ1601573725
144651	0623636CR0104R02	defence	Fluvial	Cast insitu concrete lined channel with 1.5m high walls and lined channel bed.	Lined channel.	Twickenham	20	TQ1602473713

Structures

Map ID	Asset Reference	Asset Type	Asset Protection	Asset Comment	Asset Description	Asset Location	Grid Reference
192275	0623636CR0104R01002	weir	Fluvial	Precast concrete fixed crest weir	Weir.	North of Norcutt Road	TQ1534073451
192274	0623636CR0104R01001	weir	Fluvial	Fixed crest concrete sloping weir. 7-03-2011 AP Changed to FDS, TC 3	Weir.	North of Talbot Road	TQ1546273498

Defences & Structures - centred on Richmond College created 15/05/2014 - NET41816AS-2



Environment Agency

Environment Agency
2 Bishops Square Business Park
St Albans Road West
Hatfield
Hertfordshire
AL10 9EX

0 37.5 75 150
Metres

Legend

Main Rivers

Defences Asset ID	Structures Asset ID
126257	192274
126259	192275
126260	
126461	
143354	
144651	

The following information on defences has been extracted from the Asset Information Management System (AIMS)

Produced by:
Partnerships & Strategic Overview,
Hertfordshire & North London

Historic Flood Data

We do not hold records of historic flood events from rivers and/or the sea affecting the area local to this property. However, please be aware that this does not necessarily mean that flooding has not occurred here in the past.

Please note that our records are not comprehensive. We would therefore advise that you make further enquiries locally with specific reference to flooding at this location. You should consider contacting the relevant Local Planning Authority and/or water/sewerage undertaker for the area.

We map flooding to land, not individual properties. Our historic flood event record outlines are an indication of the geographical extent of an observed flood event. Our historic flood event outlines do not give any indication of flood levels for individual properties. They also do not imply that any property within the outline has flooded internally.

Please be aware that flooding can come from different sources. Examples of these are:

- from rivers or the sea;
- surface water (i.e. rainwater flowing over or accumulating on the ground before it is able to enter rivers or the drainage system);
- overflowing or backing up of sewer or drainage systems which have been overwhelmed,
- groundwater rising up from underground aquifers

Surface Water

Managing the risk and responding to surface water flooding is a role for Lead Local Flood Authorities. The Environment Agency was funded by the government to produce new national surface water maps, which went live on our website from December 2013. See http://maps.environment-agency.gov.uk and select “Risk of Flooding from Surface Water”. We have produced these maps for the whole country and have worked with Lead Local Flood Authorities to incorporate their local surface water flood risk information where this is available.

Additional Information

Use of Environment Agency Information for Flood Risk / Flood Consequence Assessments

Important If you have requested this information to help inform a development proposal, then we recommend that you undertake a formal pre-application enquiry using the form available from our website:- http://www.environment-agency.gov.uk/research/planning/33580.aspx

Depending on the enquiry, we may also provide advice on other issues related to our responsibilities including flooding, waste, land contamination, water quality, biodiversity, navigation, pollution, water resources, foul drainage or Environmental Impact Assessment.

In **England**, you should refer to the Environment Agency's Flood Risk Standing Advice and the technical guidance to the National Planning Policy Framework for information about what flood risk assessment is needed for new development in the different Flood Zones. These documents can be accessed via:

http://www.environment-agency.gov.uk/research/planning/82587.aspx
https://www.gov.uk/government/publications/national-planning-policy-framework-technical-guidance

You should also consult the Strategic Flood Risk Assessment produced by your local planning authority.

You should note that:

1. Information supplied by the Environment Agency may be used to assist in producing a Flood Risk / Consequence Assessment (FRA / FCA) where one is required, but does not constitute such an assessment on its own.

2. This information covers flood risk from main rivers and the sea, and you will need to consider other potential sources of flooding, such as groundwater or overland runoff. The information produced by the local planning authority referred to above may assist here.

3. Where a planning application requires a FRA / FCA and this is not submitted or deficient, the Environment Agency may well raise an objection.

4. For more significant proposals in higher flood risk areas, we would be pleased to discuss details with you ahead of making any planning application, and you should also discuss the matter with your local planning authority.

Apollo Court, 2 Bishop Square Business Park, St Albans Road West, Hatfield, Hertfordshire, AL10 9EX
Customer services line: 03708 506 506
Email: NETenquiries@environment-agency.gov.uk
Website: www.environment-agency.gov.uk

APPENDIX D

Thames Water Sewer Flooding Enquiry

Sewer Flooding
History Enquiry

Thames Water Property Searches

Vastern Road

Search address supplied	Richmond-Upon-Thames College Egerton Road Twickenham TW2 7SJ
Your reference	62335
Our reference	SFH/SFH Standard/2014_2764887
Received date	**15 May 2014**
Search date	**18 May 2014**

Thames Water Utilities Ltd

Property Searches
PO Box 3189
Slough SL1 4WW

DX 151280 Slough 13

T 0118 925 1504
E searches@thameswater.co.uk
I www.thameswater-propertysearches.co.uk

Registered in England and Wales
No. 2366661, Registered office
Clearwater Court, Vastern Road
Reading RG1 8DB

Sewer Flooding
History Enquiry

Search address supplied: Richmond-Upon-Thames College,Egerton Road,Twickenham,TW2 7SJ

This search is recommended to check for any sewer flooding in a specific address or area

TWUL, trading as Property Searches, are responsible in respect of the following:-

(i) any negligent or incorrect entry in the records searched;

(ii) any negligent or incorrect interpretation of the records searched;

(iii) and any negligent or incorrect recording of that interpretation in the search report

(iv) compensation payments

Thames Water Utilities Ltd

Property Searches
PO Box 3189
Slough SL1 4WW

DX 151280 Slough 13

T 0118 925 1504
E searches@thameswater.co.uk
I www.thameswater-propertysearches.co.uk

Sewer Flooding
History Enquiry

History of Sewer Flooding

Is the requested address or area at risk of flooding due to overloaded public sewers?

The flooding records held by Thames Water indicate that there have been no incidents of flooding in the requested area as a result of surcharging public sewers.

For your guidance:

- A sewer is "overloaded" when the flow from a storm is unable to pass through it due to a permanent problem (e.g. flat gradient, small diameter). Flooding as a result of temporary problems such as blockages, siltation, collapses and equipment or operational failures are excluded.
- "Internal flooding" from public sewers is defined as flooding, which enters a building or passes below a suspended floor. For reporting purposes, buildings are restricted to those normally occupied and used for residential, public, commercial, business or industrial purposes.
- "At Risk" properties are those that the water company is required to include in the Regulatory Register that is presented annually to the Director General of Water Services. These are defined as properties that have suffered, or are likely to suffer, internal flooding from public foul, combined or surface water sewers due to overloading of the sewerage system more frequently than the relevant reference period (either once or twice in ten years) as determined by the Company's reporting procedure.
- Flooding as a result of storm events proven to be exceptional and beyond the reference period of one in ten years are not included on the At Risk Register.
- Properties may be at risk of flooding but not included on the Register where flooding incidents have not been reported to the Company.
- Public Sewers are defined as those for which the Company holds statutory responsibility under the Water Industry Act 1991.
- It should be noted that flooding can occur from private sewers and drains which are not the responsibility of the Company. This report excludes flooding from private sewers and drains and the Company makes no comment upon this matter.
- For further information please contact Thames Water on Tel: 0845 9200 800 or website www.thameswater.co.uk

Thames Water Utilities Ltd

Property Searches
PO Box 3189
Slough SL1 4WW

DX 151280 Slough 13

T 0118 925 1504
E searches@thameswater.co.uk
I www.thameswater-propertysearches.co.uk

Registered in England and Wales
No. 2366661, Registered office
Clearwater Court, Vastern Road
Reading RG1 8DB

Appendix 13.2: Outline Drainage Assessment

Sustainable Drainage Assessment: Richmond upon Thames College Redevelopment

Sustainable Drainage Assessment: Richmond upon Thames College Redevelopment

Prepared for

Cascade Consulting
The Courtyard
Ladycross Business Park
Hollow Lane
Dormansland
Surrey
RH7 6PB

Report reference: 62335R2, June 2015
Report status: FINAL

Confidential
Prepared by
ESI Ltd

New Zealand House,160 Abbey Foregate, Shrewsbury, SY2 6FD, UK
*Tel +44(0)1743 276100 Fax +44 (0)1743 248600 email **info**@esinternational.com*
Registered office: New Zealand House, 160 Abbey Foregate, Shrewsbury, SY2 6FD. Registered in England and Wales, number 3212832

Sustainable Drainage Assessment: Richmond upon Thames College Redevelopment

This report has been prepared by ESI Ltd. (ESI) in its professional capacity as soil and water specialists, with reasonable skill, care and diligence within the agreed scope and terms of contract and taking account of the manpower and resources devoted to it by agreement with its client, and is provided by ESI solely for the internal use of its client.

The advice and opinions in this report should be read and relied on only in the context of the report as a whole, taking account of the terms of reference agreed with the client. The findings are based on the information made available to ESI at the date of the report (and will have been assumed to be correct) and on current UK standards, codes, technology and practices as at that time. They do not purport to include any manner of legal advice or opinion. New information or changes in conditions and regulatory requirements may occur in future, which will change the conclusions presented here.

This report is confidential to the client. The client may submit the report to regulatory bodies, where appropriate. Should the client wish to release this report to any other third party for that party's reliance, ESI may, by prior written agreement, agree to such release, provided that it is acknowledged that ESI accepts no responsibility of any nature to any third party to whom this report or any part thereof is made known. ESI accepts no responsibility for any loss or damage incurred as a result, and the third party does not acquire any rights whatsoever, contractual or otherwise, against ESI except as expressly agreed with ESI in writing.

Confidential
Prepared by
ESI Ltd

New Zealand House,160 Abbey Foregate, Shrewsbury, SY2 6FD, UK
Tel *+44(0)1743 276100* ***Fax*** *+44 (0)1743 248600* ***email*** ***info****@esinternational.com*
Registered office: New Zealand House, 160 Abbey Foregate, Shrewsbury, SY2 6FD. Registered in England and Wales, number 3212832

62335R2. FINAL

	Name	Signature
Author	Prajnan Goswami	
Checked by	Bob Sargent	
Reviewed by	Paul Ellis	

Revision record:

Issue	Report ref	Comment	Author	Checker	Reviewer	Issue date	Issued to
1	62335R2D1	Submitted to the client for progress update	PXG			19/01/2015	Cascade Consulting
2	62335R2D2	Draft for the client comments	PXG	BS	PAE	21/05/2015	Cascade Consulting
3	62335R2D3	Draft for the client comments	PXG	BS	PAE	29/05/2015	Cascade Consulting
4	62335R2D4	Draft for the client comments	PXG	BS	PAE	09/06/2015	Cascade Consulting
5	62335R2	Final	PXG	BS	PAE	12/06/2015	Cascade Consulting

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ESI Ltd

New Zealand House,160 Abbey Foregate, Shrewsbury, SY2 6FD, UK
Tel +44(0)1743 276100 Fax +44 (0)1743 248600 email ***info****@esinternational.com*
Registered office: New Zealand House, 160 Abbey Foregate, Shrewsbury, SY2 6FD. Registered in England and Wales, number 3212832

CONTENTS

FIGURES

TABLES

APPENDICES

1 INTRODUCTION

1.1 Background

Richmond upon Thames College is situated at National Grid reference TQ 15384 73787 (nearest postal code TW2 7SJ) in Twickenham adjacent to the south side of Chertsey Road, in south west London (Figure 1.1). The total Site area is c. 9 ha and the topography is relatively flat with an average elevation between 8.5 mAOD to the south and 9.0 mAOD to the north (3 Sixty Measurement, 2008).

The northern section (Figure 1.1) is occupied by a sports hall with associated facilities, a grass sports pitch, and a car park in the north east corner. The Junction of Chertsey Road and Longhorn Drive is also a part of the Site. The central section is occupied by a collection of buildings housing the College's academic and workshop facilities. The northern section and the central section are divided by a private road which joins Langhorn drive and subsequently Chertsey Road which is the main vehicle access route. The College playing fields are bounded to the south by the River Crane, to the north by Craneford Way (a public road), and to the east by private housing.

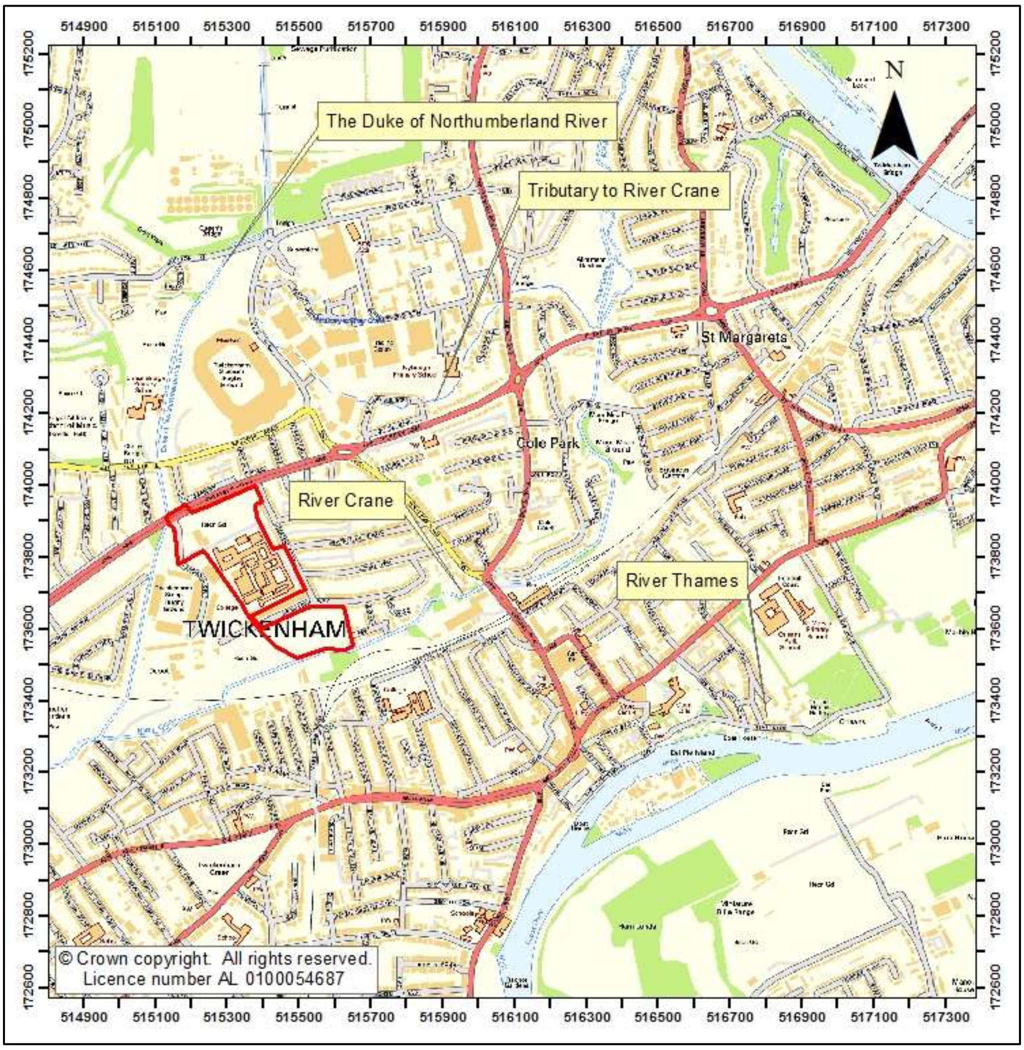

Figure 1.1 Site location

ESI Ltd. (ESI) was commissioned by Cascade Consulting Ltd in October 2014 to perform a drainage assessment and produce a Sustainable Drainage System (SuDS) design for the redevelopment of Richmond upon Thames College (the Site).

1.2 Rationale

The drainage assessment is to support an EIA accompanying an outline planning application to the London Borough of Richmond upon Thames (LBRuT) for the redevelopment of Richmond College. Recent flooding events in the Borough, particularly the event in the summer of 2007, have shown susceptibility to surface water flooding. The Borough's Local Development Framework (LBRuT, 2011) advises a policy for steady reduction in the overall amount of rainfall being discharged to the drainage system and a reduction in the Borough's susceptibility to surface water flooding.

Wherever possible, Sustainable Drainage System (SuDS) techniques must be utilised. The surface water drainage techniques for a site, including SuDS, have to be decided at an early enough stage of the development so that sufficient space can be allocated. Sustainable drainage is integral to the design of a development and is not an 'add-on'. Therefore, to reduce the risk of surface water and sewer flooding, all development proposals in the Borough are required to follow the London Plan drainage hierarchy.

1.3 Methodology

This document presents the calculations for surface run-off and the resulting run-off rates from the Site during a 1 in 100 year 6 hour storm event, which includes an allowance for climate change at 30%, as requested by LBRuT. The calculations are based on a 6 hour storm event since this is the rainfall event duration generally considered appropriate for SuDS design purposes according to the SUDS manual (CIRIA, 2007).

A site visit was made to assess the existing storm drainage and soakaways. A site-wide utility statement (Atkins, 2015) and topographic survey have been consulted to inform the layout and positon of SuDS features. A SuDS scheme will reduce the overall run-off from the redeveloped Site and the reduction attributable to the existing SuDS features has been estimated and taken into account in this report.

The assessment has been based on the Illustrative Masterplan because it requires the areas of permeable and impermeable surface in order to calculate surface water runoff volumes. The calculations are therefore indicative, as the scheme could be constructed differently within the constraints of the parameter plans, but it demonstrates that a suitable drainage scheme could be developed for the outline design.

The assessment was undertaken prior to a minor change in the red line boundary (along the River Crane), which reduced the site area. As the assessment was undertaken of the previous slightly larger site area, it provides a worst case analysis.

2 SITE SETTING

2.1 Proposed Site Plan

The Illustrative Masterplan for the Site is shown in Figure 2.1.

The northern section will be redeveloped into new college buildings, a secondary school, a school for children with special needs, a Tech Hub, STEM centre and Sports centre. The junction of Chertsey Road and Langhorn Drive will be modified to accommodate an increase in traffic after redevelopment.

The central section will be redeveloped into a residential area. The College playing fields to the south of Craneford Way will be improved with one all weather and one grass pitch.

2.2 Surface Area

The details of existing and proposed (illustrative) surface areas are listed in Table 2.1. Open spaces with soft and hard landscaping increase by 4% in the proposed development, compared to the current development. The total building footprint will be reduced 4% compared to the current development.

2.3 Geology

The underlying geology comprises London Clay (Clay and Silt). The superficial deposits comprise the Kempton Park Gravel Formation (sand and gravel).

2.4 Watercourse

The River Thames runs 1 km to the south east of the Site and is the main river the watercourses around the Site feed into. Existing watercourses are shown on the Site location map in Figure 1.1. Adjacent to Craneford Way playing fields on the south side, the River Crane runs in a man-made channel from west to east, before joining the River Thames further east at NGR TQ 16669 75383.

The Duke of Northumberland's River is located west of the Site and flows from south to north towards the River Thames which is located c. 2 km to the east of the Site. It branches off from the River Crane 500 m south west of the Site and flows under Chertsey Road further downstream. A tributary to the River Crane appears at the surface, east of Twickenham stadium to the north east of the Site and flows west to east, to join the River Crane 1 km north east of the Site (see Figure 1.1).

Figure 2.1 Illustrative Masterplan

REEC Comparison of Existing and Illustrative External Space Types

2015-06-01

Colour key	Predominant Open Space Use	Main Site (m²) Existing	Phase 1e*	Phase 2d*	Illustrative
	Grass Sports Pitches	7,420	-	-	
	Soft Landscaping (incl. podium)	16,167	5,892	7,742	9,809
	All Weather Sports Surfaces		1,818	3,223	3,397
	All Weather Sports Surfaces (derelict)		-	-	
	Hard Landscaping	5,854	8,567	10,598	12,757
	Marsh Farm Lane (path only)	692	471	471	1,359
	Private Gardens		-	3,522	5,167
	Roads / Car Parking	10,648	8,301	8,078	12,253
	Subtotal Open Space	40,781	25,050	33,634	44,740
	Open Space as a % of Total Area	68%	42%	56%	74%
	Construction Area		22,776	13,965	
	Construction Area as a % of Total Area	0%	38%	23%	0%
	Buildings	19,387	12,342	12,569	15,428
	Buildings as a % of Total Area	32%	21%	21%	26%
	Total Area	60,168	60,168	60,168	60,168

Predominant Open Space Use	Craneford Way Site (m²) Existing	Phase 1e*	Phase 2d*	Illustrative
Grass Sports Pitches	10,400	11,904	5,208	5,208
Soft Landscaping (incl. podium)	12,702	15,217	12,640	12,640
All Weather Sports Surfaces	920		8,439	8,439
All Weather Sports Surfaces (derelict)	2,787			
Hard Landscaping	214		397	397
Marsh Farm Lane (path only)	328	328	765	765
Private Gardens				
Roads / Car Parking	98		-	-
Subtotal Open Space	27,449	27,449	27,449	27,449
Open Space as a % of Total Area	100%	100%	100%	100%
Construction Area				
Construction Area as a % of Total Area	0%	0%	0%	0%
Buildings	-	-	-	-
Buildings as a % of Total Area	0%	0%	0%	0%
Total Area	27,449	27,449	27,449	27,449

Predominant Open Space Use	Total (m²) Existing	Phase 1e*	Phase 2d*	Illustrative
Grass Sports Pitches	17,820	11,904	5,208	5,208
Soft Landscaping (incl. podium)	28,869	21,109	20,382	22,449
All Weather Sports Surfaces	920	1,818	11,662	11,835
All Weather Sports Surfaces (derelict)	2,787	-	-	0
Hard Landscaping	6,068	8,567	10,994	13,153
Marsh Farm Lane (path only)	1,020	799	1,236	2,124
Private Gardens	-	-	3,522	5,167
Roads / Car Parking	10,746	8,301	8,078	12,253
Subtotal Open Space	68,230	52,499	61,083	72,189
Open Space as a % of Total Area	78%	60%	70%	82%
Construction Area	-	22,776	13,965	-
Construction Area as a % of Total Area	0%	26%	16%	0%
Buildings	19,387	12,342	12,569	15,428
Buildings as a % of Total Area	22%	14%	14%	18%
Total Area	87,617	87,617	87,617	87,617

REEC Area of Construction Site by Phase*

Phase	Construction Area (m²)
Phase 1a+1b	30,542
Phase 1c	53,638
Phase 1d+1e	22,776
Phase 2a	38,731
Phase 2b	13,806
Phase 2c+2d	13,965
Phase 3a	5,953
Phase 3b+3c	8,516

REEC Theoretical Minimum Open Space**

Development Zone	Area	Building Zone Footprint	Minimum Open Space
College	20,144	8,628	11,517
Tech Hub	2,336	1,395	941
Schools	17,806	5,042	12,764
Residential	19,882	8,035	11,847
Main Site	60,168	23,299	36,868
Playing Fields	27,449	-	27,449
SubTotal	87,617	23,299	64,318
Other Areas***	6,065	-	6,065
Total inside Red Line	93,682	23,299	70,383

*Based on Phasing Drawings dated 2015.04.23

** Minimum Space assuming 100% of building zone footprint is built; does not allow for any rooftop open space (other than any podium area)

*** Including areas of A316 Junction, Langhorn Drive, Harlquins Car Parking and Craneford Way

All figures m² unless indicated otherwise

Table 2.1 Summary of Existing and Illustrative Areas

2.5 Existing Drainage

A mapping survey of the external drainage was commissioned by RuTC in 2009 and is shown in Figure 2.2 below.

At least fifteen soakaway systems/chambers (shown as light blue areas in Figure 2.2) were identified during the mapping of the existing surface water drainage system and an additional two possible soakaways/chambers (shown as purple blue areas in Figure 2.2). The foul sewage (orange in Figure 2.2) is pumped at NGR 515270, 173830 to a main sewer running along the western boundary of the site.

The site appears to be generally flat (average gradient of c. 0.1% and slightly sloping in a north to south direction) with surface water routed via gullies along roads and concreted areas to the soakaways. Downpipes from roofs were generally not visible although it is likely that these are all routed via the local surface water drainage system to the many soakaways identified during the 2009 drainage survey.

The River Crane runs west to east along the south of the Site. The river is in a concrete channel adjacent to the entire southern boundary of the Site.

The College playing field is mostly covered by grass, there is an extensive tarmac/concrete area used for netball and other sports by both RuTC and the local residents due to the open access nature of these playing fields. These fields appeared to be well drained during the site visit. Two large manholes were identified in the middle of the fields during the site visit which were not shown in the 2009 drainage survey maps.

A site wide Utility Statement was undertaken by Atkins in May 2014 (Atkins, 2015). The report confirms presence of a soakaway system. The report also suggests a gravity connection to a combined Thames Water manhole MH 5703, serving the eastern portion of the site. However the connections are thought to be blocked and need to be verified.

It is therefore assumed that all current drainage from the developed areas is to soakaway. No formal discharge to watercourses has been found either during the site visit undertaken for this report or by Atkins in their report. It remains possible that an undetected discharge exists and it may also be possible that informal surface runoff occurs to watercourses during extreme rainfall events. In the absence of any information relating to either of these possibilities it has been assumed that at present no discharge to surface watercourses occurs from the current site.

Figure 2.2 Existing drainage and soakaway features

3 SURFACE RUNOFF CALCULATION

An estimation of run-off is required to permit effective site water management and prevent any increase in flood risk to off-site receptors. The current development discharges site runoff to the existing soakaway system and there is no evidence of water currently being discharged to surface watercourses or to the sewerage system.

It is required that no increase is runoff to surface watercourses or to the sewerage system should occur from the proposed development. It is therefore intended to use a similar infiltration system at the Site to drain the proposed development. Calculations are presented in Appendix A.

3.1 Climate change

Projections of future climate change (CC), in the UK, indicate more frequent, short-duration, high-intensity rainfall and more frequent periods of long duration rainfall. Guidance included within the National Planning Policy Framework (NPPF) recommends that the effects of CC are incorporated into Sustainable Drainage Assessments.

Recommended precautionary sensitivity ranges for peak rainfall intensities and peak river flows are outlined in the NPPF technical guidance note (DCLG, 2014). The recommended national precautionary sensitivity range for peak rainfall intensity are summarised in (Table 3.1). It is assumed that the proposed development is likely to have a lifespan beyond 2085 and therefore a 30% allowance has been made for climate change.

Table 3.1 National precautionary sensitivity ranges relevant to site

Parameter	1990 to 2025	2025 to 2055	2055 to 2085	2085 to 2115
Peak rainfall intensity	*+5%*	*+10%*	*+20%*	*+30%*
Peak river flow	*+10%*	*+20%*		

3.2 Surface water run-off from the Site

Impermeable surfaces, associated with new building developments, prevent water infiltrating into the ground as it would naturally. In this instance, there is a decrease in the area of impermeable surfaces at the Site associated with the development being proposed (Table 3.4). However, the NPPF (DCLG, 2012a) also recommends that any new development should consider future climate change scenarios for planning applications, and this may lead to increased runoff from impermeable areas.

The Flood Estimation Handbook (FEH) CD-ROM, developed by NERC, (2009), is used to derive rainfall and catchment characteristics. Surface water run-off was calculated by estimating the effective rainfall using Standard Percentage Run-off (SPR) method. SPR value has been estimated using the soil characteristics of the Site. For the impermeable surfaces, it has been assumed that 100% runoff will occur from these in the existing and proposed development. Future climate change has been accounted for in the proposed development calculations with an influence of +30% for both impermeable and permeable surfaces for proposed development.

The method used for calculating the runoff complies with the NPPF (DCLG, 2012a) and assumes that the excess runoff associated with the proposed development (plus an allowance for future CC) will need to be managed by a SuDS scheme.

The surface area for the runoff calculations is taken from the Site Plan SK - 160 (Figure 2.1). The A316 junction, Langhorn Drive, Harlequin FC's carpark and Craneford Way are not considered for runoff calculation as they are not a part of the development zone (Table 2.1). Details of permeable and impermeable surfaces for the existing and proposed development are presented in Table 3.2 and Table 3.3. Total permeable and impermeable surface areas are presented in Table 3.4.

Table 3.2 Permeable and Impermeable Area (m^2)* - Existing

	Type	Area (m^2)
Grass Sports Pitches	Permeable	17,820
Soft Landscaping (inc. Podium)	Permeable	28,869
All Weather Sports Surfaces	Permeable	920
All Weather Sports Surfaces (derelict)	Impermeable	2,787
Hard Landscaping	Impermeable	6,068
Marsh Farm Lane (path only)	Impermeable	1,020
Private Gardens	Impermeable	-
Road /Car Parking	Impermeable	10,746
Buildings	Impermeable	19,387
TOTAL		**87,617**

*Derived from Table 2.1

Table 3.3 Permeable and Impermeable Area (m^2)*- Proposed

	Type	Area (m^2)
Grass Sports Pitches	Permeable	5,208
Soft Landscaping (inc. Podium)	Permeable	22,449
All Weather Sports Surfaces	Permeable	11,835
All Weather Sports Surfaces (derelict)	Impermeable	-
Hard Landscaping	Impermeable	13,153
Marsh Farm Lane (path only)	Impermeable	2,124
Private Gardens	Permeable	5,167
Road /Car Parking	Permeable**	12,253
Buildings	Impermeable	15,428
TOTAL		**87,617**

*Derived from Table 2.1
** Roads and car parking are designed with permeable paving

Table 3.4 Total Permeable and Impermeable Area* (m^2)

	Existing	Illustrative	% increase/ decrease over existing
Permeable	47,609	56,912	19.5%
Impermeable	40,008	30,705	-23%
Total	**87,617**	**87,617**	

The total runoff volumes produced by the existing and proposed development for different return period 6 hour storm events are summarised in Table 3.5. Details of the calculations are provided in Appendix A.

Table 3.5 Estimated Storage Volume for the REEC development

Return period of rainfall event (6 hours)	Rainfall (mm)	Total run-off from Existing development volume (m^3)	Total run-off from Proposed development (m^3) incl. CC	% increase compared to the existing development
1 in 10 year	39.05	1748	1848	6%
1 in 30 year	52.57	2354	2487	6%
1 in 100 year	72.31	3237	3421	6%

4 SURFACE WATER DRAINAGE STRATEGY

4.1 Ground Investigation

Ground conditions encountered at the site are described in (Soiltechnics, 2008) as follows:

Exploratory excavations generally encountered between 0.3-1.0m of topsoil or made ground grading into orange brown clays becoming sand and gravel considered to be Kempton Park Gravel to depths of between 4.2-5.3m and locally 9.3m. Stiff grey dark grey clay considered to be London Clay was encountered underlying the Kempton Park Gravel. Groundwater was encountered at between 1.1-3.5m in exploratory excavations and water levels of between 1.33-2.54m have been observed in standpipes installed across the site. Soil infiltration tests indicate that the near surface Kempton Park Gravel exhibit some permeability.

The results of the groundwater investigation are summarised in Appendix C and it is noted that they were based on 3 monthly readings only, commencing in May 2008. Results for the boreholes completed with groundwater monitoring standpipes indicate initial post drilling water levels between 2.5m and 3m. However in subsequent visits water levels ranged from 1.33 mbgl at the northern end of the site to 2.4 mbgl at the southern end of the main college site. These boreholes are distributed evenly across the main site and are designed specifically to monitor water levels across an interval of between 0.9 and 5 to 6 meter below ground level, encompassing the Kempton Park Gravel (Appendix C). The results indicate a variable unsaturated zone beneath the base of the soakaway. There is potential for shallow water at the site although this potential is influenced by the current discharge of most of the site drainage to soakaway which will elevate the shallow water table. Individual soakaways will require site investigation at the detailed design stage.

The permeability of soils was measured in ten trial pits generally following the procedures described in Building Research Establishment (BRE) Digest 365 (2007). These tests produced infiltration rates of between 5x 10^{-6} ms-1 to 5.2 x 10^{-5} ms-1 which indicated the site has soakaway capacity. This is supported by the operation of the current site using soakaways which it is understood have worked effectively to date.

4.2 Scoping opinion of the Environment Agency

The Environment Agency (EA) was consulted on the scope of Environmental Impact Assessment of the REEC development. The EA have the following recommendations for the drainage strategy (EA, 2014):

- The proposed Site should aim to achieve a Greenfield surface water runoff rate. If this is not possible, justification should be provided and it must be no greater than 3 times the Greenfield rate or must achieve a minimum 50% reduction from the existing runoff rate, in line with the London Plan's Sustainable Design and Construction Supplementary Planning Guidance.
- Sustainable Drainage Systems (SuDS) must be used on site to provide storage for surface water generated on site, in line with the National Planning Policy Framework paragraph 103, which requires development to give priority to the use of SuDS.
- Any storage volume required to attenuate surface water run-off from the critical 1 in 100 year storm event, with an appropriate allowance for climate change, must be provided on site. Rainwater harvesting and green roofs should also be included.
- Sustainable drainage schemes can also be a valuable asset for educational venues and provide multiple benefits. Potential SuDS schemes could also link with enhancements to the River Crane.

4.3 Baseline/Operational Phase

There are at least 15 existing soakaways on the Site. Considering there is no record of historical flooding at the site (GroundSure, 2014) the current local drainage plan indicates that the site runoff drains to the soakaways. The total runoff volume produced by the current site for a 1 in 100 year storm event is 3237 m^3. Therefore the existing local drainage plan achieves a 100% reduction of surface runoff produced on site. Since the Site does not discharge any surface runoff, the re-development will have to achieve 100% reduction to avoid an unacceptable increase in runoff from the Site. However it is not known what design storm event the existing soakaways are designed for or whether there are informal discharges of surface runoff from the site during extreme rainfall events which are not recorded.

The runoff volume produced by the proposed plan for a 1 in 100 year 6 hr storm duration with 30% allowance for climate change is 3,421 m^3. A similar system of soakaways with additional SuDS features is needed to dispose of the increased runoff from the proposed development and attenuation storage will be required.

A conceptual design of SuDS system is presented in Figure 4.1. The SK-124 Site Building Zones Parameter Plan and Illustrative Masterplan SK-160 are used for planning and placement of SuDS features. The London Plan Drainage Hierarchy, 2011 is adopted wherever possible with the best information available. The main site is divided into four development zones; each zone will discharge storm runoff to the respective soakaways through downpipes installed in the buildings, with the College development zone having 2 subzones labelled A1 and A2 (Figure 4.1)

Each component of the proposed SuDS scheme is described in further detail below.

4.3.1 Green roofs

Green roofs comprise a multi-layered system that covers the roof of a building or podium structure with vegetation cover/landscaping/permeable car parking, over a drainage layer. They are designed to intercept and retain precipitation, reducing the volume so these areas have not been included in the runoff and attenuating peak flows. The type and material of green roofs should follow appropriate guidance such the GRO Green Roof Code (GRO, 2011).

Green roofs can be used to reduce the volume and rate of runoff so that downstream SuDS and other drainage infrastructure can be reduced in size. The volume of rainwater attenuated varies depending on the design of the green roof.

Although green roofs absorb most of the rainfall that they receive during ordinary events, there is still the need to discharge excess water to the building’s drainage system. This is because their hydraulic performance during extreme events tends to be fairly similar to standard roofs. The hydraulic design of green roof drainage should therefore follow the advice in BS EN 12056-3 (BSI, 2000) (although the standard relates to the design of normal roof drainage) (CIRIA, 2007).

The podium over the residential car parking area (1,310 m^2) and the flat roof area (13,100 m^2) will be converted to green roofs. It is assumed that 70% of the above building roof area will be installed with green roofs which will be 10,087 m^2. Green roofs should attenuate storms up to a 2 year return period event (CIRIA, 2007) with a 30% allowance for climate change. Therefore green roofs on site should be designed such that they will attenuate a total runoff volume up to 304 m^3 for a 1 in 2 year 6 hour storm event plus allowance for climate change. Excess runoff produced from a storm event of greater magnitude will utilise the proposed downstream SuDS features. The outline locations of the green roofs are shown on Figure 4.1 and are represented as 70% of the available roof space.

Table 4.1 Green roof storage

Green roofs area (m^2)	2 year 6 hour rainfall (mm)	Climate change factor	Runoff (m^3)
10,087	23.18	30%	304

4.3.2 Permeable Pavements

Permeable pavements provide a pavement suitable for pedestrian and/or vehicular traffic, while allowing rainwater to infiltrate through the surface and into the underlying layers. The water is temporarily stored before infiltration to the ground, reuse, or discharge to a watercourse or other drainage system. Pavements with aggregate sub-bases can provide good water quality treatment.

Any permeable pavement will need to be able to capture the required design storm event run-off volume and discharge it in a controlled manner to the subgrade or downstream drainage system, while providing sufficient structural resistance to withstand loadings imposed by vehicles above. Table 4.2 (adapted from Interpave, 2005) recommends appropriate pavement systems for a range of sub-grade conditions.

Table 4.2 Selection of a pavement type (adapted from Interpave, 2005)

Ground characteristics		System 1: Total Infiltration	System 2: Partial Infiltration	System 3: No Infiltration
Permeability of subgrade defined by coefficient of permeability k(m/s)	10^{-6} to 10^{-3}	✓	✓	✓
	10^{-8} to 10^{-6}	×	✓	✓
	10^{-10} to 10^{-8}	×	×	✓
Highest expected water level within 1000 mm of formation level		×	×	✓
Pollutants present in subgrade		×	×	✓

Referring to the ground investigation (Soiltechnics, 2008), the infiltration rate of the Site is between 10^{-5} to 10^{-7} ms^{-1}. The highest expected water level is found below 1 m of the formation level. Therefore a System 2 - partial permeable pavement would be suitable. In System 2, a series of perforated pipes at formation level will convey the proportion of the rainfall that exceeds the infiltration capacity of the sub-soils, to the soakaway system. By preventing the build-up of water above the sub-grade, the risks to soil stability are reduced.

Total area of road and car parking in the Site is 12,253 m^2. The total storage to attenuate the run-off from road and car parking for 1 in 100 year 6 hour storm event with 30% allowance for climate change is 1,152 m^3 (calculations are presented in Appendix A). The permeable pavement should be designed to attenuate 1,152 m^3 of runoff volume in its sub base to prevent runoff being generated from these areas during storm events.

The thickness of the sub base required to provide sufficient storage with discharge outlets can be calculated by detailed hydrological and hydraulic modelling. The design should also ensure that 50% of the previous storm volume is emptied within 24 hours.

The permeable paving sub-base will thus be able to store the total rainfall that falls upon it during the design storm event. The calculations in Appendix A assumed a 10% runoff from permeable areas, so if the permeable roads and car parking areas have an effective 0% runoff this reduces the total storage requirement by 115 m^2.

Additionally, these permeable areas may be able to store some runoff generated from other areas where a suitable conveyance route is achievable, provided they are at least 5 metres away from building foundations. This is considered further in the next section.

4.3.3 Soakaways

The Site has been divided into 5 zones as shown in Figure 4.1

- Zone A – Runoff produced from the college development zone
- Zone B – Runoff produced from the school development zone

- Zone C – Runoff produced from the residential development zone
- Zone D – Runoff produced from the Tech Hub development zone
- Zone E – Runoff produced from the college playing field development zone

The area comprising soft landscaping within each development zone that could be available for infiltration is shown in Figure 4.1. Each soakaway area (A1, A2, B, C, D, E) will receive discharge through a network of swales and pipes.

The required attenuation storage capacity of the soakaways is governed by the volume of water that cannot be stored in the green roofs and in the permeable pavement for a 1 in 100 year 6 hour storm event including a 30% allowance for climate change. Any run-off which cannot be accommodated by the soakaways will require management by attenuation storage, controlled surface water ponding and storage in other elements of the surface water management train. To calculate the required attenuation it has been assumed that no infiltration occurs during the critical event. This is a conservative assumption, which can be refined when the infiltration rates of the chosen soakaway sites is known.

Detailed design and soakaway testing will be required to establish the required size of each soakaway which will be sensitive to ground conditions. Storage depths of approximately 1m distributed over the available soakaway areas (Total area available = 3,700 m^2) is shown in Figure 4.1 are estimated to provide the required storage based on a combined assessment of run-off from the whole site. During the detailed design phase the capacity of each soakaway should be calculated proportional to the amount of impermeable area and run-off in each individual development zone.

The minimum separation distance between the base of the soakaway and highest water level should be 1 m. The highest expected water level is found below 1.3 m of the formation level, however a review of the influence of high river levels on adjacent shallow groundwater levels is required.

The number and sizing of soakaways for the proposed development is anticipated to be less than the existing number of soakaways.

4.3.4 Provision of Storage

The total runoff volume produced by the Site for a 1 in 100 year 6 hour storm event with 30% climate change is calculated as 3,421 m^3. Some storage volume in the green roofs and permeable pavement has been identified above, leaving a requirement for 3002 m^3 (Table 4.3).

Table 4.3 Storage Requirement for 100 year + climate change

Total Storage (m^3)	Storage in Green roofs (m^3)	Storage in permeable Pavement (m^3)	Required storage in Soakaways and surface ponding (m^3)
3,421	304	115	3002

There are several options available for providing this storage volume within the development.

- Storage can be provided in the identified soakaway areas. These are 3700 m^2 in extent so attenuation structures, comprising geocellular crates or similar, could provide the total storage requirement in less than a metre depth. The sub-base material porosity will influence the design with an overall greater volume of permeable sub-base being required if the material used has a low effective porosity. Owing to the space constraints of the development, plastic geocellular crates (various commercial solutions are available on the market) may be most appropriate since they have a high void capacity of 95%.

- Extra storage can be used with in the permeable road and car parking areas where suitable conveyance routes exist. These are already accommodating the rainfall on their surfaces but additional storage capacity can be provided within the sub-base. The area of permeable roads and car parking is 12 253 m^2, so storage of 3002 m^3 could be achieved with an additional 250 mm of geocellular grid storage under the whole area. As these areas are intended to allow infiltration, areas which receive additional inflow should be more than 5 metres from building foundations to comply with building regulations. In practice therefore, not all of the permeable areas will be available for use, but a large proportion of the storage requirement could be accommodated.
- Some storage on impermeable areas is permissible for the extreme event being considered. The areas of hardstanding could be used to store 50 -100 mm of rain, depending on their intended use, proximity to buildings and possible surface water routes away from the areas. 50 mm of rain over the 13,153 m^2 of hardstanding would provide 657 m^3 of storage, so this option can only make a small contribution and is not particularly desirable..
- The College playing fields to the south of the Site could be used as surface water storage during an extreme event to manage and attenuate excess run-off. The playground is a water compatible structure as advised in the flood risk vulnerability and flood zone 'compatibility' guidance in Table 3 of NPPF (DCLG (2014)). The excess run-off could be conveyed to the playing field after the soakaways are filled to full capacity, though this would require a culvert under the road to provide access.

In addition to the storage options presented above, a reduction in the storage volume required could also be made by reducing the area of hardstanding which is positively drained. Some of these areas could simply be drained to the surrounding soft landscaped areas, reducing the runoff collected from them.

The above options show that there are several ways in which the critical event storm water runoff volume could be stored on the site. They are not mutually exclusive, and several of them could be employed in different parts of the site. The most feasible would appear at this stage to be storage within the soakaway areas, using shallow geo-cellular tanks, with some use of the permeable area sub-base where feasible. Geo-cellular tanks are commonly used on development sites to attenuate runoff and their use on this site would seem to be quite practical.

4.3.5 Discharge to the watercourse/drainage

The current local drainage plan indicates that the Site runoff currently drains to soakaways. It seems most of the surface water is managed onsite in the current configuration through the soakaways. The old soakaways will be demolished and a number of new soakaways will be built. A ground investigation was undertaken in 2008, but a more recent infiltration test would be required to provide sufficient information for a detailed design. There is no evidence of the Site runoff discharging into the River Crane or any other natural watercourses.

A site wide Utility Statement was undertaken by Atkins in May 2014 (Atkins, 2015). The report suggests presence of a gravity connection to a combined Thames Water manhole MH 5703, serving the eastern portion of the site. The layout of the sewers and drainage is presented in Appendix B of the Utility Statement. It should be noted that some of the existing pipes could not be surveyed during the existing site survey works, due to pipe blockages and the connection to MH 5703 could need to be verified. It has been assumed that the new development will drain entirely through SuDS features and that this sewer connection, should it exist, will not be used for the new drainage plan.

Considering the complex urban setting and Victorian drainage infrastructure, a detailed site investigation will be required at reserved matters stage to confirm whether discharge to the

Thames Water drainage network is possible. In some areas it may not be possible to use infiltration drainage if permeability results are found to be too low and there are high ground water levels. In these cases alternative methods of disposal will need to be considered. If this involves connecting to the existing Thames Water drainage system, a Pre-Development Application will be submitted at detailed design Stage.

Figure 4.1 Conceptual SUDS design

4.4 Construction/Demolition Phase

4.4.1 Construction Phase

Given the scale of the development, the current expectation is that the construction programme would commence in 2015 in a phased manner over a 4 year period. For the purposes of the ES, the year of completion and full operation of the Development is therefore considered to be 2019. Whilst full details regarding the demolition and construction works are not finalised, general information about the likely timing of activities, are described in Chapter 6 of Environmental Statement (Cascade, 2015).

The assumed programme of works and the overall likely sequence for the demolition and construction activities are divided into three phases comprising preparatory works, demolition and construction. Each phase is divided into further sub-phases. As a rule of thumb, the return period for temporary construction site drainage is to use a 10 year return period for site work that will not exceed two years - provided any exceedance can be accommodated without too much harm (CIRIA). The construction area is considered to be impermeable for the duration of the construction to evaluate the surface run-off for the worst case scenario. The construction area of each sub-phase and run-off generated for a 1 in 10 year rainfall is presented in Table 4.4.

Table 4.4 Construction Area* (m^2)

Phase	Construction Area (m^2)	Total run-off from construction area (10 year 6 hr rainfall) (m^3)
1a+1b	30,542	1,193
1c	53,638	2,095
1d+1e	22,776	889
2a	38,731	1,513
2b	13,806	539
2c+2d	13,965	545
3a	5,953	232
3b+3c	8,516	333

*Derived from Table 2.1

A staged approach is undertaken to retain the interim site drainage (existing soakaways) during the construction phase, construction of interim site drainage infrastructure and construction of new drainage infrastructure as presented in Table 4.7. The detailed schematic is presented in Appendix B.

4.4.2 Dewatering

The REEC development scheme will not have large infrastructure located below ground such as basements or underground parking. For the purposes of REEC, at the time of writing this report, it is reasonable to assume dewatering of the gravel is not required. Ground investigation undertaken by Soiltechnics in 2008 reported groundwater was encountered at between 1.1-3.5 mbgl in exploratory excavations. The borehole records of Soiltechnics were reported in May, 2008. The groundwater table is anticipated to be higher in the winter. A more detailed assessment of ground conditions and excavation area would be required to provide an estimation of dewatering volumes (if any) during construction. At detailed design stage, if the depth of foundation is greater than the maximum groundwater table, dewatering may be reconsidered.

4.4.3 Construction Phase 1e and Phase 2d

Phase 1e and Phase 2d are the end of the first and second construction phases. Phase 3 represents the final drainage scheme that will become the permanent operational system. Operational Phase (Phase 3c) has been discussed in the previous chapter.

The surface water run-off and drainage strategy at the end of each construction phase is separately evaluated. Total permeable and impermeable areas at the end of construction Phase 1e and Phase 2d are presented in Table 4.5.

Table 4.5 Permeable and Impermeable Area* (m^2) of Phase 1e and Phase 2d

	Phase 1e (m^2)	**Phase 2d (m^2)**
Permeable	43,132	48,852
Impermeable	44,484	38,764
Total	**87,617**	**87,617**

*Derived from Table 2.1

The total runoff volumes produced by the existing and proposed development for different return period 6 hour storms for Phase 1e and Phase 2d are summarised in Table 4.6.

Table 4.6 Estimated run-off (m^3) at the end of Phase 1e and Phase 2d

Return period of rainfall event (6 hours)	**Rainfall (mm)**	**Phase 1e (m^3)**	**Phase 2d (m^3)**
1 in 10 year	39.05	1,906	1,705
1 in 30 year	52.57	2,565	2,295
1 in 100 year	72.31	3,528	3,156

A surface water strategy and interim drainage for Phase 1e and Phase 2d is presented in Appendix B.

Table 4.7 Surface Water Drainage during Construction/Demolition Phase

Phase	Construction area (m^2)	Total interim storage required from construction area (m^3)	Existing surface water management	Interim Surface water management	Final surface water management
1a+1b	30,542	1,193	• Protect existing drainage system • All the existing soakaways to be retained	• Install silt traps and settlement pits to prevent sediment entering soakaways, to be maintained and upgraded throughout the construction phases • Direct surface run-off from the northern construction site to Soakaway 3 and 13 • Build Soakaway E • Create an Interim Pond A to attenuate surface run-off from the southern construction area and controlled discharge to Soakaway E	• All the existing soakaways to be retained • Soakaway E is completed • An interim Pond A for the Southern construction site is completed
1c	53,638	2,095	• Protect existing drainage system • Soakaways 1, 3, 13, 15, 16, 17 to be retained	• Create an interim Pond B to attenuate surface run-off from the the northern construction site to Soakaway 3 and 13 • Attenuate surface run-off to the Pond A from the southern construction site and controlled discharge to Soakaway E • Build new Soakaway A2 and B	• Soakaways 1, 3, 13, 15, 16, 17 to be retained • Soakaways 2,4,5,6,7,8,9,10,11to be demolished • An interim Pond B for the northern construction site is completed • The interim Pond A in the southern construction site to be retained • Soakaway A2 and B are completed
1d+1e	22,776	889	• Protect existing drainage system • Soakaways 3 and13 to be retained	• Create an interim Pond C1 and Pond C2 to attenuate surface run-off from the Central construction site and controlled discharge to Soakaway 3, 13, A2 and B	• Soakaways 1,3 to be retained • Soakaways 1,15,16,17 to be demolished • Interim Pond C1 and Pond C2 for the Central construction site are completed • The interim Pond B for the Northern construction site to be demolished

2a	38,731	1,513	• Protect existing drainage system • Soakaways 3 and13 to be retained	• Relocate Pond C1 and use this to attenuate surface run-off from the Central construction site and controlled discharge to Soakaways 3 and 13 • Attenuate surface run-off from the Southern construction site to Pond A and controlled discharge to Soakaway E • Build new Soakaway A1	• The interim Pond C1 and Pond C2 for the Central construction site to be retained • Soakaway A1 is completed
2b	13,806	539	• Protect existing drainage system • Soakaways 3 and 13 to be retained	• Attenuate surface run-off from the Central construction area to Pond C2 and controlled discharge to Soakaway A1 and B	• The interim Pond A for the southern construction site to be demolished
2c+2d	13,965	545	• Protect existing drainage system • No existing soakaways	• Attenuate surface run-off from the Central construction site to Pond C1 and controlled discharge to Soakaway A1 • Create an interim Pond D to attenuate surface run-off from the Tech Hub construction site and controlled discharge to Soakaway A2 • Build new Soakaways D	• Soakaways 3, 13 to be demolished • An interim Pond D for the Tech Hub construction site is completed • The interim Pond C2 for the Central construction site to be demolished • Soakaways D is completed
3a	5,953	232	• Protect existing drainage system • No existing soakaways	• Attenuate surface run-off from the Tech Hub construction area to Pond D and controlled discharge to Soakaway A2 • Discharge of run-off from the small construction site near residential development to Soakaway A1	• The interim Pond D for the Tech Hub to be retained
3b+3c	8,516	333	• Protect existing drainage system • No existing soakaways	• Attenuate surface run-off from the Central construction site to Pond C1 and controlled discharge to Soakaway C • Build new Soakaways C	• Pond C1 and Pond D to be demolished at the end of construction

4.5 Water Quality

A key requirement of any SuDS system is that it protects the receiving water body from the risk of pollution and this is particularly true for surface water courses and groundwater aquifers. This can be effectively managed by an appropriate “train” or sequence of SuDS components that are connected in series. The frequent and short duration rainfall events or the initial phase of longer duration events are those that are mostly loaded with potential contaminants (silts, fines, heavy metals and various organic and inorganic contaminants). Therefore, the first 5-10 mm of rainfall (first flush) should be adequately treated with SuDS that are most effective in removing these potential contaminants (infiltration to the ground, filtration through a parking area sub-base, detention and sedimentation through storage in ponds and swales).

Typically, the Environment Agency will require details of the proposed soakaway systems, showing pollution prevention measures. It is a typical requirement that there is an ‘unsaturated zone’ between the base of the soakaway system and the groundwater table (saturated zone) providing attenuation capacity. The review undertaken by Soiltechnics (Soiltechnics, 2008) did not identify any recorded history of any pollution events, or trading activities which could generate a source of contamination on the site. There were no observed onsite activities or activities on adjacent sites which are likely to provide a contaminative source. Trial pits identified several localised areas where soils were potentially impacted by hydrocarbons and these will be remediated as part of the construction works. Contamination hotspots should be avoided when locating soakaway systems. The main chalk aquifer is isolated from the soakaways by the London Clay.There are superficial deposits of Kempton Park Gravel Formation (sand and gravels) beneath the Site (BGS, 2014) and these are classified as a principal aquifer. The proposed SuDS must account for a sufficient number of treatment stages to protect the receiving aquifer. The minimum number of treatment stages will depend of the sensitivity of the receiving groundwater body and the potential hazard associated with the proposed development.

The minimum number of treatment stages depends on the potential hazards on the site and are characterised in Table 4.8; together with the sensitivity of the receiving water body to pollution as categorised in Table 4.9. The site is considered to be G3 due to the presence of a principle aquifer.

Table 4.8 Level of hazard

Hazard	Source of hazard
Low	Roof drainage
Medium	Residential, amenity, commercial, industrial uses including car parking spaces and roads
High	Areas used for handling and storage or chemicals and fuels, handling of storage and waste (incl. scrap-yards).

Table 4.9 has been derived from the Draft National Standards (Defra, 2011) and indicates a series of treatment stages before the surface runoff reaches the infiltration devices.

Table 4.9 Minimum number of treatment stages for groundwater.

	Sensitivity of the groundwater below the Site	Hazard		
		Low	Med	High
G1	Source Protection Zone 1; within 50 m of an existing well, a spring or a borehole that supplies potable water	1	3	Consult with

G2	Discharge into or immediately adjacent to a sensitive receptor that could be influenced by infiltrated water. Includes designated nature conservation, heritage and landscape sites – including Biodiversity Action Plan (BAP) habitats and Protected Species.	1	3	
G3	Source protection Zone 2 or Source Protection Zone 3 or Principal Aquifer.	1	3	
G4	Secondary Aquifer.	1	2	
G5	Unproductive Strata	1	2	

4.5.1 Construction/Demolition Phase

According to Table 4.8, the construction/demolition phase of the development is considered as high hazard due to the handling of building waste and construction material. Contaminated land will be remediated prior to construction works commencing. The discharge of surface runoff from a site categorised as high hazard may not be permitted. It is advisable to consult the Environment Agency about environmental permitting to determine whether a permit is required. If a site is categorised as high hazard but a permit is not required, then it is treated as a medium hazard.

4.5.2 Operational Phase

According to the Draft National Standards (Defra, 2011) (Table 4.8), the operational phase of the development is a combination of low (roof water) to medium hazard (runoff from car parking and road). Therefore the minimum number of treatment stages required in the operational stage is according to G3.

Permeable car parking and roads would offer sufficient treatment stages (storage/attenuation, filtration through sub-base and filtration through the unsaturated soil zone). However, these would have to be built with sufficient sub-base thickness and material grading and provided the maximum groundwater level is at least 1 m below the base of the parking/road areas where the unsaturated ground can act as a filtration medium (CIRIA, 2007). Permeable parking and road surfaces would also adequately treat the first flush volumes. Roof water could be diverted to the parking area sub-base if sufficient storage volumes are available. These considerations would be made at detailed design stage.

4.6 SuDS maintenance

Regular maintenance is essential to ensure effective operation of the soakaway(s) over the intended lifespan of the proposed development. The SuDS Manual (C697) (CIRIA, 2007) provides a maintenance schedule for soakaways with details of the necessary required actions as shown in Table 4.10 below.

Table 4.10 Soakaway operation and maintenance requirements

Maintenance schedule	Required action	Frequency
Regular maintenance	Remove sediment and debris from pre-treatment devices and floor of inspection tube or chamber.	Annually.
	Cleaning of gutters and any filters on downpipes	Annually.
	Trimming any roots that may be causing blockages	Annually

		(or as required)
	Checking and removing any blockages in the soakaway overflow pipes	Monthly
Occasional maintenance	-	-
Remedial actions	Reconstruct soakaway and/or replace or clean void fill, if performance deteriorates or failure occurs.	As required.
	Replacement of clogged geotextile.	As required.
Monitoring	Inspect silt traps and note rate of sediment acclimation.	Monthly in the first year and then annually.
	Check soakaway to ensure emptying is occurring	Annually

The recommended responsibilities for the maintenance of each soakaway, in relation to the development zones, are shown on Figure 4.1.

For soakaways that are designed for the college development (zone A), the school development (zone B) and the Tech Hub development (zone D), it shall be the responsibility of the respective institution to carry out the required maintenance of the soakaway systems within their plot. Where the soakaways serve multiple properties (zone C), it is assumed that the required maintenance will be achieved through a suitable management agreement between the relevant house owners.

As for the permeable pavements, the general advice is that the maintenance schedule should allow for a bi-annual suction sweep with re-instatement of joint refill.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

- The existing use of the Site is Richmond upon Thames College. The proposed new use of the Site is a mix of new college building, secondary school and school for children with special needs, a media office and residential development. Re-development will create more open space and permeable paving. The increase in permeable ground cover is 19.5% and reduction of impermeable groundcover is 23% compared to the existing site (see Table 3.2).
- This has resulted in an increase (6%) in total runoff storage requirement for the Site during a 1 in 100 year 6 hour rainfall event, after an allowance for future climate change at 30% (see Table 3.5).
- The ground investigation results show that the Kempton Park Gravel deposits and Made Ground generally exhibit a varied permeability across the site.
- The existing soakaways are sufficient to manage the current site runoff. However they cannot be retained as the proposed building footprints overlap with the locations of the soakaways. A new drainage strategy and a conceptual SuDS design is therefore proposed.
- The new drainage scheme should be able to attenuate 100% of the site runoff through an infiltration SuDS system and options for storing runoff during the critical 6 hour 100 year plus climate change event are available on site..
- Through implementing green roofs and private gardens at the Site, the biodiversity will improve compared with the Site's previous college buildings.
- It is likely that the performance of the SuDS features and water quality will improve over the current development where the drainage effectiveness of the existing soakaways is assumed to be depreciated due to siltation and aging.

5.2 Recommendations

- London Plan Drainage Hierarchy, 2011 recommends to store rainwater for later use (recycling) as the first priority in the hierarchy tree so that amount of surface water managed at the bottom of the hierarchy is minimised. This could be further investigated to maintain the soft landscaping and other amenities with water being recycled on site.
- The green roofs and permeable pavement are designed to make sure they can intercept rainfall and site runoff to their full capacity before discharging to the soakaways.
- The amount of run-off from different zones of the Site (zone A to zone E) should be directed towards their respective soakaways on a pro-rata basis to make sure that the full capacity of each soakaway is used proportionally to the amount of run-off they are likely to intercept from the different parts of the Site, as shown in Figure 4.1.
- Emergency provision of a surface water storage area in the College playing field development zone needs to be maintained to manage the excess volume from a 1 in 100 year 6 hour + CC rainfall event.
- The SuDS features require maintenance to ensure effective operation in the long term. A schedule of required actions and management strategy has been provided in Section 4.6.
- Detailed infiltration testing and consultation with Thames Water and the Environment Agency is recommended for detailed design of the SuDS scheme.

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APPENDICES

APPENDIX A

Surface runoff calculation

Summary (Baseline/Operational Phase)

Entire site area:	8.762	ha	
Climate Change Factor	30%		
Permeable Surface (ha)		4.761	5.691
Impermeable Surface (ha)	8.762	4.001	3.071

1 in 10 year

Greenfield run-off volume total: 342.14 m^3

RUN-OFF During a 1 in 10 year 6 hour event:	**Greenfield Site**	**Current Development**	**Proposed Development +cc**
From permeable surfaces (using GF total run-off) (m^3)	342.14	185.91	288.91
From impermeable surfaces (m^3)		1562.31	1558.74
TOTAL run-off produced from Site (m^3)	342.14	1748.23	1847.65

Difference between greenfield site and proposed development (m^3):	**1505.51**
	440.02%
Difference between current and proposed development (m^3):	**99.43**
	5.69%
Peak Greenfield run-off rate that must not be exceeded in the run-off from the proposed development (l/s):	**1.05**

1 in 30 year

Greenfield run-off volume total: 460.60 m^3

RUN-OFF During a 1 in 30 year 6 hour event:	**Greenfield Site**	**Current Development**	**Proposed Development +cc**
From permeable surfaces (using GF total run-off) (m^3)	460.60	250.28	388.94
From impermeable surfaces (m^3)		2103.22	2098.41
TOTAL run-off produced from Site (m^3)	460.60	2353.50	2487.35

Difference between greenfield site and proposed development (m^3):	**2026.75**
	440.02%
Difference between current and proposed development (m^3):	**133.85**
	5.69%
Peak Greenfield run-off rate that must not be exceeded in the run-off from the proposed development (l/s):	**2.76**

1 in 100 year

Greenfield run-off volume total: 633.56 m^3

RUN-OFF During a 1 in 100 year 6 hour event:	**Greenfield Site**	**Current Development**	**Proposed Development +cc**
From permeable surfaces (using GF total run-off) (m^3)	633.56	344.26	534.99
From impermeable surfaces (m^3)		2892.98	2886.36
TOTAL run-off produced from Site (m^3)	633.56	3237.24	3421.35

Difference between greenfield site and proposed development (m^3):	**2787.79**
	440.02%
Difference between current and proposed development (m^3):	**184.11**
	5.69%
Peak Greenfield run-off rate that must not be exceeded in the run-off from the proposed development (l/s):	**3.94**

Developed site (Permeable Pavement) run-off calculation sheet

1 in 10 year

Proposed permeable area	1.225	ha
CC Factor	30%	
Total volume for 6 hour event including climate change	622.02	m³

Duration hours	**Rainfall 1 yr event mm**	**Rainfall intensity 1 yr event mm/hr**
0.25	18.05	72.20
0.5	21.36	42.72
0.75	23.57	31.43
1	25.28	25.28
2	29.91	14.96
3	33.00	11.00
4	35.39	8.85
5	37.36	7.47
6	39.05	6.51
8	41.87	5.23
10	44.20	4.42
12	46.20	3.85
16	49.86	3.12
20	52.89	2.64
24	55.51	2.31
28	57.82	2.07
32	59.90	1.87
36	61.80	1.72
40	63.55	1.59
44	65.17	1.48
48	66.69	1.39

1 in 30 year

Proposed impermeable area	1.225	ha
CC Factor	30%	
Total volume for 6 hour event including climate change	837.38	m³

Duration hours	**Rainfall 30 yr event mm**	**Rainfall intensity 30 yr event mm/hr**
0.25	26.60	106.40
0.5	30.86	61.72
0.75	33.66	44.88
1	35.80	35.80
2	41.54	20.77
3	45.31	15.10
4	48.19	12.05
5	50.55	10.11
6	52.57	8.76
8	55.91	6.99
10	58.65	5.87
12	60.99	5.08
16	65.28	4.08
20	68.82	3.44
24	71.85	2.99
28	74.52	2.66
32	76.91	2.40
36	79.08	2.20
40	81.07	2.03
44	82.92	1.88
48	84.64	1.76

1 in 100 year

Proposed impermeable area	1.225	ha
CC Factor	30%	
Total volume for 6 hour event including climate change	1151.82	m³

Duration hours	**Rainfall 100 yr event mm**	**Rainfall intensity 100 yr event mm/hr**
0.25	40.29	161.16
0.5	45.77	91.54
0.75	49.32	65.76
1	52.00	52.00
2	59.07	29.54
3	63.65	21.22
4	67.11	16.78
5	69.92	13.98
6	72.31	12.05
8	76.24	9.53
10	79.43	7.94
12	82.14	6.85
16	87.16	5.45
20	91.26	4.56
24	94.75	3.95
28	97.81	3.49
32	100.54	3.14
36	103.00	2.86
40	105.26	2.63
44	107.35	2.44
48	109.29	2.28

Summary (End of Construction Phase 1e)

Entire site area:	8.762	ha	
Climate Change Factor	0%	Existing	Proposed
Permeable Surface (ha)		0.000	4.313
Impermeable Surface (ha)	8.762	0.000	4.448

1 in 10 year

Greenfield run-off volume total: 342.14 m^3

RUN-OFF During a 1 in 10 year 6 hour event:	Greenfield Site	Current Development	Proposed Development +cc
From permeable surfaces (using GF total run-off) (m^3)	342.14	0.00	168.43
From impermeable surfaces (m^3)		0.00	1737.10
TOTAL run-off produced from Site (m^3)	342.14	0.00	1905.53

1 in 30 year

Greenfield run-off volume total: 460.60 m^3

RUN-OFF During a 1 in 30 year 6 hour event:	Greenfield Site	Current Development	Proposed Development +cc
From permeable surfaces (using GF total run-off) (m^3)	460.60	0.00	226.74
From impermeable surfaces (m^3)		0.00	2338.52
TOTAL run-off produced from Site (m^3)	460.60	0.00	2565.27

1 in 100 year

Greenfield run-off volume total: 633.56 m^3

RUN-OFF During a 1 in 100 year 6 hour event:	Greenfield Site	Current Development	Proposed Development +cc
From permeable surfaces (using GF total run-off) (m^3)	633.56	0.00	311.89
From impermeable surfaces (m^3)		0.00	3216.64
TOTAL run-off produced from Site (m^3)	633.56	0.00	3528.53

Summary (End of Construction Phase 2d)

Entire site area:	8.762	ha	
Climate Change Factor	0%	Existing	Proposed
Permeable Surface (ha)		0.000	4.885
Impermeable Surface (ha)	8.762	0.000	3.876

1 in 10 year

Greenfield run-off volume total: 342.14 m^3

RUN-OFF During a 1 in 10 year 6 hour event:	Greenfield Site	Current Development	Proposed Development +cc
From permeable surfaces (using GF total run-off) (m^3)	342.14	0.00	190.77
From impermeable surfaces (m^3)		0.00	1513.73
TOTAL run-off produced from Site (m^3)	342.14	0.00	1704.50

1 in 30 year

Greenfield run-off volume total: 460.60 m^3

RUN-OFF During a 1 in 30 year 6 hour event:	Greenfield Site	Current Development	Proposed Development +cc
From permeable surfaces (using GF total run-off) (m^3)	460.60	0.00	256.81
From impermeable surfaces (m^3)		0.00	2037.82
TOTAL run-off produced from Site (m^3)	460.60	0.00	2294.64

1 in 100 year

Greenfield run-off volume total: 633.56 m^3

RUN-OFF During a 1 in 100 year 6 hour event:	Greenfield Site	Current Development	Proposed Development +cc
From permeable surfaces (using GF total run-off) (m^3)	633.56	0.00	353.25
From impermeable surfaces (m^3)		0.00	2803.02
TOTAL run-off produced from Site (m^3)	633.56	0.00	3156.27

Construciton site (1a+1b) run-off calculation sheet

1 in 10 year

Proposed area	3.054	ha
CC Factor	0%	
Total volume for 6 hour event	1192.67	m³

Duration hours	Rainfall 10 yr event mm	Rainfall intensity 10 yr event mm/hr
0.25	18.05	72.20
0.5	21.36	42.72
0.75	23.57	31.43
1	25.28	25.28
2	29.91	14.96
3	33.00	11.00
4	35.39	8.85
5	37.36	7.47
6	39.05	6.51
8	41.87	5.23
10	44.20	4.42
12	46.20	3.85
16	49.86	3.12
20	52.89	2.64
24	55.51	2.31
28	57.82	2.07
32	59.90	1.87
36	61.80	1.72
40	63.55	1.59
44	65.17	1.48
48	66.69	1.39

1 in 30 year

Proposed impermeable area	3.054	ha
CC Factor	0%	
Total volume for 6 hour event	1605.59	m³

Duration hours	Rainfall 30 yr event mm	Rainfall intensity 30 yr event mm/hr
0.25	26.60	106.40
0.5	30.86	61.72
0.75	33.66	44.88
1	35.80	35.80
2	41.54	20.77
3	45.31	15.10
4	48.19	12.05
5	50.55	10.11
6	52.57	8.76
8	55.91	6.99
10	58.65	5.87
12	60.99	5.08
16	65.28	4.08
20	68.82	3.44
24	71.85	2.99
28	74.52	2.66
32	76.91	2.40
36	79.08	2.20
40	81.07	2.03
44	82.92	1.88
48	84.64	1.76

1 in 100 year

Proposed impermeable area	3.054	ha
CC Factor	0%	
Total volume for 6 hour event	2208.49	m³

Duration hours	Rainfall 100 yr event mm	Rainfall intensity 100 yr event mm/hr
0.25	40.29	161.16
0.5	45.77	91.54
0.75	49.32	65.76
1	52.00	52.00
2	59.07	29.54
3	63.65	21.22
4	67.11	16.78
5	69.92	13.98
6	72.31	12.05
8	76.24	9.53
10	79.43	7.94
12	82.14	6.85
16	87.16	5.45
20	91.26	4.56
24	94.75	3.95
28	97.81	3.49
32	100.54	3.14
36	103.00	2.86
40	105.26	2.63
44	107.35	2.44
48	109.29	2.28

Construciton site (1c) run-off calculation sheet

1 in 10 year

Proposed area	5.364	ha
CC Factor	0%	
Total volume for 6 hour event	2094.56	m^3

Duration hours	Rainfall 10 yr event mm	Rainfall intensity 10 yr event mm/hr
0.25	18.05	72.20
0.5	21.36	42.72
0.75	23.57	31.43
1	25.28	25.28
2	29.91	14.96
3	33.00	11.00
4	35.39	8.85
5	37.36	7.47
6	39.05	6.51
8	41.87	5.23
10	44.20	4.42
12	46.20	3.85
16	49.86	3.12
20	52.89	2.64
24	55.51	2.31
28	57.82	2.07
32	59.90	1.87
36	61.80	1.72
40	63.55	1.59
44	65.17	1.48
48	66.69	1.39

1 in 30 year

Proposed impermeable area	5.364	ha
CC Factor	0%	
Total volume for 6 hour event	2819.75	m^3

Duration hours	Rainfall 30 yr event mm	Rainfall intensity 30 yr event mm/hr
0.25	26.60	106.40
0.5	30.86	61.72
0.75	33.66	44.88
1	35.80	35.80
2	41.54	20.77
3	45.31	15.10
4	48.19	12.05
5	50.55	10.11
6	52.57	8.76
8	55.91	6.99
10	58.65	5.87
12	60.99	5.08
16	65.28	4.08
20	68.82	3.44
24	71.85	2.99
28	74.52	2.66
32	76.91	2.40
36	79.08	2.20
40	81.07	2.03
44	82.92	1.88
48	84.64	1.76

1 in 100 year

Proposed impermeable area	5.364	ha
CC Factor	0%	
Total volume for 6 hour event	3878.56	m^3

Duration hours	Rainfall 100 yr event mm	Rainfall intensity 100 yr event mm/hr
0.25	40.29	161.16
0.5	45.77	91.54
0.75	49.32	65.76
1	52.00	52.00
2	59.07	29.54
3	63.65	21.22
4	67.11	16.78
5	69.92	13.98
6	72.31	12.05
8	76.24	9.53
10	79.43	7.94
12	82.14	6.85
16	87.16	5.45
20	91.26	4.56
24	94.75	3.95
28	97.81	3.49
32	100.54	3.14
36	103.00	2.86
40	105.26	2.63
44	107.35	2.44
48	109.29	2.28

Construciton site (1d+1e) run-off calculation sheet

1 in 10 year

Proposed impermeable area	2.278	ha
CC Factor	0%	
Total volume for 6 hour event	889.40	m³

Duration hours	Rainfall 10 yr event mm	Rainfall intensity 10 yr event mm/hr
0.25	18.05	72.20
0.5	21.36	42.72
0.75	23.57	31.43
1	25.28	25.28
2	29.91	14.96
3	33.00	11.00
4	35.39	8.85
5	37.36	7.47
6	39.05	6.51
8	41.87	5.23
10	44.20	4.42
12	46.20	3.85
16	49.86	3.12
20	52.89	2.64
24	55.51	2.31
28	57.82	2.07
32	59.90	1.87
36	61.80	1.72
40	63.55	1.59
44	65.17	1.48
48	66.69	1.39

1 in 30 year

Proposed impermeable area	2.278	ha
CC Factor	0%	
Total volume for 6 hour event	1197.33	m³

Duration hours	Rainfall 30 yr event mm	Rainfall intensity 30 yr event mm/hr
0.25	26.60	106.40
0.5	30.86	61.72
0.75	33.66	44.88
1	35.80	35.80
2	41.54	20.77
3	45.31	15.10
4	48.19	12.05
5	50.55	10.11
6	52.57	8.76
8	55.91	6.99
10	58.65	5.87
12	60.99	5.08
16	65.28	4.08
20	68.82	3.44
24	71.85	2.99
28	74.52	2.66
32	76.91	2.40
36	79.08	2.20
40	81.07	2.03
44	82.92	1.88
48	84.64	1.76

1 in 100 year

Proposed impermeable area	2.278	ha
CC Factor	0%	
Total volume for 6 hour event	1646.93	m³

Duration hours	Rainfall 100 yr event mm	Rainfall intensity 100 yr event mm/hr
0.25	40.29	161.16
0.5	45.77	91.54
0.75	49.32	65.76
1	52.00	52.00
2	59.07	29.54
3	63.65	21.22
4	67.11	16.78
5	69.92	13.98
6	72.31	12.05
8	76.24	9.53
10	79.43	7.94
12	82.14	6.85
16	87.16	5.45
20	91.26	4.56
24	94.75	3.95
28	97.81	3.49
32	100.54	3.14
36	103.00	2.86
40	105.26	2.63
44	107.35	2.44
48	109.29	2.28

Construciton site (2a) run-off calculation sheet

1 in 10 year

Proposed impermeable area	3.873	ha
CC Factor	0%	
Total volume for 6 hour event	1512.45	m^3

Duration hours	**Rainfall 10 yr event mm**	**Rainfall intensity 10 yr event mm/hr**
0.25	18.05	72.20
0.5	21.36	42.72
0.75	23.57	31.43
1	25.28	25.28
2	29.91	14.96
3	33.00	11.00
4	35.39	8.85
5	37.36	7.47
6	39.05	6.51
8	41.87	5.23
10	44.20	4.42
12	46.20	3.85
16	49.86	3.12
20	52.89	2.64
24	55.51	2.31
28	57.82	2.07
32	59.90	1.87
36	61.80	1.72
40	63.55	1.59
44	65.17	1.48
48	66.69	1.39

1 in 30 year

Proposed impermeable area	3.873	ha
CC Factor	0%	
Total volume for 6 hour event	2036.09	m^3

Duration hours	**Rainfall 30 yr event mm**	**Rainfall intensity 30 yr event mm/hr**
0.25	26.60	106.40
0.5	30.86	61.72
0.75	33.66	44.88
1	35.80	35.80
2	41.54	20.77
3	45.31	15.10
4	48.19	12.05
5	50.55	10.11
6	52.57	8.76
8	55.91	6.99
10	58.65	5.87
12	60.99	5.08
16	65.28	4.08
20	68.82	3.44
24	71.85	2.99
28	74.52	2.66
32	76.91	2.40
36	79.08	2.20
40	81.07	2.03
44	82.92	1.88
48	84.64	1.76

1 in 100 year

Proposed impermeable area	3.873	ha
CC Factor	0%	
Total volume for 6 hour event	2800.64	m^3

Duration hours	**Rainfall 100 yr event mm**	**Rainfall intensity 100 yr event mm/hr**
0.25	40.29	161.16
0.5	45.77	91.54
0.75	49.32	65.76
1	52.00	52.00
2	59.07	29.54
3	63.65	21.22
4	67.11	16.78
5	69.92	13.98
6	72.31	12.05
8	76.24	9.53
10	79.43	7.94
12	82.14	6.85
16	87.16	5.45
20	91.26	4.56
24	94.75	3.95
28	97.81	3.49
32	100.54	3.14
36	103.00	2.86
40	105.26	2.63
44	107.35	2.44
48	109.29	2.28