

FORMER COX & WYMAN SITE
CARDIFF ROAD
READING

**FLOOD RISK ASSESSMENT
SUDS ASSESSMENT**

THAMES PROPERTIES LTD

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This Flood Risk Assessment was commissioned by Thames Properties Ltd in February 2017 to assess the risk of flooding and develop a surface water management plan for the former Cox & Wyman site.

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GLOSSARY

AOD	Above Ordnance Datum
BGL	Below Ground Level
BGS	British Geological Survey
DEFRA	Department for Environment Food and Rural Affairs
DTM	Digital Terrain Model
EA	Environment Agency
FEH	Flood Estimation Handbook
FRA	Flood Risk Assessment
LBRuT	The London Borough of Richmond-upon-Thames
LiDAR	Light Detection And Ranging
LLFA	Lead Local Flood Authority
LPA	Local Planning Authority
NPPF	National Planning Policy Framework
PFRA	Preliminary Flood Risk Assessment
PPG	Planning Practise Guide
SFRA	Strategic Flood Risk Assessment
SuDS	Sustainable Drainage Systems
SWMP	Surface Water Management Plan

EXECUTIVE SUMMARY

The proposed development is located on the former Cox & Wyman site in Reading, 350m south of the River Thames. The site has an approximate area of 1.33 ha and proposals are for construction of 96 residential units with associated car parking and landscaping. The site lies within Flood Zone 1 of the Environment Agency Flood Map for Planning and is surrounded by Flood Zone 2. This Flood Risk Assessment and drainage strategy has been prepared in accordance with the National Planning Policy Framework and associated Planning Practice Guidance to accompany the planning application.

The risk of flooding including anticipated impacts of climate change from all sources have been assessed for the lifetime of the development. The dominant source of flooding at the site is identified as fluvial flooding from the River Thames. Modelled flood levels for the 1% annual probability event were provided by the Environment Agency and an appropriate allowance for climate change was added to produce a design level for flood mitigation of 38.42 m AOD ('central' climate change allowance). Based on the topographic survey of the site, a small area in the south-east corner of the site would flood to a maximum of depth of 170mm in this event.

Proposed finished floor levels for the development have been raised a minimum of 300 mm freeboard above the design flood level to 38.72 m AOD where possible. In order to achieve step free access to the houses on the south-eastern corner of the site, floor levels have been set to a minimum of 130 mm above the design flood level. In addition, all finished floor levels are set above the minimum recommended flood level to inform flood resilience of 38.52 m AOD ('higher central' climate change allowance).

The proposed building footprint encroaches on 31 m² of the 1% annual probability plus climate change flood extent in the south-east of the site, thereby potentially reducing available floodplain storage. Floodplain compensatory storage will be provided on a level-for-level basis with a hydraulic connection to the floodplain by lowering part of the landscaping/rear gardens in the same location.

The drainage strategy has been prepared in accordance with national policy ensuring, through application of the Sustainable Drainage Systems hierarchy, that surface water runoff rates are reduced to as close as possible to greenfield rates post-development, including an allowance for climate change. The peak runoff rate for the existing site in the 100-year rainfall event is estimated to be 349 l/s. Through a combination of increased permeable landscaping, and provision of green roofs and permeable paving with granular sub-base, the peak runoff rate for the 100-year plus climate change event will be limited to 18 l/s, equal to a 95% reduction on the existing scenario.

No surface water flooding is predicted in the 100-year plus climate change event, due to the attenuation storage provided in the sub-base of permeable paving. Surface water runoff will discharge to assumed connections to the Thames Water surface water sewer network in Addison Road, Cardiff Road and Milford Road.

1 INTRODUCTION

General Information

- 1.1 The proposed development is located on the former Cox & Wyman site on Meadow Road in Reading. The site area is approximately 1.33 ha and the number of residential units proposed is 96.
- 1.2 The site lies within Flood Zone 1 and is surrounded by Flood Zone 2 of the Environment Agency (EA) Flood Map for Planning. A full Flood Risk Assessment has therefore been prepared to accompany the planning application.

Scope of Study

- 1.3 The main objectives of this study are to:
 - assess the risk and implications of flooding on the site from all possible flood sources, including the future risk as a result of projected climate change over the lifetime of the development;
 - assess the impact of the proposed development on flood risk elsewhere, with particular consideration of surface water management on the site;
 - provide a Flood Risk Assessment of the site, compliant with the guidelines set out in the NPPF¹ and associated Planning Practice Guidance (PPG)², to accompany any application for planning permission;
 - produce a drainage strategy for the proposed development incorporating SuDS wherever practicable, achieving betterment on the existing scenario in terms of surface water runoff rates and volumes, in accordance with national policy;
 - provide advice on the site layout and design that will ensure safe operation of the site in an extreme flood or rainfall event, and avoid causing an unacceptable impact on the risk of flooding elsewhere.

¹ Department for Communities and Local Government (2012), National Planning Policy Framework.

² Department for Communities and Local Government (2014), Planning Practice Guidance: Flood risk and coastal change. www.gov.uk/guidance/flood-risk-and-coastal-change. Accessed 21/07/2017.

2 SITE DESCRIPTION

Location

- 2.1 The proposed development is located at the former Cox & Wyman site in central Reading, centred on grid coordinates (470934, 174118), 350m south of the River Thames. The site is bounded to the north by Meadow Road, to the west by Milford Road, to the south by Cardiff Road and to the east by Addison Road, as shown in Figure 1.

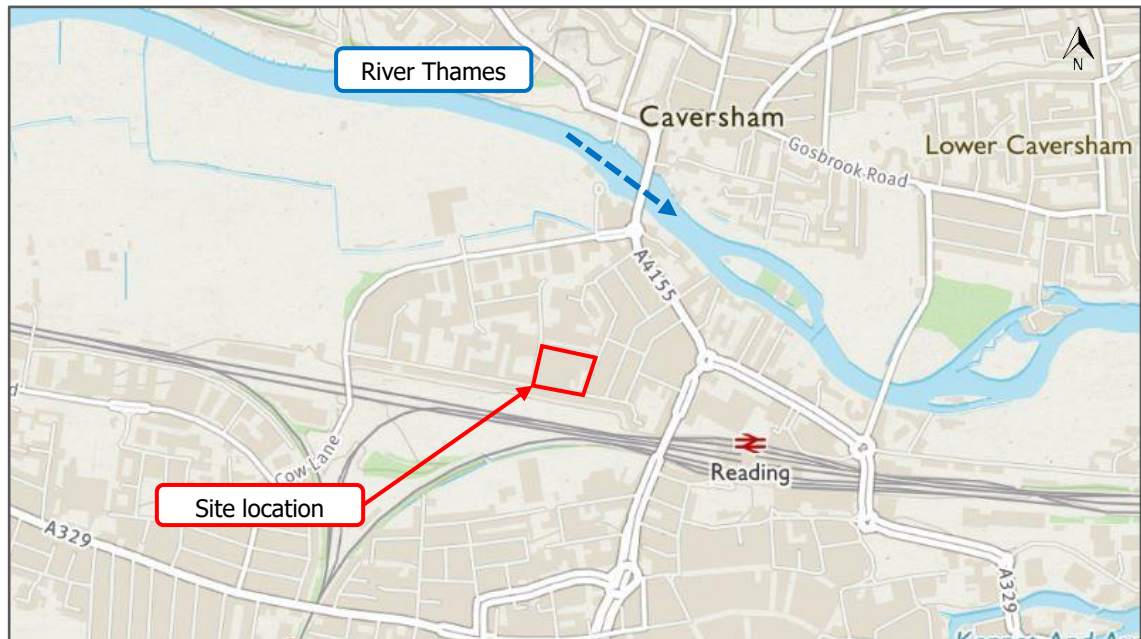


Figure 1 – Location of proposed development³

Existing Development

- 2.2 The existing site is occupied by the decommissioned Cox and Wyman print works. The site is covered by impermeable surfaces with the roof of the print works occupying the majority of the site area.

Topographic Survey

- 2.3 A topographic survey was undertaken in November 2016 by Solent Surveys with levels related to the Ordnance Survey GPS Network (Appendix A).
- 2.4 Given the size of the site it is relatively flat. Ground levels external to the building are at approximately 38.70m AOD except in the south-eastern corner of the site where levels fall to 38.25m AOD.

Proposed Development

- 2.5 The proposals are to demolish all existing buildings and construct a residential development comprising 96 residential units and associated car parking and landscaping. The site layout drawing is provided in Appendix A at the end of this report.

³ © Crown copyright and database rights 2017 Ordnance Survey

- 2.6 The proposals are considered 'major' development since there are more than 10 dwellings in the scheme, meaning a suitable sustainable drainage scheme is required with the application submission.

3 PLANNING POLICY

National Planning Policy Framework

- 3.1 The NPPF was released in March 2012 and sets out the Governments' planning policies for England and how these are expected to be applied. The NPPF states that:

"Inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk, but where development is necessary, making it safe without increasing flood risk elsewhere."

- 3.2 This is implemented through the Sequential Test and Exception Test.

Sequential Test

- 3.3 The aim of the Sequential Test is to steer new development to areas with the lowest probability of flooding. Only where there are no reasonably available sites in Flood Zone 1, should sites in Flood Zone 2 and then Flood Zone 3 be considered. It is also important to consider the flood risk vulnerability of proposed land uses and, if required, apply the Exception Test.
- 3.4 In addition to the NPPF, online Planning Practice Guidance was released in March 2014 to clarify planning aspects of flood risk management. The Planning Practice Guidance supersedes the Technical Guidance to the NPPF and clarifies which development types are considered appropriate within each flood zone.
- 3.5 The site is located in Flood Zone 1 and therefore passes the Sequential Test.

Exception Test

- 3.6 Table 3 of the PPG 'Flood risk vulnerability and flood zone compatibility' shows that the exception test is not required for 'More vulnerable' development within Flood Zone 1.

Sustainable Urban Drainage Systems (SuDS)

- 3.7 In accordance with the NPPF, as a minimum requirement, run-off rates and volumes should not increase from any site following development, to prevent an increase in flood risk elsewhere as a result of the development.
- 3.8 The proposed development falls under the classification of 'major development', as the proposed plans involve the provision of more than 10 dwellings. Therefore, under The Town and Country Planning (Development Management Procedure) (England) Order 2015, the site must adopt a sustainable drainage approach, through the use of SuDS.
- 3.9 According to The Town and Country Planning (Development Management Procedure) (England) Order 2015, the Lead Local Flood Authority (LLFA) is now the statutory consultee regarding surface water drainage of a major development, which for the site is Reading Borough Council.
- 3.10 The NPPF states that:

'Generally, the aim should be to discharge surface run off as high up the following hierarchy of drainage options as reasonably practicable:

- *into the ground (infiltration);*
- *to a surface water body;*
- *to a surface water sewer, highway drain, or another drainage system;*

- to a combined sewer.

Particular types of sustainable drainage systems may not be practicable in all locations. It could be helpful therefore for local planning authorities to set out those local situations where they anticipate particular sustainable drainage systems not being appropriate.'

- 3.11 The Non-Statutory Technical Standards for SuDS⁴ was published in March 2015, to be used in conjunction with the NPPF and associated PPG. The document sets out the requirements for the provision of sustainable drainage within development, from design to construction and maintenance. The specific technical criteria considered within this SuDS strategy are as follows:

Peak Flow Control

- 3.12 This section of the guidance is in relation to the control of peak rainfall runoff from the site post development. The policies in relation to peak flow control are quoted below:

S3 *For developments which were previously developed, the peak runoff rate from the development to any drain, sewer or surface water body for the 1 in 1 year rainfall event and the 1 in 100 year rainfall event must be as close as reasonably practicable to the greenfield runoff rate from the development for the same rainfall event, but should never exceed the rate of discharge from the development prior to redevelopment for that event.*

Volume Control

- 3.13 This section of the guidance is in relation to the control of the volume of rainfall off the site post development. The policies in relation to peak flow control are quoted below:

S5 *Where reasonably practicable, for developments which have been previously developed, the runoff volume from the development to any highway drain, sewer or surface water body in the 1 in 100 year, 6 hour rainfall event must be constrained to a value as close as is reasonably practicable to the greenfield runoff volume for the same event, but should never exceed the runoff volume from the development site prior to redevelopment for that event.*

S6 *Where it is not reasonably practicable to constrain the volume of runoff to any drain, sewer or surface water body in accordance with [S4] or S5 above, the runoff volume must be discharged at a rate that does not adversely affect flood risk.*

Local Planning Policy

- 3.14 Local planning policy is set out in the Reading Borough Council Core Strategy, adopted January 2008 and revised January 2015. Policy CS1 'Sustainable Construction and Design' states the following in relation to the incorporation of Sustainable Drainage Systems to mitigate the flood risk from new development.

Policy CS1

"Sustainable Construction and Design: ...Developments incorporate sustainable urban drainage facilities and techniques as part of the layout of a development as appropriate and as advised by the Environment Agency, including minimising the size of impermeable areas so that peak run-off and annual water run-off is reduced where possible and in any case is no greater than the original conditions of the site. Particular care will be needed in areas of flood risk where different solutions may be required.."

- 3.15 The Council's approach to flood risk is set out in Policy CS35 'Flooding', as detailed below:

⁴ Department for Environment, Food and Rural Affairs, Sustainable Drainage Systems - Non-statutory Technical Standards for Sustainable Drainage Systems, 2015

Policy CS35

"Flooding Planning permission will not be permitted for development in an area identified as being at high risk of flooding, where development would reduce the capacity of the flood plain to store floodwater, impede the flow of floodwater or in any way increase the risks to life and property arising from flooding."

- 3.16 The RBC 'Sites and Detailed Policies Document, October 2012, with Alteration Adopted January 2015' (SDPD) includes policies on adapting to the effects of climate change. Policy DM1 relates to climate change and an extract – in relation to surface water runoff – is detailed below

Policy DM1: Adaptation to climate change

"All developments will demonstrate how they have been designed to incorporate measures to adapt to climate change. The following measures shall be incorporated into development...

... All development shall minimise the impact of surface water runoff from the development in the design of the drainage system."

Reading Strategic Flood Risk Assessment

- 3.17 Reading Borough Council recently published the Strategic Flood Risk Assessment (SFRA) in June 2017 which assesses the flood risk in Reading to inform planning policy and decisions. The SFRA informs the site-specific flood risk assessment and is referred to throughout this report.

4 POTENTIAL SOURCES OF FLOODING

- 4.1 The geographical location of Reading ensures that tidal flooding is not a risk to the area, however all other sources of flooding are potential concerns across the Borough and are assessed in this section.

Historic Flooding Information

- 4.2 Two historic records of fluvial flooding have been recorded in the area by the Environment Agency in 1947 and 2003 and were provided within the product 4 information for the site. The site was not within the floodplain for either flooding events shown, however, the 1947 flood extent reached as far as Milford Road at the western boundary of the site.
- 4.3 Map F3 of the Reading SFRA displays historic flooding records collated from all available data sources. The nearest record is shown on Addison Road north of the site labelled as 'flood information' RBC Highways. No other records are shown within 200 m of the site.

Flooding from Rivers

- 4.4 The site is located within Flood Zone 1 on a 'dry island' surrounded by Flood Zone 2 as shown in the Environment Agency Flood Map for Planning (Figure 2). Flood Zone 2 is defined as having between a 0.1% (1 in 1000) and 1% (1 in 100) chance of flooding from a river each year. The flood zones shown are the present-day flood extents and do not account for future effects of climate change.

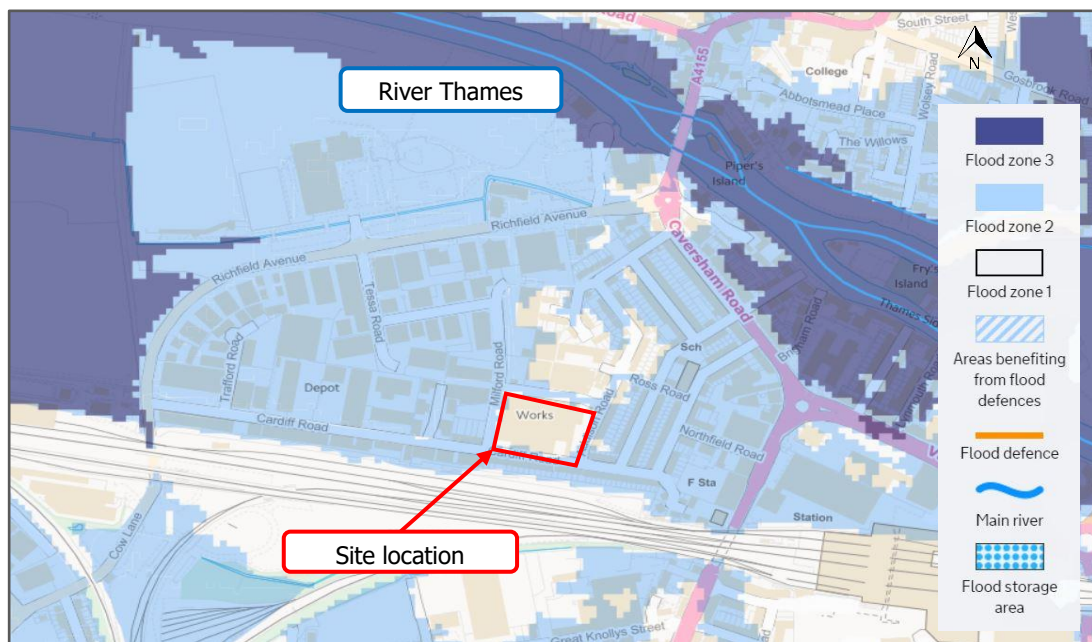


Figure 2: EA Map for Planning (Flood Zone map)

Flooding from Surface Water

- 1.1 Flooding from surface water arises during intense rainfall events when flood water is unable to infiltrate into the ground or discharge into local ditches or artificial drainage infrastructure. In an urban environment, the risk of flooding from surface water and from overloaded sewers is closely related, and both are generally included in the relevant surface water flooding datasets. Flooding

events are typically of short duration (unless there is a drainage system blockage), but can be severe.

- 4.5 The Environment Agency online mapping covers the risks of surface water flooding. The Environment Agency online maps are a useful tool in assessing the extent and frequency of flooding in a general area but do come with a caveat that they should not be used for site-specific development or property level. Therefore, engineering judgement needs to be applied when using these maps and the information checked against other sources of data.



Figure 3: EA Surface water map – Extent of flooding

- 4.6 The site is shown in Figure 3 to be at 'very low' risk of surface water flooding, with 'low' risk in the enclosing streets. Very low risk is equivalent to <0.1% annual probability of flooding and 'low' risk is equivalent to between 0.1% and 1% of surface water flooding, excluding future effects climate change. Climate change has been taken into account with the design of the surface water management system, as described in section 6.

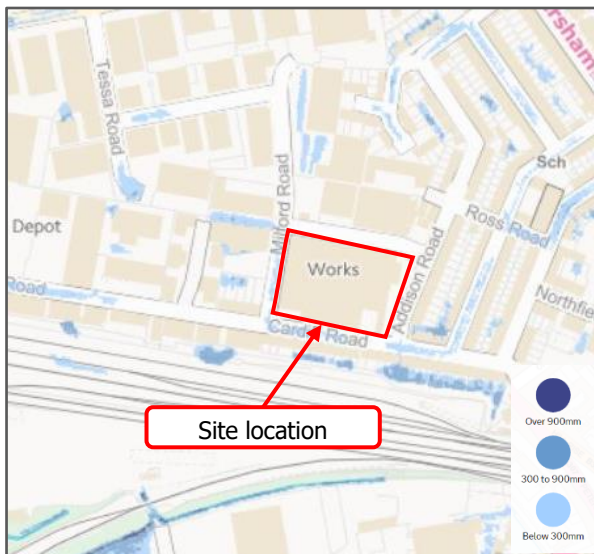


Figure 4: EA Surface water map – 'Medium' risk

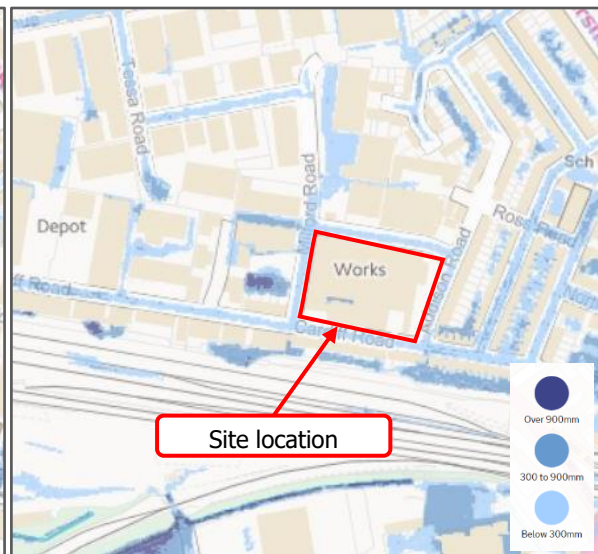


Figure 5: EA Surface water map – 'Low' risk

4.7 Figure 4 and Figure 5 show the risk of surface water flooding to the site is likely to be 'low', with no flooding shown on the site and up to 300 mm depth in the road for the 0.1% annual probability event.

4.8 The risk of surface water flooding is therefore considered low.

Flooding from Sewers

4.9 Thames Water have provided data known as the DG5 Register which shows that between 21 and 50 sewer flooding incidents have been recorded for properties within postcode district RG1 8, since 2016, which includes internal flooding from surface water and foul sewers.

4.10 The local area is served by surface water sewers as shown on the Thames Water Asset data, which suggests the area is well drained.

Flooding from Groundwater

4.11 The British Geological Survey (BGS) online maps (1:50,000) indicate the site is underlain by superficial deposits of Langley Silt Member (clay and silt) and bedrock geology of Lewes Nodular, Seaford and Newhaven Chalk Formations. The chalk is capable of supporting groundwater and the clay and silt is likely to be impermeable.

4.12 The BGS geology is confirmed by borehole logs produced following a ground investigation by Geotechnical Engineering Limited. Analysis of the borehole logs shows made ground to depths of between 1.4 m and 2.9 m below ground level (bgl), underlain by clay and sand gravel layers. The chalk formation is present from 7.6 m bgl.

4.13 Groundwater was encountered within boreholes during drilling at depths of between 3.1 and 4.0m bgl. Post-fieldwork monitoring recorded groundwater levels of 2.06m to 2.72m bgl.

4.14 There are no basement dwellings proposed, only a lower ground level car park and finished floor levels are raised above ground level.

4.15 Groundwater emergence at the surface would follow local flow paths similar to surface water. The risk to the development from groundwater flooding is considered to be low.

Flooding from Other Sources

4.16 The online Environment Agency maps showing flood risk from reservoirs, show the site is not within the flooding extent during a breach scenario.

4.17 No other sources of flooding have been identified.

Climate Change

4.18 During the lifetime of the Development, climate change is expected to result in increased risk of flooding due to increased intensity and frequency of extreme rainfall events. In February 2016, guidance for the assessment of climate change within flood risk assessments (FRA) was replaced and new allowances⁵ have been provided for specific river basin districts to replace the UK-wide 20% increase to peak river flows previously used.

4.19 For developments with a lifetime extending beyond the year 2070 in the Thames river basin, the following increases to peak river flow are used as benchmarks by the Environment Agency to account for anticipated effects of climate change:

⁵ Climate change allowances (2016), www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

- +25% - central allowance (50% chance of being exceeded)
 - +35% - higher central allowance (30% chance of being exceeded)
 - +70% - upper end allowance (10% chance of being exceeded)
- 4.20 More detail on the way these benchmarks have been used in this assessment and applied to modelled flood levels is presented in the next section.
- 4.21 Climate change allowances have also been updated for peak rainfall intensity in small and urban catchments. For developments with a lifetime extending beyond 2070 these are an increase of 20% and 40% for the central and upper end allowances respectively, and apply to the whole of England. These allowances are applied in the drainage strategy section.

5 ASSESSMENT OF FLUVIAL FLOOD RISK

Modelled Flood Water Levels

- 5.1 As part of the Reading SFRA process, PBA have re-run the EA River Thames model to generate the flood extents based on the updated climate change allowances. The EA also confirmed that they are in the process of updating the hydraulic models through the Reading area, with outputs currently anticipated in late 2017/early 2018.
- 5.2 An extract of Map F5 for Character Area Central from the SFRA is shown in Figure 6. This map shows that the site will not be affected by fluvial flooding in the 100 year + 25% and 100 year + 35% scenario and only small parts of the site around the boundaries may be affected by the 100 year + 70% scenario.
- 5.3 RBC was contacted for flood levels based on the re-run of the model for comparison with ground levels on the site and to plot the extents of flooding more precisely, however no site-specific flood level data is available. The SFRA suggests that the Environment Agency Thames Area climate change guidance should be used to predict flood levels including future climate change.

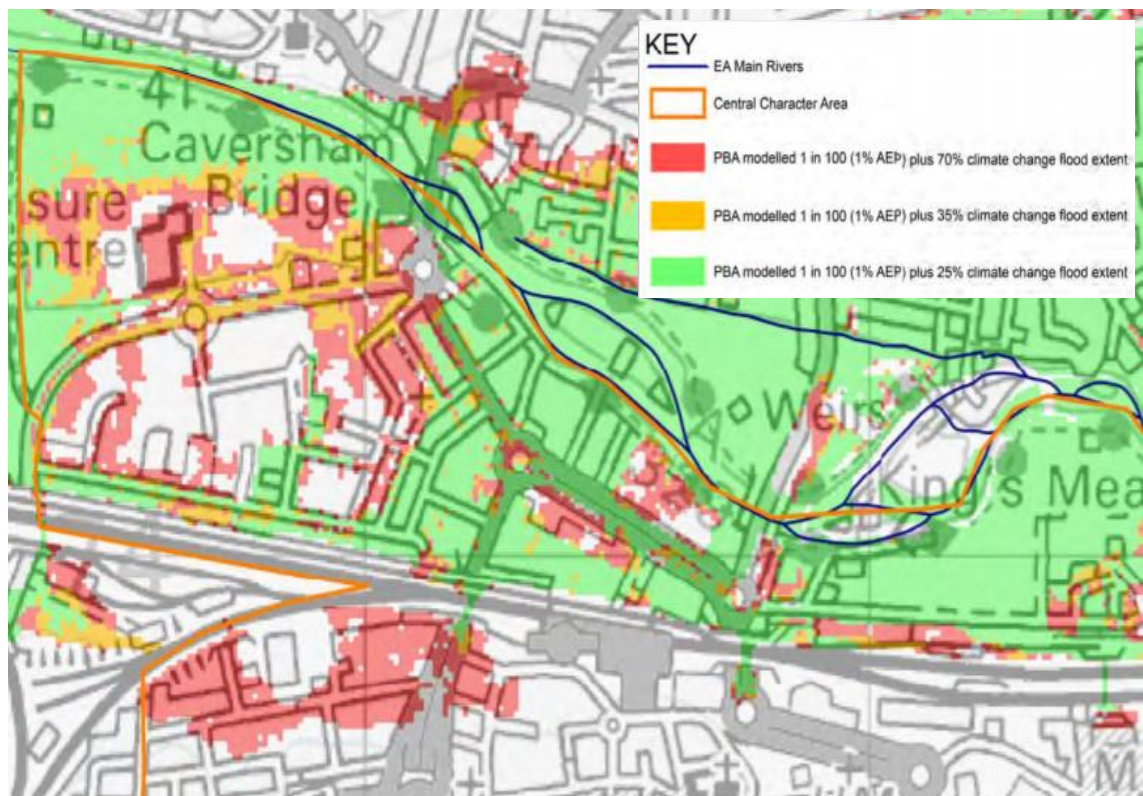


Figure 6: Modelled flood extents for 25%, 35% and 70% climate change allowances

- 5.4 Flood water levels have been provided by the Environment Agency for in-channel nodes as well as points in the floodplain closest to the site as displayed in Table 1 and Table 2. The location of the flood levels is shown in the Environment Agency Product 4 information included in Appendix B.
- 5.5 The term 'annual exceedance probability' (AEP) used below is defined as the probability that a flood will equal or exceed a particular level in any given year.

Table 1: Modelled in-channel flood levels

Node Label	In-channel flood levels (m AOD)		
	1% AEP	1% AEP (+20% climate change)	0.1% AEP
06100_MN_36.032	38.15	38.39	38.71

Table 2: Modelled floodplain flood levels

2D grid cell reference	Floodplain flood levels (m AOD)		
	1% AEP	1% AEP (+20% climate change)	0.1% AEP
Flood Point 1	No Data	No Data	38.69
Flood Point 2	No Data	38.20	38.48

- 5.6 The data from the EA includes the 1% AEP +20% climate change flood levels, which apply the 'old' climate change allowance used across the UK until February 2016. The Environment Agency has not yet updated the hydraulic model of the River Thames with the new climate change allowances described in Section 4. Instead, the Environment Agency have released local guidance (Thames Area Climate Change Guidance⁶ – hereafter referred to as TACCG) on how to apply the allowances to existing modelled data.
- 5.7 Table A of the TACCG defines three possible approaches to account for flood risk impacts due to climate change: basic, intermediate and detailed. The indicated method is based on the 'vulnerability classification', Flood Zone and type of proposed development. The TACCG considers either the 'basic' or 'intermediate' approaches to be appropriate for 'more vulnerable' development of type 'large-major' (more than 30 dwellings) in Flood Zone 2.
- 5.8 The TACCG states that the '**central' allowance is the minimum benchmark for flood risk mitigation of 'more vulnerable' development in Flood Zone 2** that is not in a 'sensitive' location. The Environment Agency do not have a formal definition of a 'sensitive' location, however the proposed development is actually within Flood Zone 1 surrounded by Flood Zone 2 and is therefore not considered to fall into this category.

'Intermediate Method'

- 5.9 The data provided by the Environment Agency contains modelled flows and flood levels up to the 0.1% AEP event, which provides enough information to apply the 'intermediate' method.
- 5.10 The 'intermediate' approach makes use of existing modelled node flood levels (stage) and associated flow data (discharge) to construct a stage-discharge rating curve. This curve may be used to interpolate a flood level based on the peak flow for the chosen event and allowance. In-channel node 06100_MN_36.032 has been used for this analysis which generates the highest flood level and is close to the floodplain level given by flood point 1 nearest the site.
- 5.11 The stage-discharge curve used for the 'intermediate' method is included in Appendix C and Table 3 displays the interpolated flood levels based on this analysis.

⁶ Environment Agency, Thames Area Climate Change Guidance, Jan 2017. Copy provided in Appendix B

Table 3: Climate change allowances and 'intermediate' method flood levels

	1% AEP event + various climate change allowances			
		Climate change allowances		
In-channel node 06100_MN_36.032	'Old' climate change	Central	Higher Central	Upper
Increase to peak river flow	+20%	+25%	+35%	+70%
Modelled and interpolated flood levels (m AOD)	38.39	38.42	38.52	38.89

- 5.12 Following guidance from the TACCG document, the 'central' climate change allowance is considered appropriate for flood risk mitigation on this development. The 1% AEP flood level + 25% for future climate change from Table 3 is **38.42 m AOD and is the minimum 'design' flood level that should be used for the development.**
- 5.13 The Reading SFRA states that "the generally accepted approach is to use the lower end of the specified range of climate change allowances as a baseline for mitigation requirements, and the higher end as a sensitivity test", i.e. 'central' and 'higher central' allowances.

Flood Levels in Relation to the Site

- 5.14 The 1% AEP flood level including an allowance for climate change has been determined to be 38.42 m AOD and, comparing with site levels, the site is not predicted to flood except for a small area in the south-east corner.
- 5.15 In accordance with Section 5.5.2 of the British Standard (BS), it is recommended that floor levels of new development are set a minimum of 300mm above the modelled 1 in 100 annual probability plus appropriate allowance for climate change fluvial flood level.
- 5.16 Proposed finished floor levels are summarised in Table 4 and have been raised a minimum of 300 mm freeboard above the 'design' flood level where possible, i.e. 38.72 m AOD. In order to achieve step free access to the houses on the south-eastern corner of the site, levels have been set below this, but remain above the 'higher central' flood level of 38.52 m AOD and a minimum of 130 mm freeboard above the 'design' flood level.

Table 4: Finished Floor Levels

Building	Finished Floor Levels (m AOD)
South eastern corner houses	38.55 – 38.625
South western corner houses	38.75 - 38.825
Two blocks south of eastern site access	38.75
Buildings north of central access road	38.90
Access road and car parking	38.70

Flood Resilience

- 5.17 The 'central' climate change allowance has been considered for flood risk mitigation, however, to inform flood resilience measures the 'higher central' flood level should be considered. All finished floor levels are raised above this level and therefore the buildings are at low risk of damage from flooding in this scenario.

Floodplain Compensatory Storage

- 5.18 The proposed house in the south-eastern corner of the site encroaches on the 1% annual probability including climate change flood level and will reduce the available capacity of the floodplain post-development. To mitigate against increased flooding elsewhere as a result of development, an area of floodplain compensation will be provided on a level-for-level basis in 100 mm to 200 mm depth level bands.
- 5.19 This is proposed by lowering land adjacent and to the rear of the house in the south-east corner of the site.
- 5.20 The proposed development's footprint reduces floodplain storage for the slice between 38.32 m AOD and 38.42 m AOD only, by an area of 31 m². The floodplain storage will be replaced by lowering an equivalent area in the rear garden of the house (currently outside the floodplain) to a level of 38.32 m AOD with a hydraulic connection to the floodplain at the eastern site boundary also at 38.32m AOD. Refer to Appendix A for drawing showing area of proposed floodplain compensation.

Flood Warning

- 5.21 The Environment Agency provides a local Flood Warning service for the River Thames at Reading and Caversham area. This includes the Portman Road and Richfield Avenue industrial estates, Caversham Road area of Reading and the Lower Caversham area.
- 5.22 Residents are advised to register for the service either online via GOV.UK or by calling the Floodline on 0345 988 1188.
- 5.23 Subscribers to this service are eligible to receive free warnings by telephone, mobile, email, SMS text message or fax, whichever is most convenient. Residents who sign up for the telephonic service, for instance, will receive an automated message via their phone telling them that flooding is expected and giving advice as to what actions should be taken.

Safe Access Arrangements

- 5.24 The Reading states the following regarding safe access arrangements relevant to the development site:
- "Proposed development may be located on an area of high ground that becomes a 'dry island' surrounded by potentially significant depths of floodwater in a major flood event – for example, the Portman Road area, land south of Richfield Avenue and areas around the A33. While the development may be outside the floodplain, it is important to fully consider the impact on safe access routes from the site to the wider land outside the floodplain. This should include consideration of the duration that the access route is impacted in addition to the depths along the route. For example, if the area is affected by the floodplain of the River Thames this could be for a prolonged period and this would be a material factor when considering the safety of future occupants, as residents are unlikely to have access to medicines, food, water and utilities (i.e. electricity and telephone). It is essential that any future development within these areas considers carefully the emergency response in times of flood."
- 5.25 The site is not predicted to flood in a 1000-year event according to the EA modelling and the 100-year event including a 70% increase in flood flows to account for climate change according to the most recent modelling in the Reading SFRA. Residents can therefore remain safely within the site in the event of such an extreme flood.
- 5.26 In addition, the EA modelling shows that the site is within an area roughly bound by Cow Lane to the west, the River Thames to the north and the existing residential area to the east which is

not predicted to flood in a 100-year event. Dry access is shown from the site north along Milford Road and then west to Richfield Avenue or east along Meadow Road and north along Addison Road and Randolph Road to the A4155 Caversham Road. Access to land wholly outside the floodplain is reached across Caversham Bridge.

- 5.27 The most recent modelling undertaken as part of the Reading SFRA shows that the majority of land north and west of the site bounded by Richfield Avenue will remain dry in a 100 year plus climate change event with some roads predicted to flood depending on the allowance for climate change (25%, 35% or 70%).

Effect on the risk of flooding elsewhere

- 5.28 The risk to flooding elsewhere as a result of the proposed development is expected to decrease due to the increase in permeable areas and significant reduction in runoff rates and volumes achieved by the proposed surface water management system.

Residual Risk

- 5.29 The design flood levels only consider flooding events with a 1% annual probability including climate change impacts. There remains a risk of flooding from the River Thames for more extreme, lower likelihood events than the design event.

6 DRAINAGE STRATEGY

- 6.1 In accordance with the NPPF, surface water runoff rates and volumes should not increase as a result of development. Surface water will be managed through the implementation of Sustainable Urban Drainage Systems (SuDS).

Existing Site Drainage

- 6.2 The existing brownfield site is predominantly hardstanding, comprising warehouses, concrete paved surfaces and a small amount of soft landscaping and can be divided into the following permeable and impermeable areas:

	Area (ha)
Impermeable	1.27
Permeable	0.06
Total	1.33

- 6.3 Based on an estimate of the time of concentration of the surface water runoff from the site of 9 minutes, the 9-minute critical storm has been used in the following calculations of runoff rates.
- 6.4 A 1 year, 9-minute critical storm (M5-60 of 17mm and an 'R' value of 0.4) has been applied to arrive at a rainfall intensity 33.7 mm/h. The resulting runoff rate has been calculated to be 115 l/s for the 1 in 1 annual probability rainfall event.
- 6.5 A 30 year, 9-minute critical storm (M5-60 of 17mm and an 'R' value of 0.4) has been applied to arrive at a rainfall intensity 80.3 mm/h. The resulting runoff rate has been calculated to be 275 l/s for the 1 in 30 annual probability rainfall event.
- 6.6 A 100 year, 9-minute critical storm (M5-60 of 17mm and an 'R' value of 0.4) has been applied to arrive at a rainfall intensity 102 mm/h. The resulting runoff rate has been calculated to be 349 l/s for the 1 in 100 annual probability rainfall event.
- 6.7 The existing site generates a total volume of runoff above Greenfield of 470 m³ during the 100 year, 6 hour storm.

Sustainable Drainage Principles

- 6.8 The aim of Sustainable Urban Drainage Systems (SuDS) is to emulate natural processes with the result that watercourses and storage areas receive the hydrological profiles under which they evolved, and that water quality in local ecosystems is protected or improved. The best practice guide⁷ states that a sustainable drainage system will:
- reduce the impact of additional urbanisation on the frequency and size of floods;
 - protect or enhance river and groundwater quality;
 - be sympathetic to the needs of the local environment and community; and
 - encourage natural groundwater recharge.
- 6.9 The SuDS hierarchy (Table 5) shows the available SuDS techniques ordered by most sustainable to the least sustainable method.

⁷ CIRIA C523 – Sustainable Urban Drainage Systems – Best Practice Manual

Table 5: SuDS hierarchy/suitability

Most Sustainable	SuDS Technique	Suitability
	Living Roofs	Yes
	Basins and ponds - Constructed wetlands - Balancing ponds - Detention basins - Retention ponds	No – very limited space due to high density urban development and difficult to incorporate on a level site.
	Filter strips and swales	No – very limited space due to high density urban development and difficult to incorporate on a level site.
	Infiltration devices - Soakaways - Infiltration trenches and basins	Unsuitable ground conditions due to presence of made ground.
	Permeable surfaces and filter drains - Gravelled areas - Solid paving blocks - Porous paviers	Yes
Least Sustainable	Tanked systems - Over-sized pipes/tanks - Storm cells	Yes – but only if necessary as this is the least sustainable option.

Proposed Site Drainage

- 6.10 The proposed drainage strategy aims to reduce the rate and volume of runoff to as close to greenfield rates as is reasonably practicable, providing betterment over the existing situation, and considering future effects of climate change over the lifetime of the development.
- 6.11 Based on the types of SuDS specifically suitable to the site described in the previous sub-section, a combination of green roofs and porous car parking will form part of the proposed drainage system.
- 6.12 Green roofs are proposed on four of the garage roofs on the southern terraced-housing. A green roof type construction is also proposed over the basement car park in the building complex in the north west of the site.
- 6.13 Porous paving is proposed for all car parking and vehicular access roads (total area 3274 m³) with a 450 mm granular sub-base and 30% void ratio providing 442 m³ of attenuation storage.
- 6.14 The proposed development will result in a significant reduction of hardstanding areas due to an increase in soft landscaping as well as the introduction of green roofs as summarised in the table below:

	Area (ha)	Post-development change (% of site area)
Impermeable	0.96	-23%
Permeable	0.30	+18%
Green roof	0.07	+5%
Total	1.33	-

- 6.15 The following calculations of runoff rates are based on an estimated critical storm of 11 minutes and include the proposed green roof areas, but exclude the attenuating effect of the porous car parking.
- 6.16 A 1 year, 11-minute critical storm (M5-60 of 17mm and an 'R' value of 0.4) has been applied to arrive at a rainfall intensity 29.4 mm/h. The resulting runoff rate has been calculated to be 87l/s

for the 1 in 100 annual probability rainfall event (121 l/s including a nominal increase of 40% in the rainfall intensity to allow for future climate change).

- 6.17 A 30 year, 11-minute critical storm (M5-60 of 17mm and an 'R' value of 0.4) has been applied to arrive at a rainfall intensity 71.0 mm/h. The resulting runoff rate has been calculated to be 209l/s for the 1 in 100 annual probability rainfall event (293l/s including a nominal increase of 40% in the rainfall intensity to allow for future climate change).
- 6.18 A 100 year, 11-minute critical storm (M5-60 of 17mm and an 'R' value of 0.4) has been applied to arrive at a rainfall intensity 90.6 mm/h. The resulting runoff rate has been calculated to be 267l/s for the 1 in 100 annual probability rainfall event (374l/s including a nominal increase of 40% in the rainfall intensity to allow for future climate change).
- 6.19 The proposed development volume of runoff above Greenfield during the 100 year, 6 hour storm is calculated to be 534 m³ including a nominal increase of 40% in the rainfall intensity to allow for future climate change.
- 6.20 A limiting discharge rate of 18 l/s is proposed for the 100 year event +40% for climate change, which results in a required 429 m³ of attenuation storage, which will be fully contained within the porous car parking (442 m³). This represents a 95% reduction from the present-day 100 year peak runoff from the existing site for the lifetime of the development.
- 6.21 Assumed connections to the surface water sewers in Addison Road, Cardiff Road and Milford Road will be reused, and the discharge rates will be significantly reduced for all rainfall events.

7 CONCLUSIONS AND RECOMMENDATIONS

- 7.1 The dominant source of flooding at the site is identified as fluvial flooding from the River Thames. Modelled flood levels for the 1% annual probability event were provided by the Environment Agency and an appropriate allowance for climate change was added to produce a design level for flood mitigation of 38.42 m AOD ('central' climate change allowance). Based on the topographic survey of the site, a small area in the south-east corner of the site would flood to a maximum of depth of 170mm in this event.
- 7.2 Mitigation has been incorporated into the layout and design the proposed buildings by raising finished floor levels for the development a minimum of 300 mm freeboard above the design flood level to 38.72 m AOD where possible. In order to achieve step free access to the houses on the south-eastern corner of the site, floor levels have been set to a minimum of 130 mm above the design flood level. In addition, all finished floor levels are set above the minimum recommended flood level to inform flood resilience of 38.52 m AOD ('higher central' climate change allowance).
- 7.3 The proposed building footprint encroaches on 31 m² of the 1% annual probability plus climate change flood extent in the south-east of the site, reducing available floodplain storage. As a result, floodplain compensatory storage will be provided on a level-for-level basis with a hydraulic connection to the floodplain by lowering part of the landscaping/rear gardens.
- 7.4 The drainage strategy has been prepared in accordance with national policy ensuring, through application of the Sustainable Drainage Systems hierarchy, that surface water runoff rates are reduced to as close as possible to greenfield rates post-development, including an allowance for climate change. The peak runoff rate for the existing site in the 100-year rainfall event is estimated to be 349 l/s. Through a combination of increasing permeable landscaping, and provision of green roofs and permeable paving with granular sub-base, the peak discharge rate from the development for the 100-year plus climate change event will be limited to 18 l/s, equal to a 95% reduction on the existing scenario.
- 7.5 No surface water flooding is predicted in the 100-year plus climate change event, due to the attenuation storage provided in the sub-base of permeable paving. Surface water runoff will discharge to assumed connections to the Thames Water surface water sewer network in Addison Road, Cardiff Road and Milford Road.

APPENDIX A

Drawing 1 – Topographic survey

Solent Surveys Drawing No. 13859 S1

Topographic survey of existing site, with levels related to Ordnance Survey GPS Network.

Drawing 2 – Proposed Site Plan

Barton Willmore Drawing No. A/PP-P10-01

Proposed ground level layout of development.

Drawing 3 – Proposed Roof Plan

Barton Willmore Drawing No. A/PP-P10-02

Proposed roof plan with landscaping.

Drawing 4 – Proposed SuDS Strategy and Floodplain Compensation

Water Environment Ltd Drawing No. 15055-SK01

Proposed location of SuDS elements and proposed lowering for floodplain compensation.

[illegible]

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* Entail occurred, inactionable or not occurred

Tell us in this sharing remains, with Robert Surveys

TITLE/PROJECT
 Cox & Wyman premises
 Cardiff Road
 Reading
 Berkshire
 RG1 8EX
 Survey Drawing



SOLENT SURVEYS
BUILDING AND LAND SURVEY CONSULTANTS
SOLENT HOUSE 7 KENILWORTH GARDENS
WEST END SOUTHAMPTON SO30 3RE
e-mail: mail@solentsurveys.co.uk
Tel 02380 471591

SCALE 1:200 	DRAWN BY J.R. Clark Associates
DATE Nov 2016	LEVELS BASED ON GPS/OSBM Datum
DRAWING NUMBER 13859 S1	REVISIONS

The scaling of this drawing cannot be assured				
Revision	Date	Drn	Ckd	
A Parking layout & boundary treatment updated	03/10/17	DC	PN	



Note:
For detailed landscape design refer to Barton Willmore
Landscape drawing: 24325-RG-L-01

PLANNING

Project			
Former Cox & Wyman Site			
Cardiff Road, Reading			
Drawing Title			
Proposed Site Plan			
Date	Scale	Drawn by	Check by
29/09/17	1 : 500 @ A2	DC	PN
Project No	Drawing No	Revision	
24325	A/PP-P10-01	A	

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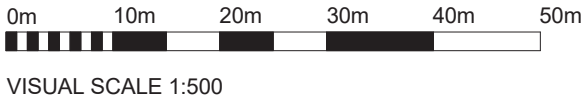
The scaling of this drawing cannot be assured				
Revision	Date	Drn	Ckd	
A Parking layout & boundary treatment updated	03/10/17	DC	PN	



Note:
For detailed landscape design refer to Barton Willmore
Landscape drawing: 24325-RG-L-01

PLANNING

Project			
Former Cox & Wyman Site			
Cardiff Road, Reading			
Drawing Title			
Proposed Roof Plan			
Date	Scale	Drawn by	Check by
29/09/17	1 : 500 @ A2	DC	PN
Project No	Drawing No	Revision	
24325	A/PP-P10-02	A	



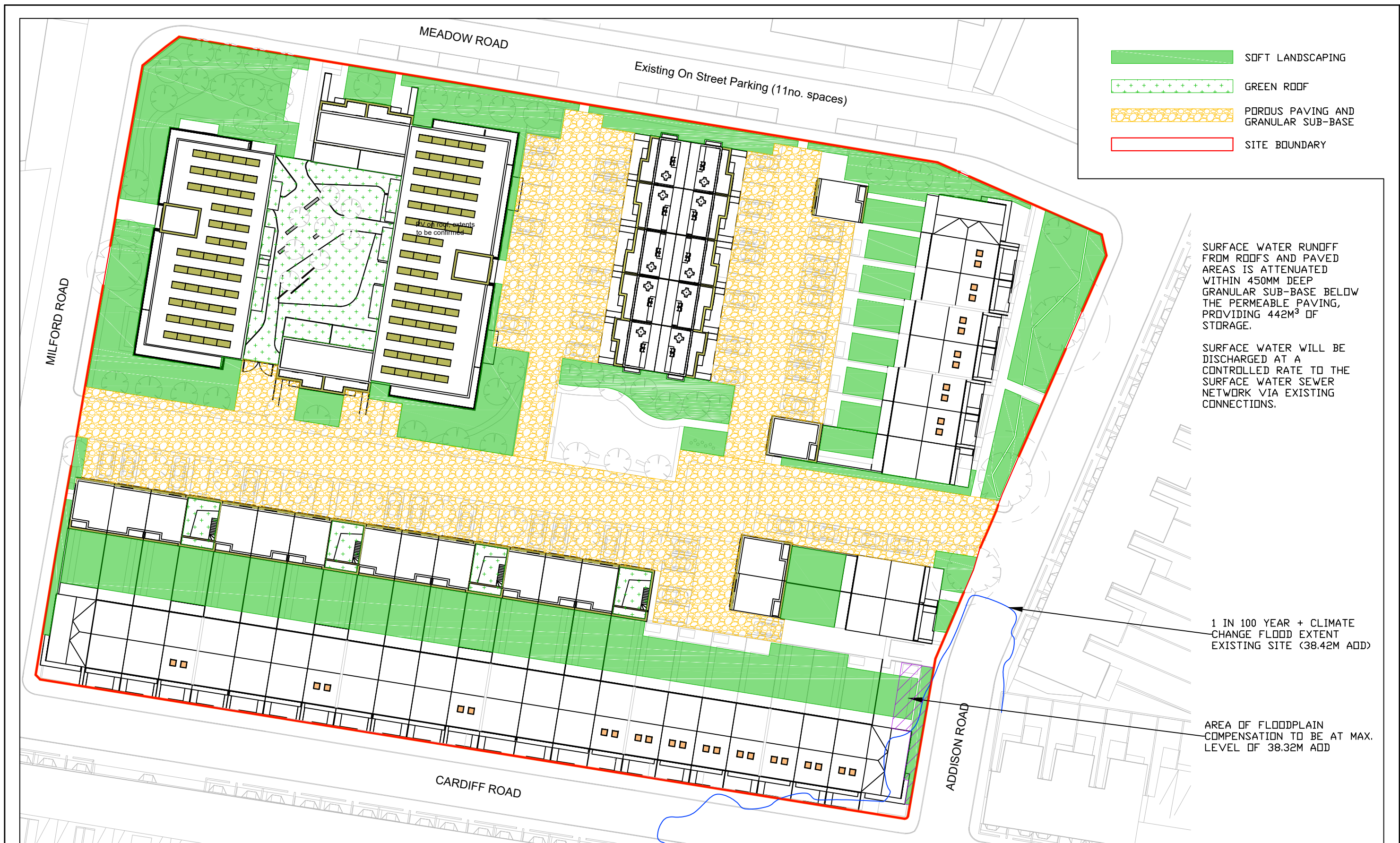
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Rev	Date	Amendments	Drawn	Approved

Client	THAMES PROPERTIES LTD	Drawing No	15055-SK01
Job Title	15055 FORMER COX & WYMAN	Rev	-
Drawing Title	SUDS STRATEGY AND FLOODPLAIN COMPENSATION	Scale	NTS
		Date	13/10/17
		Drawn by	GE
		Checked by	GL
		Approved by	GL

APPENDIX B

- Environment Agency Product 4
- Thames Water Asset Location Map

Product 4 (Detailed Flood Risk) for Meadow Road, Reading RG1 8EX

Our Ref: WT20783

Product 4 is designed for developers where Flood Risk Standing Advice FRA (Flood Risk Assessment) Guidance Note 3 Applies. This is:

- i) "all applications in Flood Zone 3, other than non-domestic extensions less than 250 sq metres; and all domestic extensions", and
- ii) "all applications with a site area greater than 1 ha" in Flood Zone 2.

Product 4 includes the following information:

Ordnance Survey 1:25k colour raster base mapping;
Flood Zone 2 and Flood Zone 3;
Relevant model node locations and unique identifiers (for cross referencing to the water levels, depths and flows table);
Model extents showing *defended* scenarios;
FRA site boundary (where a suitable GIS layer is supplied);
Flood defence locations (where available/relevant) and unique identifiers; (supplied separately)
Flood Map areas benefiting from defences (where available/relevant);
Flood Map flood storage areas (where available/relevant);
Historic flood events outlines (where available/relevant, not the Historic Flood Map) and unique identifiers;
Statutory (Sealed) Main River (where available within map extents);

A table showing:

- i) Model node X/Y coordinate locations, unique identifiers, and levels and flows for *defended* scenarios.
- ii) Flood defence locations unique identifiers and attributes; (supplied separately)
- iii) Historic flood events outlines unique identifiers and attributes; and
- iv) Local flood history data (where available/relevant).

Please note:

If you will be carrying out computer modelling as part of your Flood Risk Assessment, please read the enclosed guidance which sets out our requirements and best practice for computer river modelling.

This information is based on that currently available as of the date of this letter. You may feel it is appropriate to contact our office at regular intervals, to check whether any amendments/ improvements have been made. Should you re-contact us after a period of time, please quote the above reference in order to help us deal with your query.

This information is provided subject to the enclosed notice which you should read.

This letter is not a Flood Risk Assessment. The information supplied can be used to form part of your Flood Risk Assessment. Further advice and guidance regarding Flood Risk Assessments can be found on our website at

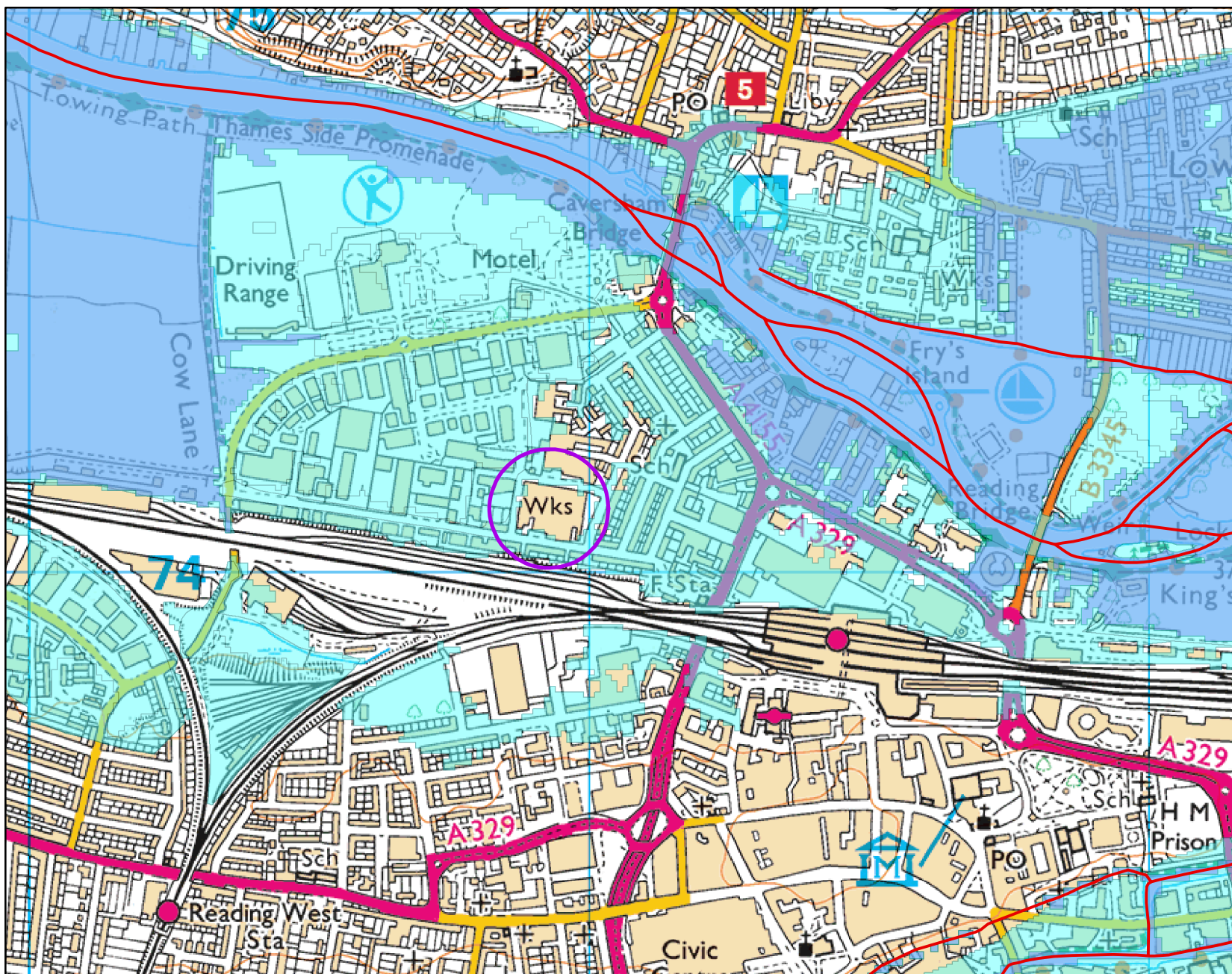
<http://www.environment-agency.gov.uk/research/planning/82584.aspx>

If you would like advice from us regarding your development proposals you can complete our pre application enquiry form which can be found at

<http://www.environment-agency.gov.uk/research/planning/33580.aspx>

Flood Map for Planning centred on Meadow Road, Reading RG1 8EX

Created on 17/06/2015 REF: WT20783



Kilometres
0 0.1 0.2



Legend

- Site
- Main River
- Flood defences
- Areas benefiting from flood defences
- Flooding from rivers or sea (FZ3)
- Extent of extreme flood (FZ2)
- Flood Map - flood storage areas

Flooding from rivers or sea without 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.

The Extent of an extreme flood (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.

Defence information

Defence Location: No defences on Main River

Description: This location is not currently protected by any formal defences and we do not currently have any flood alleviation works planned for the area. However we continue to maintain certain watercourses and the schedule of these can be found on our internet pages.

Model information

WT20783

Model: Thames (Mapledurham to Sonning) 2011

Description: The information provided is taken from the Thames (Reading Complex Change) Flood Alleviation Study completed in June 2011. The study was carried out using 2D modelling software (ISIS-Tuflow).

Model design runs:

1 in 5 / 20% AEP; 1 in 20 / 5% AEP; 1 in 50 / 2% AEP; 1 in 100 / 1% AEP; 1 in 1000 / 0.1% AEP and 1 in 100+20% / 1% AEP with climate change

Mapped Outputs:

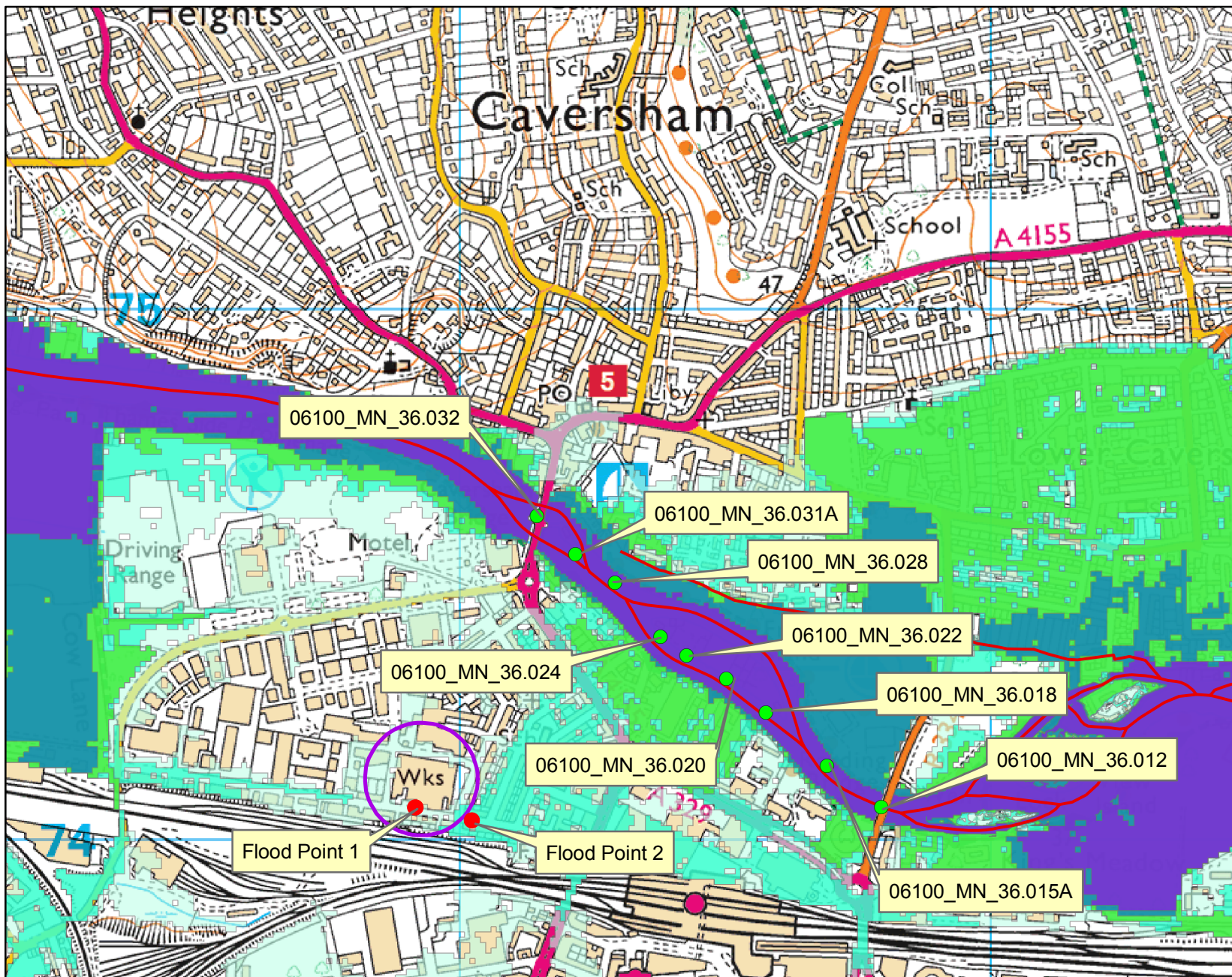
1 in 5 / 20% AEP; 1 in 20 / 5% AEP; 1 in 50 / 2% AEP; 1 in 100 / 1% AEP; 1 in 1000 / 0.1% AEP and 1 in 100+20% / 1% AEP with climate change

Model accuracy:

Levels $\pm$ 250mm

Detailed FRA Map centred on Meadow Road, Reading RG1 8EX

Created on 17/06/2015 REF: WT20783



Kilometres

0 0.1 0.2



Legend

- Site
- Nodes
- Main River
- 20% AEP Flood Outline
- 5% AEP Flood Outline
- 1% AEP Flood Outline
- 1%CC AEP Flood Outline
- 0.1% AEP Flood Outline

AEP = Annual Exceedance Probability
The probability of a flood of a particular magnitude, or greater, occurring in any given year

1%CC = 1% Climate Change extent
This is the 1% AEP event with an allowance for climate change (+20% on river flows)

Modelled in-channel flood flows and levels

WT20783

The modelled flood levels and flows for the closest most appropriate model node points for your site that are within the river channel are provided below:

Node label	Model	Easting	Northing	Flood Levels (mAOD)				
				20% AEP	5% AEP	1% AEP	1% AEP with climate change allowance (+20% on river flows)	0.1% AEP
06100_MN_36.032	Thames (Mapledurham to Sonning) 2011	471148	174609	37.23	37.64	38.15	38.39	38.71
06100_MN_36.031A	Thames (Mapledurham to Sonning) 2011	471220	174537	37.20	37.59	38.06	38.26	38.51
06100_MN_36.028	Thames (Mapledurham to Sonning) 2011	471294	174484	37.18	37.58	38.05	38.25	38.50
06100_MN_36.024	Thames (Mapledurham to Sonning) 2011	471380	174382	37.15	37.55	38.02	38.23	38.47
06100_MN_36.022	Thames (Mapledurham to Sonning) 2011	471429	174347	37.14	37.54	38.02	38.22	38.46
06100_MN_36.020	Thames (Mapledurham to Sonning) 2011	471504	174303	37.12	37.53	38.02	38.22	38.48
06100_MN_36.018	Thames (Mapledurham to Sonning) 2011	471579	174240	37.07	37.48	37.98	38.18	38.43
06100_MN_36.015A	Thames (Mapledurham to Sonning) 2011	471694	174139	37.05	37.45	37.96	38.17	38.43
06100_MN_36.012	Thames (Mapledurham to Sonning) 2011	471796	174061	36.98	37.35	37.82	38.00	38.23

Node label	Model	Easting	Northing	Flood Flows (m3/s)				
				20% AEP	5% AEP	1% AEP	1% AEP with climate change allowance (+20% on river flows)	0.1% AEP
06100_MN_36.032	Thames (Mapledurham to Sonning) 2011	471148	174609	223.10	284.45	374.33	450.03	571.71
06100_MN_36.031A	Thames (Mapledurham to Sonning) 2011	471220	174537	223.10	284.45	374.33	450.03	571.71
06100_MN_36.028	Thames (Mapledurham to Sonning) 2011	471294	174484	223.09	282.98	368.24	440.77	557.55
06100_MN_36.024	Thames (Mapledurham to Sonning) 2011	471380	174382	223.09	283.73	369.35	440.90	555.83
06100_MN_36.022	Thames (Mapledurham to Sonning) 2011	471429	174347	223.10	284.32	371.74	444.86	565.00
06100_MN_36.020	Thames (Mapledurham to Sonning) 2011	471504	174303	223.09	279.43	355.67	418.40	517.57
06100_MN_36.018	Thames (Mapledurham to Sonning) 2011	471579	174240	223.09	268.80	324.55	377.28	456.53
06100_MN_36.015A	Thames (Mapledurham to Sonning) 2011	471694	174139	223.09	272.21	314.11	354.09	421.78
06100_MN_36.012	Thames (Mapledurham to Sonning) 2011	471796	174061	223.08	281.34	353.30	405.25	476.08

Modelled floodplain flood levels

WT20783

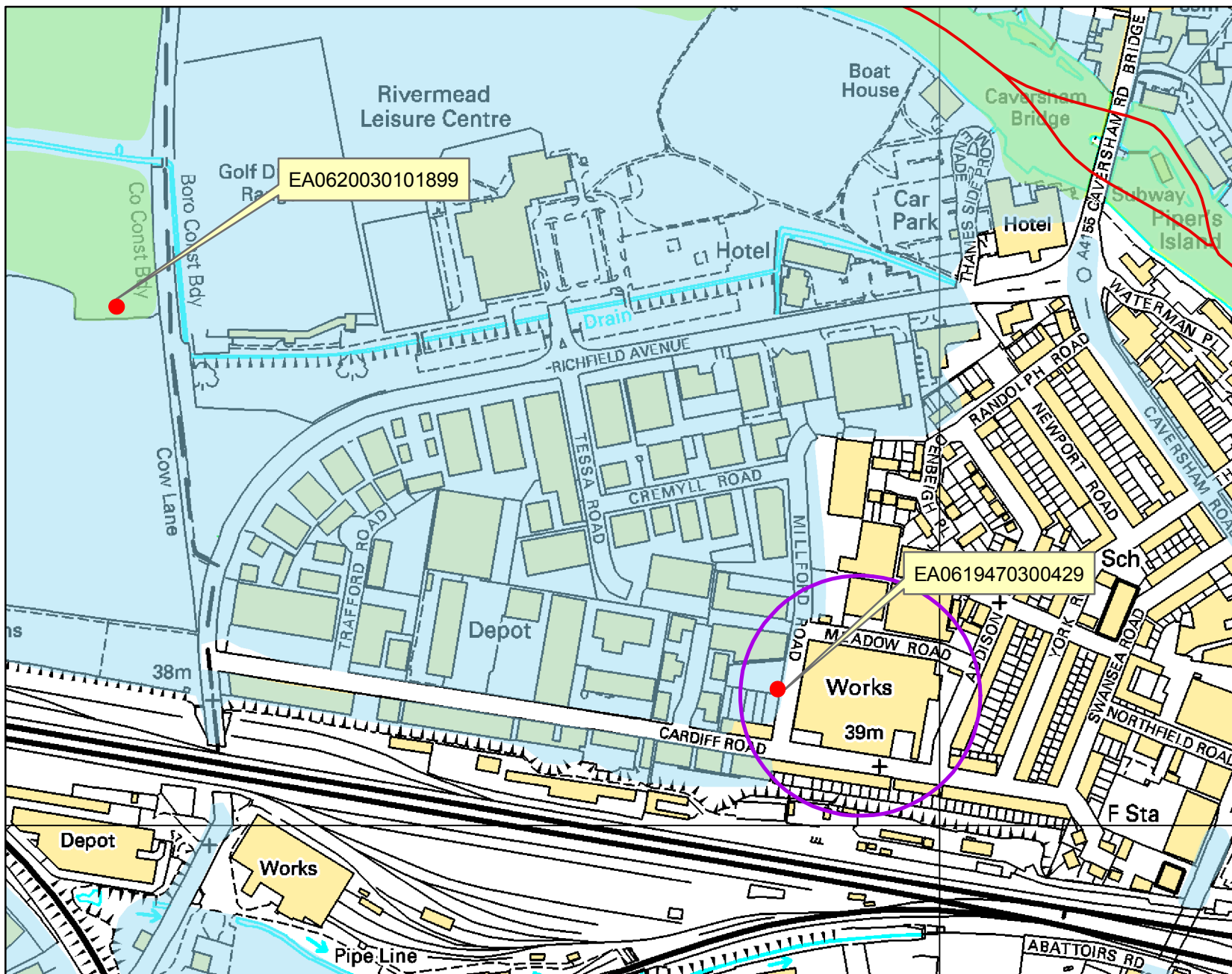
The modelled flood levels for the closest most appropriate model grid cells for your site are provided below:

2D grid cell reference	Model	Easting	Northing	flood levels (mAOD)				
				20% AEP	5% AEP	1% AEP	1% AEP with climate change allowance (+20% on river flows)	0.1% AEP
Flood Point 1	Thames (Mapledurham to Sonning) 2011	470919	174056	No Data	No data	No Data	No data	38.69
Flood Point 2	Thames (Mapledurham to Sonning) 2011	471026	174034	No Data	No data	No Data	38.20	38.48

This flood model has represented the floodplain as a grid.
The flood water levels have been calculated for each grid cell.

Historic Flood Map centred on Meadow Road, Reading RG1 8EX

Created on 17/06/2015 REF: WT20783



Kilometres
0 0.040.08



Legend

- Site
- Main River

Historic Flood Outline

- 1947
- 2003

Flooding from rivers or sea without 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.

The Extent of an extreme flood (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.

Historic flood data

WT20783

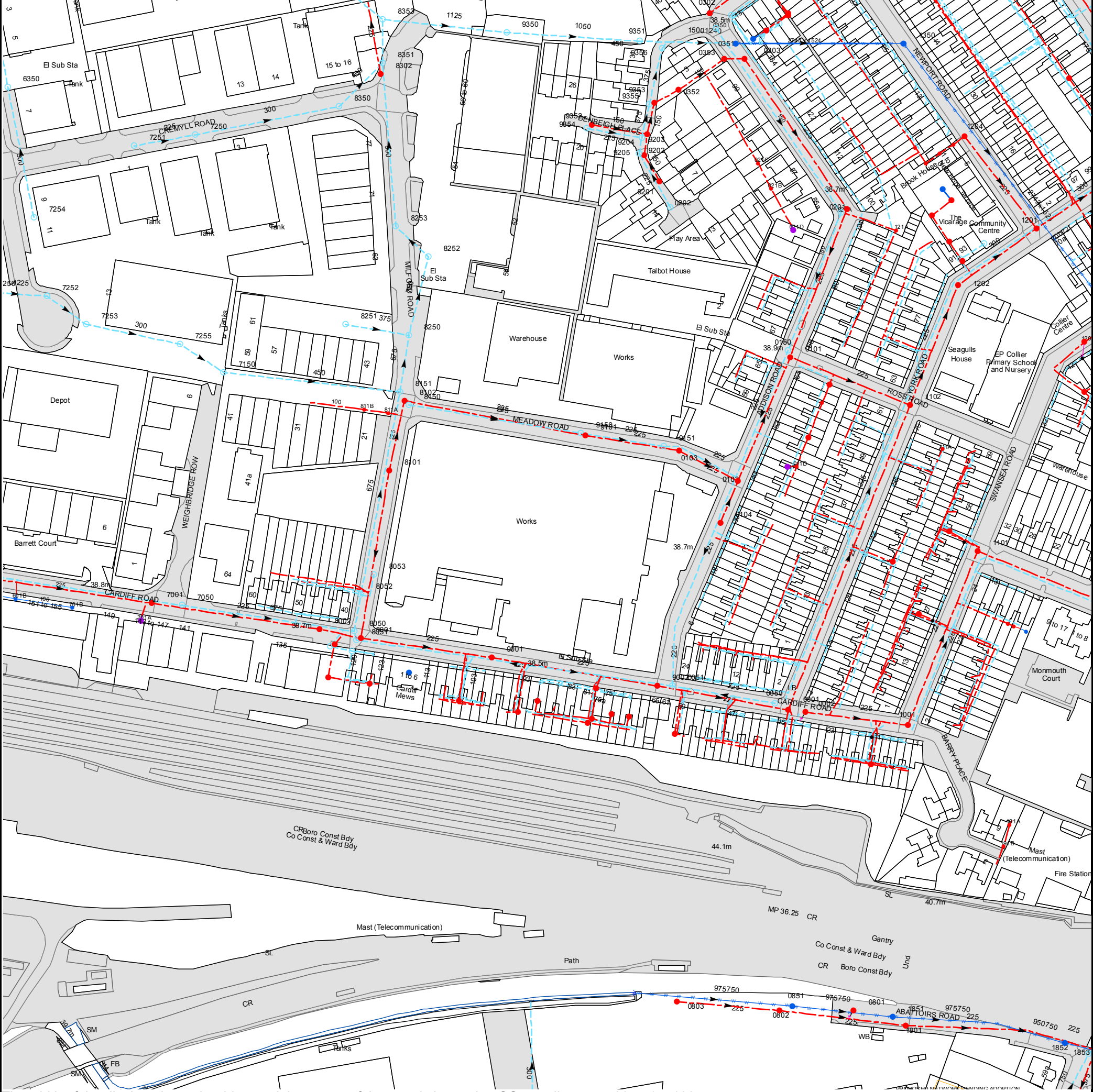
Our records show that the area of your site has been affected by flooding. Information on the floods that have affected your site is provided in the table below:

[illegible]

Please note the Environment Agency maps flooding to land not individual properties. Floodplain extents are an indication of the geographical extent of a historic flood. They do not provide information regarding levels of individual properties, nor do they imply that a property has flooded internally.

Start and End Dates shown above may represent a wider range where the exact dates are not available.

Asset Location Search Sewer Map - ALS/ALS Standard/2015 3156212



The width of the displayed area is 500 m and the centre of the map is located at OS coordinates 470944,174109
The position of the apparatus shown on this plan is given without obligation and warranty, and the accuracy cannot be guaranteed. Service pipes are not shown but their presence should be anticipated. No liability of any kind whatsoever is accepted by Thames Water for any error or omission. The actual position of mains and services must be verified and established on site before any works are undertaken.

Based on the Ordnance Survey Map with the Sanction of the controller of H.M. Stationery Office, License no. 100019345 Crown Copyright Reserved.

NB. Levels quoted in metres Ordnance Newlyn Datum. The value -9999.00 indicates that no survey information is available

Manhole Reference	Manhole Cover Level	Manhole Invert Level
0351	n/a	n/a
9351	38.48	36.4
03LJ	n/a	n/a
03KN	n/a	n/a
03LH	n/a	n/a
0350	38.63	37.13
03LC	n/a	n/a
03KK	n/a	n/a
03XZ	n/a	n/a
03LF	n/a	n/a
0302	38.47	36.47
12KJ	n/a	n/a
121A	n/a	n/a
021D	n/a	n/a
12KK	n/a	n/a
021A	n/a	n/a
0201	38.75	36.59
0202	n/a	n/a
12KM	n/a	n/a
021B	n/a	n/a
9201	38.52	37.56
12YR	n/a	n/a
021C	n/a	n/a
9202	38.4	37.42
9205	38.39	37.02
121C	n/a	n/a
121B	n/a	n/a
9204	38.59	36.91
9203	38.57	37.36
9354	38.69	37.13
9352	38.68	37.54
9355	38.42	36.9
9353	38.42	37.27
0352	38.45	37.16
0353	38.68	n/a
0303	38.41	36.81
9356	38.46	36.82
1350	n/a	n/a
12KL	n/a	n/a
121D	n/a	n/a
1204	38.18	36.57
12KE	n/a	n/a
13ZR	n/a	n/a
1201	38.27	36.1
13ZT	n/a	n/a
13ZP	n/a	n/a
9150	38.71	37.15
9101	38.7	36.71
90KL	n/a	n/a
90YW	n/a	n/a
90YV	n/a	n/a
90ZR	n/a	n/a
90ZS	n/a	n/a
9002	38.2	36.78
9151	38.68	37.03
0051	38.2	37.02
00ZY	n/a	n/a
0103	38.7	36.65
0104	38.74	36.66
0102	38.77	36.58
0050	38.26	37.04
011B	n/a	n/a
0001	38.31	36.73
0150	38.8	36.74
0101	38.8	36.46
011D	n/a	n/a
0002	38.28	36.97
0153	n/a	n/a
011E	n/a	n/a
0152	n/a	n/a
0154	n/a	n/a
00WT	n/a	n/a
1105	n/a	n/a
1001	38.3	36.93
1102	38.24	36.38
10YS	n/a	n/a
111A	n/a	n/a
11ZV	n/a	n/a
1202	38.19	36.28
12KD	n/a	n/a
12KH	n/a	n/a
1101	38.24	36.59
101A	n/a	n/a
101B	n/a	n/a
101C	n/a	n/a
1106	n/a	n/a
1203	38.1	36.1
0803	n/a	n/a
0802	n/a	n/a
0851	n/a	n/a
0801	n/a	n/a

Manhole Reference	Manhole Cover Level	Manhole Invert Level
1851	38.4	n/a
1801	38.37	36.13
191B	n/a	n/a
191A	n/a	n/a
1852	38.37	n/a
1853	38.07	35.99
7251	39.05	n/a
7250	39.07	n/a
8350	39.05	37.58
6350	39.15	37.9
8302	39.15	37.86
8351	39.12	36.52
9350	n/a	n/a
8353	39.27	36.51
7254	n/a	n/a
7252	39.07	37.78
7253	39.24	37.55
7255	n/a	n/a
7150	39.59	37.22
8251	38.99	36.64
811B	n/a	n/a
811A	n/a	n/a
8101	38.62	37.22
8253	n/a	n/a
8151	38.69	36.89
8102	38.69	36.94
8150	38.66	37.31
8250	38.82	36.57
8252	38.84	36.68
90ZX	n/a	n/a
90WY	n/a	n/a
90ZV	n/a	n/a
80YS	n/a	n/a
80MK	n/a	n/a
80LK	n/a	n/a
80YP	n/a	n/a
9001	38.58	36.95
80MJ	n/a	n/a
80MH	n/a	n/a
80LJ	n/a	n/a
8051	38.56	37.01
8001	38.64	37.05
8050	38.63	36.93
8002	38.72	37.12
701A	n/a	n/a
701B	n/a	n/a
7050	38.66	37.01
7001	38.72	37.24
601B	n/a	n/a
8052	38.63	36.88
8053	38.6	37.5
The position of the apparatus shown on this plan is given without obligation and warranty, and the accuracy cannot be guaranteed. Service pipes are not shown but their presence should be anticipated. No liability of any kind whatsoever is accepted by Thames Water for any error or omission. The actual position of mains and services must be verified and established on site before any works are undertaken.		



ALS Sewer Map Key

Public Sewer Types (Operated & Maintained by Thames Water)

	Foul: A sewer designed to convey waste water from domestic and industrial sources to a treatment works.
	Surface Water: A sewer designed to convey surface water (e.g. rain water from roofs, yards and car parks) to rivers or watercourses.
	Combined: A sewer designed to convey both waste water and surface water from domestic and industrial sources to a treatment works.
	Trunk Surface Water
	Trunk Foul
	Storm Relief
	Trunk Combined
	Vent Pipe
	Bio-solids (Sludge)
	Proposed Thames Surface Water Sewer
	Proposed Thames Water Foul Sewer
	Gallery
	Foul Rising Main
	Surface Water Rising Main
	Combined Rising Main
	Sludge Rising Main
	Proposed Thames Water Rising Main
	Vacuum

Notes:

- 1) All levels associated with the plans are to Ordnance Datum Newlyn.
- 2) All measurements on the plans are metric.
- 3) Arrows (on gravity fed sewers) or flecks (on rising mains) indicate direction of flow.
- 4) Most private pipes are not shown on our plans, as in the past, this information has not been recorded.
- 5) 'na' or '0' on a manhole level indicates that data is unavailable.

Sewer Fittings

A feature in a sewer that does not affect the flow in the pipe. Example: a vent is a fitting as the function of a vent is to release excess gas.

	Air Valve
	Dam Chase
	Fitting
	Meter
	Vent Column

Operational Controls

A feature in a sewer that changes or diverts the flow in the sewer. Example: A hydrobrake limits the flow passing downstream.

	Control Valve
	Drop Pipe
	Ancillary
	Weir

End Items

End symbols appear at the start or end of a sewer pipe. Examples: an Undefined End at the start of a sewer indicates that Thames Water has no knowledge of the position of the sewer upstream of that symbol, Outfall on a surface water sewer indicates that the pipe discharges into a stream or river.

	Outfall
	Undefined End
	Inlet

Other Symbols

Symbols used on maps which do not fall under other general categories

	Public/Private Pumping Station
	Change of characteristic indicator (C.O.C.I.)
	Invert Level
	Summit

Areas

Lines denoting areas of underground surveys, etc.

	Agreement
	Operational Site
	Chamber
	Tunnel
	Conduit Bridge

Other Sewer Types (Not Operated or Maintained by Thames Water)

	Foul Sewer
	Surface Water Sewer
	Combined Sewer
	Gully
	Culverted Watercourse
	Proposed
	Abandoned Sewer

- 6) The text appearing alongside a sewer line indicates the internal diameter of the pipe in millimetres. Text next to a manhole indicates the manhole reference number and should not be taken as a measurement. If you are unsure about any text or symbology present on the plan, please contact a member of Property Insight on 0845 070 9148.

APPENDIX C

- Greenfield runoff rates – UK SuDS Tool
- Calculations of rainfall runoff and volume – Water Environment Calculation Sheets
- 'Intermediate' method stage-discharge

Calculated by: Water Environment

Site name: Former Cox & Wyman

Site location: RG1 8LB

Site coordinates

Latitude: 51.46162° N

Longitude: 0.98032° W

This is an estimation of the greenfield runoff rate limits that are needed to meet normal best practice criteria in line with Environment Agency guidance "Preliminary rainfall runoff management for developments", W5-074/A/TR1/1 rev. E (2012) and the SuDS Manual, C753 (Ciria, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Reference: 5971772

Date: 2017-07-28T17:05:14

Methodology	IH124
-------------	-------

Site characteristics

Total site area (ha)	1.33
----------------------	------

Methodology

Qbar estimation method	Calculate from SPR and SAAR
SPR estimation method	Calculate from SOIL type

	Default	Edited
SOIL type	1	1
HOST class	---	---
SPR/SPRHOST	0.1	0.1

Hydrological characteristics

	Default	Edited
SAAR (mm)	646	646
Hydrological region	6	6
Growth curve factor: 1 year	0.85	0.85
Growth curve factor: 30 year	2.3	2.3
Growth curve factor: 100 year	3.19	3.19

Notes:

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

Normally limiting discharge rates which are less than 2.0 l/s/ha are set at 2.0 l/s/ha.

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

Where flow rates are less than 5.0 l/s consents are usually set at 5.0 l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set in which case blockage work must be addressed by using appropriate drainage elements

(3) Is $SPR/SPRHOST \leq 0.3$?

Where groundwater levels are low enough the use of soakaways to avoid discharge offsite may be a requirement for disposal of surface water runoff.

Greenfield runoff rates

	Default	Edited
Qbar (l/s)	0.2	0.2
1 in 1 year (l/s)	0.17	0.17
1 in 30 years (l/s)	0.47	0.47
1 in 100 years (l/s)	0.65	0.65

ANNEX A: CALCULATIONS		COVER SHEET																															
Job No. Job Name Engineer Checked By Date	15055 Cox & Wyman Gabriel Eve Guy Laister 26/09/2017 GE GL																																
Site Characteristics																																	
Site Area (ha)	1.33 Overall Discharging from site																																
Existing Pervious Surfaces (ha)	0.06 5% 0.06 β 100%																																
Existing Impervious Surfaces (ha)	1.27 95% 1.27 α 100%																																
Total: 1.33	Total: 1.33																																
Proposed Pervious Surfaces (ha)	0.3 23% 0.3 β 100%																																
Proposed Impervious Surfaces (ha)	0.96 72% 0.96 α 100%																																
Proposed Green Roof	0.07 5% 0.07 γ 100%																																
Total: 1.33	Total: 1.33																																
Green Roof Type: sedum-herbaceus-grass plants >10-15 cm Course Depth Construction Depth: 100-150mm Gradient: of up to 15°,																																	
Peak Rate of Runoff																																	
Existing Site	BROWNFIELD																																
Detailed Modelling Used?	No e.g. Microdrainage, HydroCAD, Multiple Catchments																																
Runoff Calculation Method (Existing)	Wallingford/Modified Rational Calculation Sheets Attached																																
Runoff Calculation Method (Proposed)	Wallingford/Modified Rational Calculation Sheets Attached																																
Allowance for Future Climate Change	To 2115 40%																																
Surface Water Management Strategy	Controlled Outfall																																
Existing Discharge Rate	<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th>1yr</th> <th>30yr</th> <th>100yr</th> </tr> </thead> <tbody> <tr> <td>115.2</td> <td>274.7</td> <td>349.2</td> </tr> <tr> <td>0.2</td> <td>0.5</td> <td>0.6</td> </tr> </tbody> </table>			1yr	30yr	100yr	115.2	274.7	349.2	0.2	0.5	0.6																					
1yr	30yr	100yr																															
115.2	274.7	349.2																															
0.2	0.5	0.6																															
IoH Greenfield Discharge Rate (full site)	I/s																																
Detailed modelling output/FEH:	I/s																																
Limiting Discharge Rate	I/s																																
Post-Development Discharge Rate	I/s																																
Detailed modelling output:	I/s																																
including allowance for climate change	I/s																																
Proposed Discharge Rate	I/s																																
Bespoke Limiting Discharge Rate	I/s																																
Design discharge rate:	I/s																																
Minimum Storage Required	m ³																																
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th>1yr</th> <th>30yr</th> <th>100yr</th> </tr> </thead> <tbody> <tr> <td>115.2</td> <td>274.7</td> <td>349.2</td> </tr> <tr> <td>0.2</td> <td>0.5</td> <td>0.6</td> </tr> <tr> <td>115.2</td> <td>274.7</td> <td>349.2</td> </tr> <tr> <td>86.7</td> <td>209.2</td> <td>267.0</td> </tr> <tr> <td>121.3</td> <td>292.8</td> <td>373.9</td> </tr> <tr> <td>115.2</td> <td>274.7</td> <td>349.2</td> </tr> <tr> <td>5.0</td> <td>13.0</td> <td>18.0</td> </tr> <tr> <td>5.0</td> <td>13.0</td> <td>18.0</td> </tr> <tr> <td>158.5</td> <td>339.9</td> <td>429.4</td> </tr> </tbody> </table>				1yr	30yr	100yr	115.2	274.7	349.2	0.2	0.5	0.6	115.2	274.7	349.2	86.7	209.2	267.0	121.3	292.8	373.9	115.2	274.7	349.2	5.0	13.0	18.0	5.0	13.0	18.0	158.5	339.9	429.4
1yr	30yr	100yr																															
115.2	274.7	349.2																															
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5.0	13.0	18.0																															
158.5	339.9	429.4																															
Volume of Runoff																																	
Additional Volume (above Greenfield) of Runoff Generated																																	
Existing Site	470.0 m ³																																
Proposed Site (unmitigated)	533.6 m ³																																
Rainwater retained on-site for re-use (where limited)	0.0 m ³																																
Long Term Storage Required	63.7 m ³																																
Proposed Site (including soakaways/infiltration SUDS)	515.5 m ³																																
Off-site discharge must be restricted and storage provided																																	
Justification for not using infiltration or preventing discharge: Unsuitable ground condit																																	
Limiting discharge rates:	1yr Qbar 2 l/s/ha Min Flow* 115.2 0.20 2.66 5 (l/s)																																
*as stated in the Code for Sustainable Homes																																	
Preferred Limiting Discharge Rate:	115.2 l/s Design and model outputs attached																																

Date Printed: 29/09/2017

Wallingford Procedure : Existing Peak Runoff			15055	Cox & Wyman	
			Calculations By: GE	Checked By: GL	Date: 26/09/2017
Site Characteristics					
Site Area	AREA	ha	1.33		
Drained Catchment Area	AREA	ha	1.33		
Approximate Longest Drainage Path	L	m	150		
Difference in Ground Levels	ΔH	m	0.3		
Slope	Slope (S)		1: 500		
Permeable Surfaces (Rational Method runoff coefficient = 0.4)		ha	5%		
Impermeable Surfaces (Rational Method runoff coefficient = 0.95)		ha	95%		
Area Weighted Rational Method Runoff Coefficient			0.925		
Site parameters from The Wallingford Procedure for Europe: Best Practice Guide to urban drainage modelling, HR Wallingford, July 2000 (CD)					
60minute, 5 year return period rainfall	M5-60	mm	17		
Ratio of M5-60 to 2day, 5 year return period rainfall	r	-	0.40		
Time of Concentration					
Recommended Tc Method:	SCS: Sheet Flow				
Tc Method Choice:	SCS: Shallow Concentrated Flow				
Shallow Concentrated Flow					
Surface Description		Paved			
Flow Length, L	m	150			
Land Slope	m/m	0.00200			
Velocity	m/s	0.28			
Tc	hr	0.15			
Time of Concentration	T_c	min	9.0		
Critical Storm Duration (minimum 5min)	T_{crit}	min	9.0		
Critical Storm Rainfall and Runoff					
$Z1_{TC}$	0.49 *Wallingford Procedure Figure 3.6				Discharge Rate Q = 2.78CiA
$M5-T_{crit}$	8.3				
C	0.925				
	Return Period (years)	Z2*	Depth (mm)	Intensity (mm/hr)	Discharge Rate l/s
	1	0.61	5.1	33.7	115.16
	2	0.79	6.5	43.3	148.17
	10	1.21	10.0	66.2	226.57
	30	1.46	12.1	80.3	274.71
	50	1.61	13.3	88.5	302.72
	100	1.86	15.4	102.1	349.23
*Wallingford Procedure Table 3.2					

Wallingford Procedure : Developed Peak Runoff		15055	Cox & Wyman		
		Calculations By: GE	Checked By: GL	Date: 26/09/2017	
Site Characteristics					
Site Area	AREA	ha	1.33		
Drained Catchment Area	AREA	ha	1.33		
Approximate Longest Drainage Path	L	m	150		
Difference in Ground Levels	ΔH	m	0.3		
Slope	Slope (S)		1: 500		
Permeable Surfaces (Rational Method runoff coefficient = 0.4)		ha	23%		
Impermeable Surfaces (Rational Method runoff coefficient = 0.95)		ha	72%		
Green Roof of gradient of up to 15°, and depth of 100-150mm, c=		0.4 *	5%		
Area Weighted Rational Method Runoff Coefficient			0.80		
*in line with Table 10.1 of CIRIA C644					
Site parameters from The Wallingford Procedure for Europe: Best Practice Guide to urban drainage modelling, HR Wallingford, July 2000 (CD)					
60minute, 5 year return period rainfall	M5-60	mm	17		
Ratio of M5-60 to 2day, 5 year return period rainfall	r	-	0.40		
Time of Concentration					
Recommended Tc Method:	SCS: Sheet Flow				
Tc Method Choice:	SCS: Shallow Concentrated Flow				
Shallow Concentrated Flow					
Surface Description	Unpaved				
Flow Length, L	m	150			
Land Slope	m/m	0.00200			
Velocity	m/s	0.22			
Tc	hr	0.19			
Time of Concentration	T _c	min	11.4		
Critical Storm Duration (minimum 5min)	T _{crit}	min	11.4		
Critical Storm Rainfall and Runoff					
Z _{1T_c}	0.54 *Wallingford Procedure Figure 3.6			Discharge Rate Q = 2.78CiA	
M5-T _{crit}	9.1				
C	0.797				
Return Period (years)	Z2*	Depth (mm)	Intensity (mm/hr)	Discharge Rate l/s	Future Rate l/s
1	0.61	5.6	29.4	86.65	121.31
2	0.79	7.2	38.0	111.86	156.60
10	1.21	11.1	58.3	171.89	240.65
30	1.48	13.5	71.0	209.18	292.85
50	1.63	14.9	78.4	231.07	323.50
100	1.89	17.2	90.6	267.04	373.85
*Wallingford Procedure Table 3.2					

MRM 100 year Event Storage Calculator		15055	Cox & Wyman
		Calculations By: GE	Checked By: GL Date: 26/09/2017
Site Parameters			
Drained Catchment Area	AREA	ha	1.33
Approximate Longest Drainage Path	L	m	150
Difference in Ground Levels	ΔH	m	0.3
Slope	Slope (S)		1: 500
Permeable Surfaces (Rational Method runoff coefficient = 0.4)		ha	23%
Impermeable Surfaces (Rational Method runoff coefficient = 0.95)		ha	72%
Green Roof of gradient _____ of up to 15°, _____ and depth of 100-150mm , c=		0.4 *	5%
Area Weighted Rational Method Runoff Coefficient			0.80
*in line with the FLL Guidelines on Planning, Execution and Upkeep of Green Roof Sites, 2002			
Site parameters from The Wallingford Procedure for Europe: Best Practice Guide to urban drainage modelling, HR Wallingford, July 2000 (CD)			
60minute, 5 year return period rainfall	M5-60	mm	17
Ratio of M5-60 to 2day, 5 year return period rainfall	r	-	0.40
Time of Concentration	T_c	min	11.4
Maximum Storm Runoff Storage Volume (modified rational method)			
5			
T_d	286.8	min	
Z_{1T_D}	1.47	*Wallingford Procedure Figure 3.6	
$M5-T_d$	25.0	mm	
C	0.80		
Z_{2100}	2.01	*Wallingford Procedure Table 3.2	
$M_{100}-T_d$	50.2	mm	
Intensity	10.5	mm/hr	
Q_d	31.0	l/s	
$Q_{d,climate\ change}$	43.4	l/s	
$Q_{limiting\ discharge}$	18.0	l/s	
Maximum storage required			429.4
The graph titled 'Storage Requirements' plots Storage Volume in cubic meters (m³) on the y-axis (0.0 to 500.0) against Storm Duration in minutes on the x-axis (0 to 60). A series of data points connected by a dashed line shows an increasing trend. Key points include (5, 160), (10, 210), (20, 310), (30, 330), (40, 360), (50, 390), and (60, 430).			

SUDS Manual Volume Calculation (Existing)		15055	Cox & Wyman																			
		Calculations By: GE	Checked By: GL	Date: 26/09/2017																		
Site Characteristics																						
Site Area	AREA	ha	1.33																			
Permeable Surfaces (Existing Case)			5%																			
Proportion discharging to sewer network or local watercourses		β	100%																			
*zero if all runoff collected from unpaved surfaces is retained on site or discharged to ground																						
Impermeable Surfaces (Existing Case)		PIMP	95%																			
Proportion discharging to sewer network or local watercourses		α	100%																			
*zero if all runoff from paved surfaces remains on site or is collected and discharged to ground																						
Soil Index (from FSR or Wallingford Procedure WRAP maps)*	SOIL		0.1																			
*SOIL is the SPR for the soil type, and for larger sites is a weighted sum of the individual soil classes for the site, where: $SOIL = \frac{0.1A_{SOIL1} + 0.3A_{SOIL2} + 0.37A_{SOIL3} + 0.47A_{SOIL4} + 0.53A_{SOIL5}}{AREA}$ For smaller sites, use the SPR for the local soil type, as follows: <table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th style="padding: 5px;">SOIL TYPE</th> <th style="padding: 5px;">1</th> <th style="padding: 5px;">2</th> <th style="padding: 5px;">3</th> <th style="padding: 5px;">4</th> <th style="padding: 5px;">5</th> </tr> </thead> <tbody> <tr> <td style="padding: 5px;">AREA</td> <td style="padding: 5px;">1.33</td> <td style="padding: 5px;">0</td> <td style="padding: 5px;">0</td> <td style="padding: 5px;">0</td> <td style="padding: 5px;">0</td> </tr> <tr> <td style="padding: 5px;">SPR</td> <td style="padding: 5px;">0.1</td> <td style="padding: 5px;">0.3</td> <td style="padding: 5px;">0.37</td> <td style="padding: 5px;">0.47</td> <td style="padding: 5px;">0.53</td> </tr> </tbody> </table> SOIL: 0.1					SOIL TYPE	1	2	3	4	5	AREA	1.33	0	0	0	0	SPR	0.1	0.3	0.37	0.47	0.53
SOIL TYPE	1	2	3	4	5																	
AREA	1.33	0	0	0	0																	
SPR	0.1	0.3	0.37	0.47	0.53																	
Site parameters from The Wallingford Procedure for Europe: Best Practice Guide to urban drainage modelling, HR Wallingford, July 2000 (CD)																						
60minute, 5 year return period rainfall	M5-60	mm	17																			
Ratio of M5-60 to 2day, 5 year return period rainfall	r	-	0.40																			
Volume Calculation for the 100 year return period 6hr storm																						
Z _{16hr}	1.55 *Wallingford Procedure Figure 3.6																					
M5-6hr	26.4																					
Z _{2100yr}	2.00 *Wallingford Procedure Table 3.2																					
M100-6hr	52.9																					
Additional volume (m³) of existing site runoff over Greenfield runoff: $Vol = "M100-6hr".AREA.10[PIMP/100 (0.8\alpha) + (1 - PIMP/100)SOIL . \beta - SOIL]$																						
* EQ24.10 CIRIA C753 The SUDS Manual © CIRIA 2015																						
Additional Volume of Runoff (above Greenfield state):			m³	470.0																		

SUDS Manual Volume Calculation (Proposed)		15055	Cox & Wyman																			
		Calculations By: GE	Checked By: GL	Date: 26/09/2017																		
Site Characteristics																						
Site Area	AREA	ha	1.33																			
Permeable Surfaces (Proposed Case)			23%																			
Proportion discharging to sewer network or local watercourses β			100%																			
*zero if all runoff collected from unpaved surfaces is retained on site or discharged to ground																						
Impermeable Surfaces (Proposed Case)			77%																			
Proportion discharging to sewer network or local watercourses α			100%																			
*zero if all runoff from paved surfaces remains on site or is collected and discharged to ground																						
Soil Index (from FSR or Wallingford Procedure WRAP maps)*			SOIL	0.1																		
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SOIL TYPE	1	2	3	4	5																	
AREA	1.33	0	0	0	0																	
SPR	0.1	0.3	0.37	0.47	0.53																	
Site parameters from The Wallingford Procedure for Europe: Best Practice Guide to urban drainage modelling, HR Wallingford, July 2000 (CD)																						
60minute, 5 year return period rainfall			M5-60	mm																		
Ratio of M5-60 to 2day, 5 year return period rainfall			r	-																		
Volume Calculation for the 100 year return period 6hr storm																						
Z _{16hr}		1.55 *Wallingford Procedure Figure 3.6																				
M5-6hr		26.4																				
Z _{2100yr}		2.00 *Wallingford Procedure Table 3.2																				
M100-6hr		52.9																				
With Climate Change		74.0 40%																				
Additional volume (m³) of development runoff over Greenfield runoff: $Vol = M100-6hr.AREA.10 \left[\frac{PIMP}{100} (0.8\alpha) + \left(1 - \frac{PIMP}{100} \right) SOIL . \beta - SOIL \right]$ * EQ24.10 CIRIA C753 The SUDS Manual © CIRIA 2015																						
Additional Rainfall Volume (above Greenfield state) for the developed site:			m³	533.6																		

