

Flood Risk Assessment & Drainage Strategy



Land at East Street, Reading



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Studios Development (Reading) Ltd.

Report No.

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Project

Land at East Street, Reading (Section 73 Application)

Flood Risk Assessment & Drainage Strategy

Client Name

Studios Development (Reading) Ltd.

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Report Prepared by:

Andrew Vowles

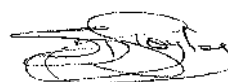
Assistant Engineer (Hydrology and Flood Risk)



Approved for Issue by:

Seymour D'Oyley

Associate Director (Hydrology and Flood Risk)



Issuing Office

X

The Cocoa House, 129 Cumberland Road, Bristol, BS1 6UY
Tel: +44 (0)117 929 2244

GF Suite, Bickleigh House, Park Five Business Centre, Exeter, EX2 7HU
Tel: +44 (0)1392 369098

Unit 17.1, The Leathermarket, 11-13 Weston Street, London, SE1 3ER
Tel: +44(0)20 7939 0959

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Executive Summary

Client	Studios Development (Reading) Ltd.
Site	The site is located by National Grid Reference SU 71870 73168 or postcode RG1 4QJ.
Development Description and Planning Policy	The minor material amendments includes for 5 additional student accommodation units (bringing to a total of 108), associated external alterations and changes to internal layout. The extant permission APP/E0345/W/17/3190317 (as amended by 181629), to which these alterations are being made, included for the erection of a 4 storey building to provide 103 student accommodation units (Suit Generis), landscaping, access and ancillary works, following removal of a 49 space car park. In accordance with Paragraph 066, the development can be categorised as 'More-Vulnerable'.
Flood Sources & Flood Risk	According to the EA's Flood Map for Planning the majority of the Site is within Flood Zone 1 with a small part of the northern border in Flood Zone 2. However, detailed site-specific hydraulic modelling undertaken for this Site showed that the EA map is in error and that the Site is entirely within Flood Zone 1 and the 0.1% annual exceedance probability event would not come close to the Site. This flood zone 1 classification was also confirmed and upheld during the LPA Planning appeal (Appeal ref: APP/E0345/W/17/3190317). Other sources of flood risk have also been assessed and can be summarised as follows: Flooding from Ordinary Watercourses – Low risk Flooding from Groundwater – Low risk Flooding from Sewers – Low Risk Flooding elsewhere from the proposed development – Low risk
Sequential Test Requirement	The FRA which accompanied the planning appeal (Appeal ref: APP/E0345/W/17/3190317) concluded that the Sequential Test is deemed to have been passed as the site is located entirely within Flood Zone 1. A sequential test document (dated 19th June 2018) was subsequently submitted at the request of Reading Borough Council. Below is an extract from Reading Borough Council's response: <i>"Having reviewed this document the LPA is now satisfied that the sequential test has been undertaken to appropriate standard. The sequential test report is considered to have demonstrated that there are no reasonably available sites entirely within flood zone 1 which could practicably accommodate the proposed development. Therefore, the LPA is satisfied that the sequential test has been passed."</i>

Flood Risk
Management
Measures

Comparison of the River Kennett flood levels with ground levels at the site from the topographic survey shows that the site is far above the 1 in 100 year plus climate change flood level, which means no flood mitigation is required to protect against river (fluvial) flooding.

The Drainage Strategy will mitigate any flood risk elsewhere from surface water runoff or from off-site discharge to local sewers.

1 Introduction

1.1 Overview

Clarkebond (UK) Ltd was commissioned by Studios Development (Reading) Ltd. in November 2018 to provide an updated Flood Risk Assessment (FRA) and drainage strategy to support a Section 73 application for minor material amendments to APP/E0345/W/17/3190317 (as amended by 181629), which included for new purpose-built student accommodation on East Street in Reading.

The report has been undertaken in accordance with policy contained within the National Planning Policy Framework (NPPF 2018) and is informed by the Strategic Flood Risk Assessment (SFRA) for the wider area, as well as detailed site-specific hydraulic modelling undertaken for this site to establish the risk of flooding from fluvial flood hazards.

1.2 Site Location and Description

The site is located by National Grid Reference SU 71870 73168 or postcode RG1 4QJ. **Figure 1** shows an aerial view of the existing site. The site is currently a car park, classified as 'Brownfield' land and covers an area of approximately 1520m² (0.152ha). The majority of land cover is impermeable (approximately 0.133ha) with some planting. There is an electricity substation within the site boundary. Vehicular access is via East Street and pedestrian access is possible via Queen's Road to the north and from London Street to the west via a side road.



Figure 1: Site Boundary

1.3 Proposed Development

The minor material amendments include for 5 additional student accommodation units (bringing to a total of 108), associated external alterations and changes to internal layout. The extant permission, to which these alterations are being made, included for the erection of a 4 storey building to provide 103 student accommodation units (Suit Generis), landscaping, access and ancillary works, following removal of a 49 space car park.

The ground floor plan is attached as **Appendix A**.

1.4 Objectives

The main objectives of this FRA report, as recommended in the NPPF, are:

- To assess the site suitability in terms of the Sequential Test and, if required, the Exception Test;
- To identify the probability of flooding at the development;
- To assess the compatibility of the development with the flood risk zone;
- To identify the consequence of flooding at the development and suitable mitigation measures if required;
- Demonstrate that the development will not increase flood risk elsewhere, and where possible, will reduce flood risk.

1.5 Limitations

The information, views and conclusions drawn concerning the site are based, in part, on information supplied to Clarkebond by other parties. Clarkebond has proceeded in good faith on the assumption that this information is accurate. Clarkebond accepts no liability for any inaccurate conclusions, assumptions or actions taken resulting from any inaccurate information supplied to Clarkebond from others.

2 Planning and Flood Risk Policy Review

2.1 Overview of National Planning Policy Framework (NPPF)

National policy on flood risk is set out in paragraphs 155 to 165 of the NPPF (2018) which is also supplemented by National Planning Practice Guidance (NPPG) for flood risk and coastal change. The overarching aim of the NPPF is to ensure inappropriate development in areas at risk of flooding are avoided, which is achieved via application of the Sequential Test.

2.1.1 Sequential Test Process

In summary this test aims to highlight the areas at lowest probability of flooding (Flood Zone 1) and steer new development to these areas. If the location of the low risk area is not suitable due to wider sustainability objectives then progressively higher risk areas (Flood Zone 2/Flood Zone 3) can be considered, provided the development will be suitably safe from flooding and does not increase flood risk to other areas.

The process for undertaking the Sequential Test is shown in **Figure 2**. Flood Zones 1-3 relate to the risk of flooding from Main Rivers (rivers managed by the EA) and the sea, and are used as the primary indicator of whether land is suitable for development. **Table 1** (taken from Table 1 of NPPG) details the corresponding meaning of flood zones in relation to flood risk.

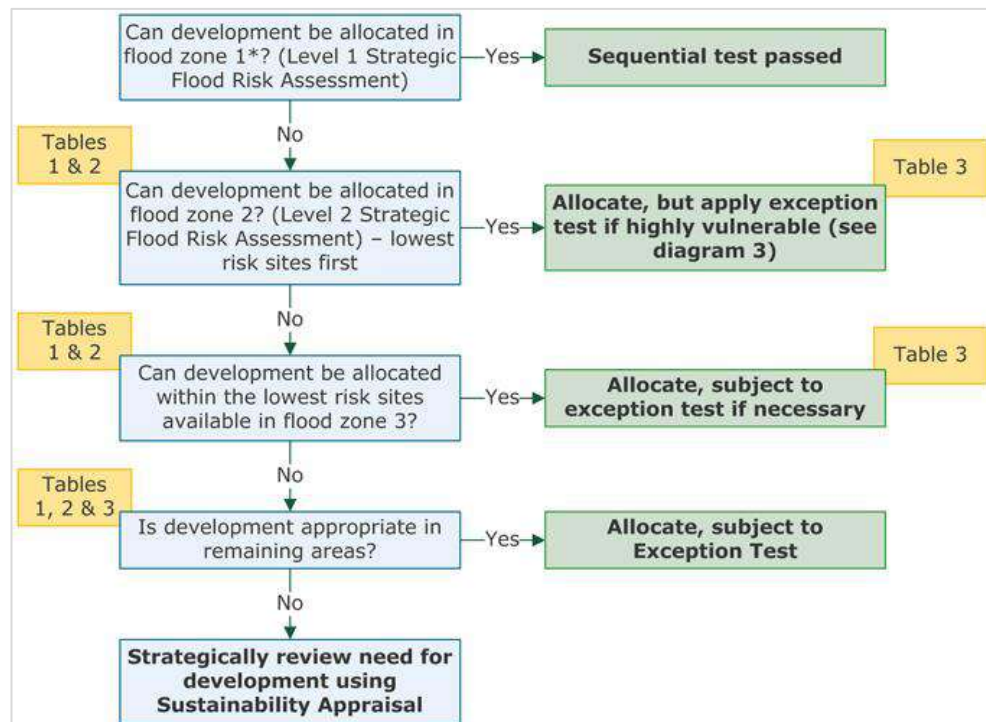


Figure 2: Process of the Sequential Test

Table 1: Definition of Flood Zones (as defined in the NPPG)

Flood Zone	Definition
Zone 1 Low Probability	Land having a less than 1 in 1,000 annual probability of river or sea flooding.
Zone 2 Medium Probability	Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding; or Land having between a 1 in 200 and 1 in 1,000 annual probability of sea flooding.
Zone 3a High Probability	Land having a 1 in 100 or greater annual probability of river flooding; or Land having a 1 in 200 or greater annual probability of sea flooding.
Zone 3b The Functional Floodplain	This zone comprises land where water has to flow or be stored in times of flood. The Strategic Flood Risk Assessments should identify the areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency.

The Sequential Test is considered to be passed if a site is within Flood Zone 1 or has been allocated in the Council's Local Plan where the Sequential Test has already been undertaken. If neither of these applies, a Sequential Test is required to demonstrate that there are no other available and suitable sites at a lower risk of flooding.

2.1.2 Development Vulnerability, Flood Zone Compatibility and the Exception Test

After undertaking the Sequential Test, the vulnerability of development to flooding must be considered so that more vulnerable uses are given priority for lower risk land. This exercise is undertaken by making reference to Table 2 (Paragraph 066) of NPPG which shows the vulnerability classifications of various land use types and Table 3 (Paragraph 067) of NPPG which shows the compatibility of the different vulnerability categories with the Flood Zones and requirements for the Exception Test.

If a site has a range of flood zones, a sequential approach to development should also be taken within the site itself to direct development to the areas of lowest flood risk (Flood Zone 1 first, followed by Flood Zone 2, and finally Flood Zone 3). If it isn't possible to locate all of the development in Flood Zone 1, then the most vulnerable elements of the development should be located in the lowest risk parts of the site (unless there is an overriding reason to choose a different location).

Certain development may require an Exception Test before it is considered acceptable in Flood Zones 2 and 3. To pass this test, the following needs to be demonstrated:

1. The development provides wider sustainability benefits to the community that outweigh flood risk, informed by a Strategic Flood Risk Assessment where one has been prepared; and

2. the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

2.1.3 Sequential Test Requirement at Land at East Street, Reading

The FRA which accompanied the planning appeal (Appeal ref: APP/E0345/W/17/3190317) concluded that the Sequential Test is deemed to have been passed as the site is located entirely within Flood Zone 1.

A sequential test document (dated 19th June 2018) was subsequently submitted at the request of Reading Borough Council. Below is an extract from Reading Borough Council's response:

"Having reviewed this document the LPA is now satisfied that the sequential test has been undertaken to appropriate standard. The sequential test report is considered to have demonstrated that there are no reasonably available sites entirely within flood zone 1 which could practicably accommodate the proposed development. Therefore, the LPA is satisfied that the sequential test has been passed."

Based on the conclusions from the above statement, the Sequential Test for the proposed development is considered to have been passed.

2.1.4 Design Flood Event

According to NPPF and the Environment Agency (EA) flood risk guidance, the proposed development should be flood resistant and resilient including safe access and escape routes for the following extreme flood events, also known as the 'design flood':

- 1 in 100 year (1%) fluvial flood accounting for climate change
- 1 in 200 year (0.5%) tidal/coastal flood accounting for climate change

Climate change is projected to increase the likelihood of flooding from most flood sources and therefore an assessment of the effects of climate change should be considered over the estimated development lifetime.

The lifetime of residential development is accepted as 100 years in accordance with NPPG; from a baseline of **2020** (assumed date of first occupancy) this means assessing the flood level up to **2120**.

2.1.5 Surface Water Runoff Drainage Hierarchy

Surface water drainage from the proposed development must be dealt with in accordance with the following hierarchy taken from Paragraph 080 of NPPG:

1. Infiltration to the ground using a soakaway or other suitable sustainable drainage system.
2. If this is not feasible, discharge to a watercourse or river; generally at a controlled rate unless it does not affect flood risk e.g. if to the sea or an estuary.
3. Discharge at a controlled rate to a surface water sewer or drain.
4. Discharge at a controlled rate to a combined sewer system – this will only be considered if the above have all been investigated and it has been proved that none of these options are suitable. The approval for this can only be given by the Water Authority.

Guidance on how surface water runoff should be managed, notably the discharge rate with which it can leave a development site, is taken from the 'Non-Statutory Technical Standards for Sustainable Drainage Systems' (2015).

2.2 Flood Risk Assessment Requirements

Footnote 50 of the NPPF states that a site-specific FRA is required for developments which:

- Are in Flood Zone 2 or 3;
- Are more than 1 hectare (ha) in Flood Zone 1;
- Are in an area which has critical drainage problems as notified by the Environment Agency;
- Land identified in a strategic flood risk assessment as being at increased flood risk in the future; or
- Could be affected by sources of flooding other than rivers and the sea (e.g. surface water drains, reservoirs) where a development will introduce a more vulnerable use.

The focus of FRAs for the higher risk zones is to fully assess the extent, depth and hazard of flood waters, detail the required mitigation to manage flood risk (e.g. floor levels and access, evacuation routes, compensatory storage) and outline a surface water management plan. FRAs for sites where the risk of flooding from rivers or the sea is classified as low (Flood Zone 1) will still need to assess all other sources of flood risk, but will have a strong focus on management of surface water runoff.

2.3 Relevant Local Planning Policy

Local planning policy provides more specific detail on development requirements based on the flood risk in the local county or borough. The site is within the administrative boundary of Reading Borough Council. The following list shows the relevant planning policy documents that were consulted during this FRA:

- Reading Borough LDF Core Strategy 2008 (Altered 2015) – particularly Policy CS35;
- Sustainable Design and Construction Supplementary Planning Document (2011);
- Level – 1 SFRA (2017);
- Level – 2 SFRA (2017);
- Thames River Basin Management Plan (2015);

- Thames Catchment Flood Management Plan (2009).

Specific policies that apply to this development have been extracted from these documents and provided in **Appendix B**.

3 Background Information

3.1 Site Levels

A topographic survey drawing of the East Street site was produced by Land Development Services in September 2016 (See **Appendix C**).

Within the site boundary, there is a gradual slope from south to north, with a maximum level of 42.47m AOD in the south-west corner of the site and a minimum level of 40.37m AOD to the north (where the main entrance of the proposed building is located). Levels along East Street gradually increase southwards.

3.2 Public Sewers

The Thames Water public sewer map location search is included as **Appendix D**. The nearest public sewers to the site are as follows:

- 450mm diameter foul sewer along East Street which drains northwards, connecting to a 600mm diameter sewer on Queen's Road
- 225mm diameter surface water sewer along East Street which drains northwards, connecting to a 900mm sewer on Queen's Road which outfalls at Gunter's Brook.

The site perimeter is outside of the required public sewer easements in accordance with Sewers for Adoption 6th Edition.

The location of private surface water and foul drainage can be inferred from the manholes and gullies shown in the topographic survey. The site is currently positively drained by a number of gullies which are expected to outfall to the public surface water sewer. There are no manholes shown within the site boundary which suggests there are no drains serving offsite areas which could be affected by the development construction.

3.3 Hydrology

The site is located within the catchment of the River Kennet (see **Figure 3**). The River Kennet rises as winterbournes above Avebury in Wiltshire and flows in an easterly direction through Wiltshire and Berkshire before discharging into the River Thames near Reading. The catchment is largely rural and is characterised by chalk uplands which give the river a strong base flow component, reducing the variability between high and low flows and reducing the likelihood of flooding. The river has several sections which have been divided to form the Kennet and Avon Canal, an artificial watercourse stretching from London to Bristol with levels controlled through locks and dams. The main tributaries of the river are the Lambourn, Dun and Enbourne.

The River Kennet flows in an easterly direction past the site, discharging into the River Thames approximately 1.4km downstream after passing below the railway line. This railway line acts as an informal defence, protecting the south of Reading from the Thames. There is a marina and a

number of lakes downstream of the site alongside the Thames, as well as a number of large lakes upstream of the site, many of which feed into the Kennet.

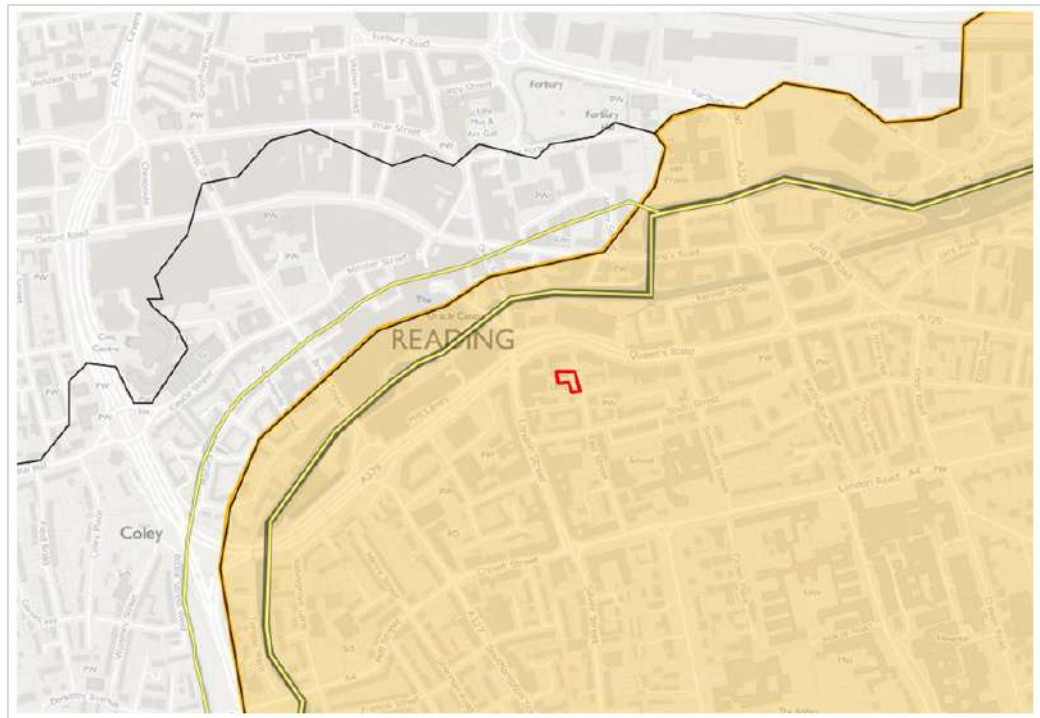


Figure 3: Catchment of the River Kennet

The section of the River Kennet which passes the site forms part of the Kennet and Avon Canal, which is partly protected from flooding by the management of water levels with locks and weirs (although this is unlikely to be effective in more extreme floods). The nearest waterbody to the site is a small section of open channel which was identified in the Groundsure report as River Gunter's. This feature is approximately 120m from the site – it is assumed that part of this watercourse is culverted upstream of this open channel section, although this culverted section is not identified in the Groundsure mapping (See **Appendix E**).

3.4 Geology, Groundwater and Soils

The British Geological Survey (BGS) maps indicate that the site is underlain by the solid bedrock geology of the Seaford Chalk Formation. Superficial (unconsolidated) deposits of 'Taplow Gravel Formation' could also be present in the southern half of the site, overlaying the solid bedrock.

The BGS Lexicon describes the Taplow Gravel Formation as *"Sand and gravel, locally with lenses of silt, clay or peat."* The Seaford Chalk Formation is described as *"Firm white chalk with conspicuous semi-continuous nodular and tabular flint seams. Hardgrounds and thin marls are known from the lowest beds. Some flint nodules are large to very large."*

A previous geotechnical report was undertaken at the site, which was provided to Clarkebond by the client (Refer to *Geotechnical Report, Brewery Site Queens Road Reading Berkshire*, on behalf of Fenchurch Estates Limited. Dated August 1994, Ref: 11459).

One borehole was excavated within the site boundary (BH4; refer to map and borehole log in **Appendix F**). The boreholes described in the report concur with the BGS mapping, showing Made Ground to a depth of 2.70m below ground level (m bgl), below which was “Valley Gravel” (believed to be a previous term for the superficial gravels now known as the Kempton Park and Taplow Gravel Formations). The Valley Gravels were encountered beneath the Made Ground to a depth of 7m bgl and were described as comprising slightly clayey, silty sandy coarse flint gravel with occasional cobbles. Upper Chalk (now known as the Seaford Chalk Formation) was recorded from 7m bgl to a depth of 20m bgl where the borehole ended.

Groundwater was reported to have been encountered in the borehole at 11.8m bgl in the Seaford Chalk, and slowly rose to a level of 11.20m bgl during the testing period. This is significantly deeper than the groundwater levels reported for the borehole to the north of the site which were between 3.8 and 5.8m bgl. Although the Seaford Chalk is deeper below the site, this is not likely to account for such a large difference in groundwater levels. The report also mentions the addition of water (flushing) during the boring which is likely to have led to inaccurate readings.

3.5 Previous Assessment

Argyll Environmental produced a risk assessment report in May 2016 which covered the site and wider area.

4 Flood Risk Assessment

4.1 Flood Zones and Development Compatibility

The EA Flood Map for Planning was reviewed which shows the Flood Zones based on risk from both rivers and the sea as part of the due diligence for this FRA. **Figure 4** indicates that the majority of the site is in Flood Zone 1, with the northern border within Flood Zone 2.

As the site is far inland, and there is no tidal influence on the rivers at this location, the flood extent is only attributable to fluvial sources.

However, detailed site-specific hydraulic modelling undertaken for this site in an earlier planning application (application ref:170019), which recently (2018) received consent, showed that the EA map is in error and that the Site is entirely within Flood Zone 1, and the 0.1% annual exceedance probability event would not come close to the Site. This flood zone classification was also confirmed and upheld during the LPA Planning appeal (Appeal ref: APP/E0345/W/17/3190317).

This means that the site has less than a 1 in 1000 chance of fluvial flooding each year.

As the site is within Flood Zone 1, the Sequential Test is deemed to be passed. Refer to Section 2.1.3.

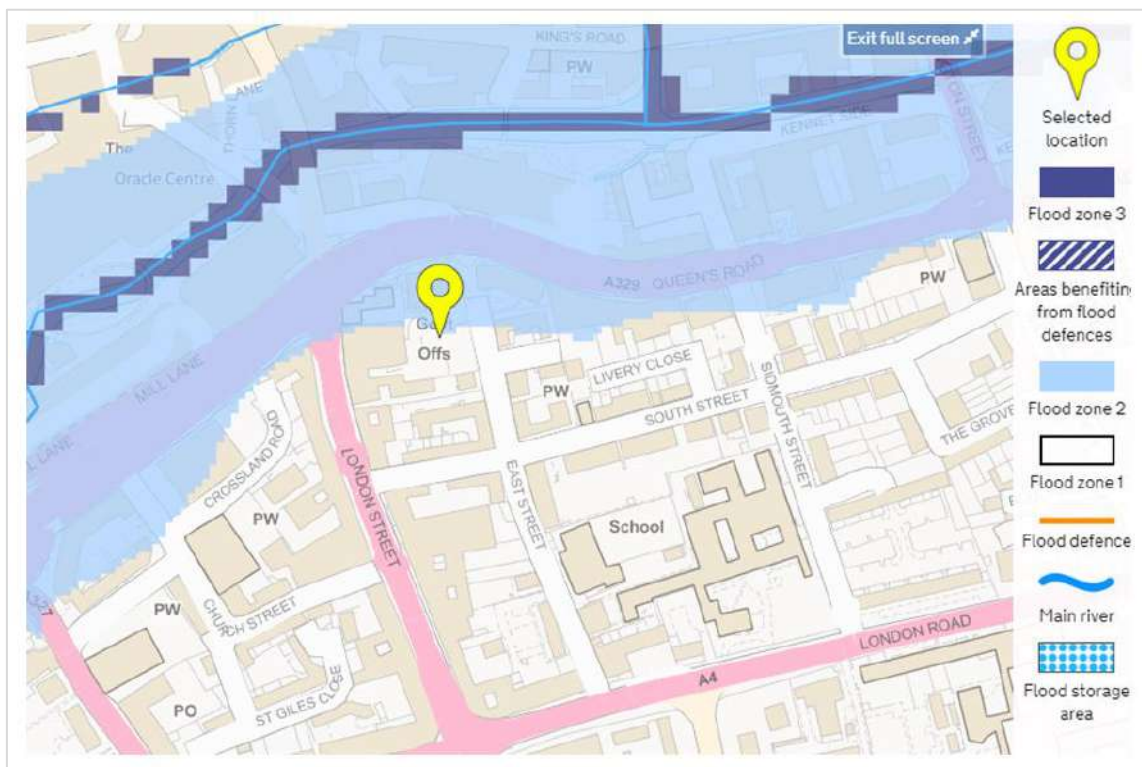


Figure 4: EA 'Flood Map for Planning'

All forms of development are compatible in Flood Zone 1 in accordance with **Table 2** (taken from Table 3 of the NPPG), and More-Vulnerable development (e.g. residential) is also compatible following successful completion of the Sequential Test.

Table 2: Flood Risk Vulnerability and Flood Zone 'Compatibility'

Flood Risk Vulnerability Classification	Essential Infrastructure	Water Compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Flood Zones	Zone 1	✓	✓	✓	✓
	Zone 2	✓	Exception Test required	✓	✓
	Zone 3a	Exception Test required	X	Exception Test required	✓
	Zone 3b	Exception Test required	X	X	X

Where ✓ means the development is appropriate and X means the development should not be permitted

4.2 Impact of Climate Change

Although the Site is not identified as being within a high risk zone for fluvial/tidal modelled flood data, the NPPF states that the FRA should assess the increased risk posed by climate change over the development lifetime. The Site will also be affected by the projected increased risk of surface water and sewer flooding and so the new drainage system for the site should accommodate the projected increase in surface water flows over the development lifetime.

EA guidance on climate change allowances to support the NPPF came into effect in February 2016. The proposed development site is situated within the Severn River Basin district with a development lifespan of ~100 years. Based on NPPG guidance for 'More Vulnerable' development in Flood Zone 1, the central allowance should be used to assess a range of allowances for fluvial flood events, as shown in **Table 3**.

Table 3: Peak River Flow Allowances for Thames River Basin District

	Total Change 2015-2039	Total Change 2040-2069	Total change 2070-2115
Upper End	25%	40%	70%
Higher Central	15%	25%	35%
Central	10%	20%	25%

Table 4 shows the recommended allowances for peak rainfall intensity for different statistical likelihoods. The upper end allowance should be used in areas where there are known flooding issues and there is highly vulnerable development in the downstream sewer network.

Table 4: Peak Rainfall Intensity Allowance in Small and Urban Catchments

	Total Change 2015-2039	Total Change 2040-2069	Total change 2070-2115
Upper End	10%	20%	40%
Central	5%	10%	20%

Supplementary guidance for the West Thames Area states that for minor developments (1-9 dwellings) classified as ‘more vulnerable’ and in Flood Zone 2, a basic approach can be used for estimating the new climate change flood level (see **Appendix G**). This means adding an allowance to the present day flood level in order to avoid completing detailed hydrologic modelling for the estimated increase in river flows. This approach can be used if the EA flood level data has not been updated using the new climate change guidance.

4.3 Fluvial/Tidal Flood Risk

The 2009 SFRA states that the primary source of flood risk in the Borough of Reading comes from fluvial flooding from the River Thames and Kennet. The definition of risk is based on the likelihood of the flood occurring, as well as the extent of the impact if this type of flooding were to occur.

Appendix H includes the flood level data provided by the EA. 'Flood Point 3' should be used to inform the flood levels at the site as it is just upstream; this gives a flood level of 37.58m AOD in the 1 in 100 year event (1% Annual Exceedance Probability) in present day. However, no data was provided for the 100 year plus climate change and 1000 year events and the EA have confirmed that hydraulic model runs have not been undertaken for these events. The EA's basic approach to estimating the climate change level (shown in **Appendix G**) stipulates that a minimum of 500mm should be added ('Central' allowance) but as a conservative approach, 700mm is recommended which relates to the 'Higher Central' allowance¹. This gives an estimated flood level of 38.28m AOD for the 100 year plus climate change event.

The minimum recorded level of the site is 40.37m AOD which is over 2m above the flood level of 38.28m AOD meaning the site is flood free in the 1 in 100 year plus climate change event. Although the 1000 year flood level has not been provided, the likelihood of the depth of flooding for this event being over 2m greater than the 100 year plus climate change event is low.

To confirm this assumption, Clarkebond undertook hydraulic modelling to confirm whether the development site was within Flood Zone 1 (WB04333 – FR08, see **Appendix I**). This concluded, contrary to the EA indicative flood map, that the site is outside the 1000 year flood extent (FZ1) and therefore at very low risk.

4.4 Other Sources of Flood Risk

Other sources of flooding which need to be assessed are:

- Ordinary watercourses (watercourses not under jurisdiction of EA)
- Groundwater
- Surface water
- Sewers (sewer and drain exceedance and pumping station failure)
- Reservoirs, canals and other artificial waterbodies

¹ The Higher Central allowance is based on the 70th percentile meaning there is only 30% chance of levels increasing by greater than 700mm.

4.4.1 Ordinary Watercourse Flooding

The SFRA mentions that there are a number of culverted watercourses in Reading which are not represented in the EA Flood Zone outlines, but pose a fluvial flood risk either due to capacity issues or blockage. The closest culverted watercourse mentioned in the SFRA is the Holy Brook which flows below Reading town centre. However, this is not considered to pose a risk to the site as it is some distance away and this culvert does not carry significant flows during a flood event. River Gunter's (the nearest surface waterbody to the site) is assumed to not be a culverted watercourse which could pose a flood risk as it is not mentioned in the SFRA. Therefore the risk from this feature is considered to be very low.

4.4.2 Groundwater Flooding

Groundwater flooding typically occurs when water levels rise up above surface elevations from underlying rocks or springs following prolonged rainfall. The two most common mechanisms of groundwater flooding are:

1. Bedrock Flooding – Occurs following extended periods of rainfall in areas underlain by a permeable bedrock outcrop. Typically, chalk aquifers pose the greater risk, where the large pore spaces in the rock allow the water table to rise rapidly. Settlements most at risk are those in low-lying areas and at the base of steep-sided valleys at the interface between permeable and impermeable strata (where the groundwater table is naturally closer to the ground surface).
2. Superficial Deposit Flooding – Occurs in permeable unconsolidated deposits (e.g. gravel) which lie on river floodplains following high in-bank river levels.

As previously mentioned, the Groundsure report identified the site as potentially being at risk of groundwater flooding. Review of the Argyll report also indicates that the site is at high risk of groundwater flooding with a return period of 1 in 100 years or more (See **Figure 5**). The map in **Figure 5** is based on ESI data which uses algorithms and calibrated predictions of the risk of groundwater flooding occurring in England and Wales. A major limitation of this mapping is it does not adequately consider the physical characteristics of an area such as proximity to a watercourse and the site topography (which constitute important controls on superficial deposit and bedrock groundwater flooding). Therefore, further site-specific assessment is required to quantify and determine the groundwater flood risk.

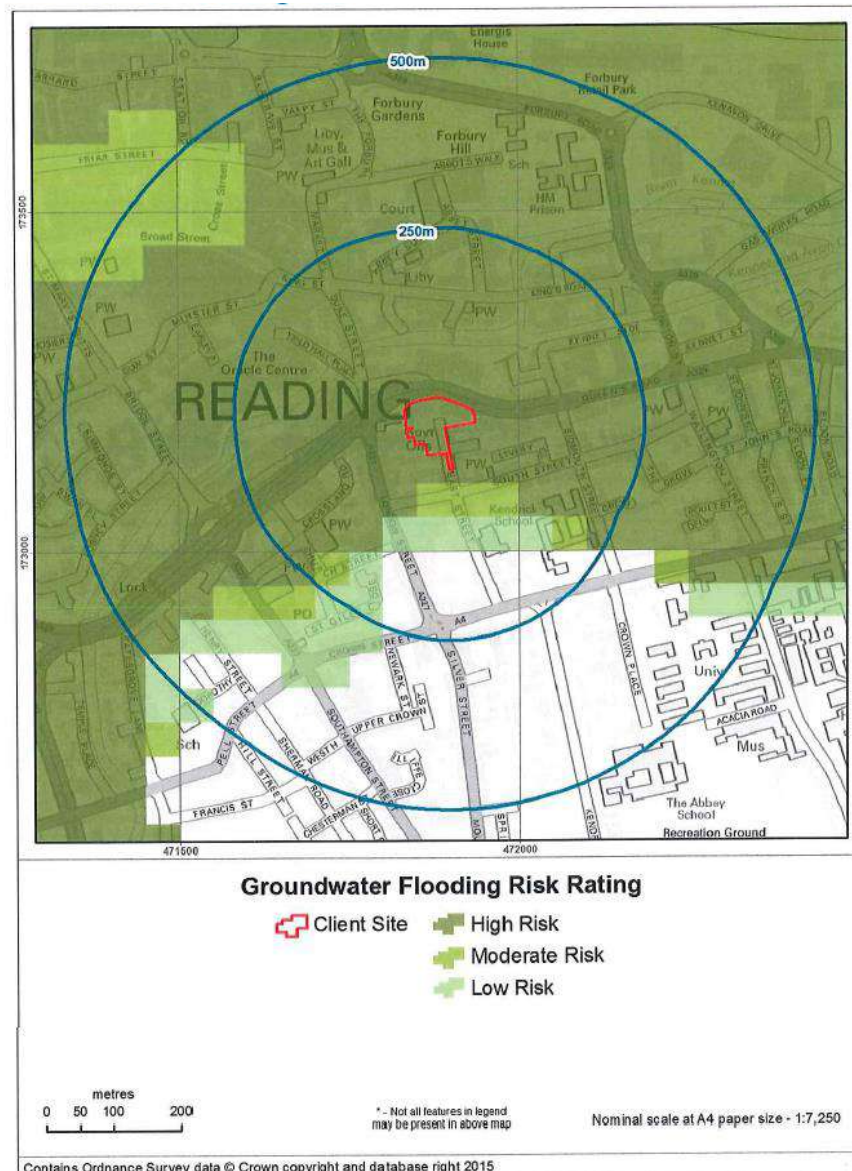


Figure 5: Groundwater Flood Risk Map

Groundwater flooding within permeable superficial deposits occurs during high in-bank river levels when the adjacent land is in hydraulic connection with the river. The risk of the site flooding from the superficial deposits is considered to be negligible for the following reasons:

- The deposits are classified as Secondary A Aquifers which are unlikely to support regional scale groundwater flows or facilitate rapid rise in water levels.
- The deposits do not appear to be connected to any watercourse or large surface water feature and are at a higher level than the River Kennett.

The chalk bedrock is classified as a 'Principal Aquifer' which is capable of supporting large quantities of groundwater and is highly productive. This means that the groundwater table is capable of rising significantly during periods of extended rainfall. The site is also at a relatively

low elevation in comparison to surrounding areas and near to the River Kennett which would suggest it is closer to the water table.

Based on the above geology and topography, the groundwater flood risk would be considered to be relatively high. However, the historic borehole suggested that the groundwater table was at 11m bgl and a rise in water table by over 11m would not occur in an unconfined aquifer. This suggests that groundwater is unlikely to be encountered in the construction process, but further boreholes are recommended to confirm this as there is low confidence in the groundwater readings due to the method of borehole excavation (which involved water flushing). Due to the level of confidence in the boreholes, the likelihood of encountering groundwater during the construction process is considered to be moderate.

Another important factor which influences the likelihood of groundwater flooding is the presence of unproductive strata / impermeable surfacing above an aquifer. As the site is within a large urban area with paved surfaces and made ground which would inhibit rising water tables from lower strata, the likelihood of the emergence of groundwater at the surface is considered to be low. Groundwater emergence from nearby areas not covered by impermeable surfacing could occur, and in these instances, the water would follow the natural flow paths of surface water flows. However, as the development is not within an area at risk of surface water flooding, emerged groundwater for nearby areas would also not affect the site. This means the risk of groundwater flooding for the completed development is considered to be low.

4.4.3 Sewer Flooding

Thames Water is the statutory water undertaker and keeps a record of historic sewer flood events in a database called the DG5 register. According to data presented in the Level-1 SFRA, taken from the DG5 register, there have been 51-100 reported flood incidents for the Site's postcode area (RG1 4). It should be noted the DG5 register provides a 'snapshot' in time and will be outdated by the addition of new properties.

For the reasons discussed, and the relationship between probability and impact, the baseline risk to the Site from sewer flooding is determined to be **low**. The proposed Drainage Strategy will however ensure that there is no increase in flood risk on Site or elsewhere.

4.4.4 Surface Water Flooding

Surface water flooding is caused by heavy rainfall events that cause significant surface runoff and ponding of accumulated water. The probability and impact of flooding is heavily dependent on the topography of a site, as well as the ground conditions and its infiltration capability. The EA states that "flooding from surface water is difficult to predict as rainfall location and volume are difficult to forecast".

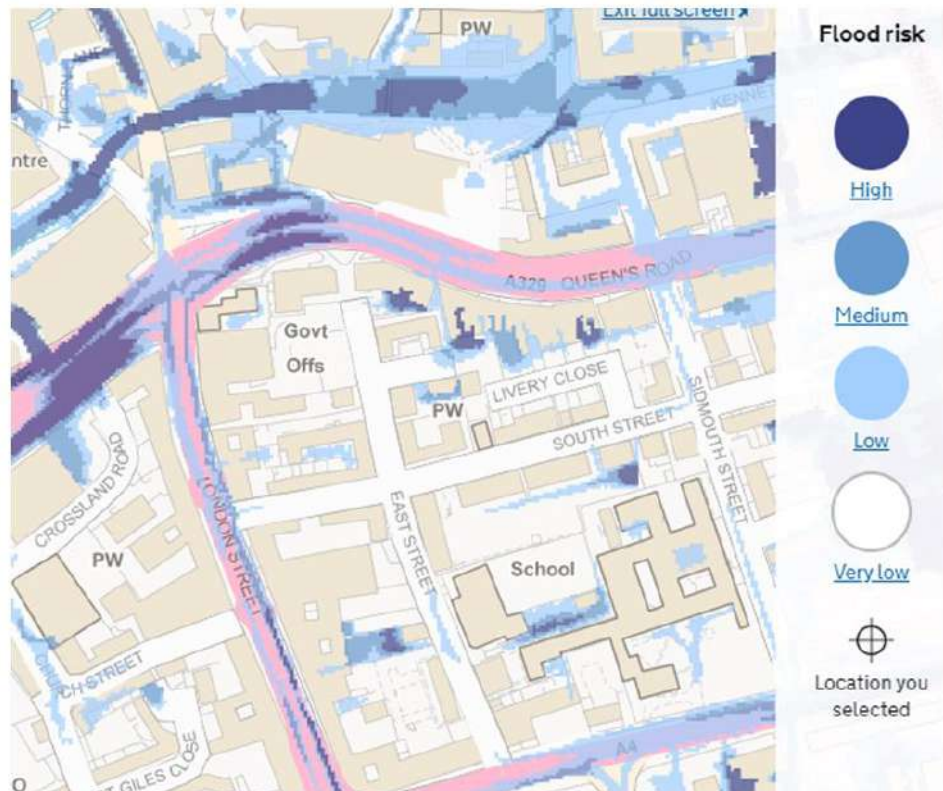


Figure 6: EA Surface Water Flood Map

As can be seen from the EA surface water flood map (**Figure 6**), the entirety of the Site is at very low risk of surface water flooding. This represents a less than 0.1% annual probability of occurrence. Therefore the risk from surface water flooding to the Site is considered to be **very low**.

4.4.5 Flooding from Artificial Infrastructure Failure

The proposed development site is not within an area at risk of flooding from reservoirs, therefore the risk posed to the site from Artificial Infrastructure Failure is **none**.

4.5 Cumulative Impact on Flood Risk

Under the new NPPF guidelines, the cumulative impact on flood risk from both the Proposal and surrounding developments must be assessed. This should involve determining where there are common flood sources, pathways and receptors and assessing the scale and timings of any impacts likely.

As the majority of the surrounding area is brownfield land, any redevelopment of these Sites alongside the Proposal isn't likely to cause a worsening flood risk situation. As identified for the Site, the surrounding area is at very low risk from fluvial/tidal sources. Therefore the key risks to the wider area are likely from surface water and sewers. Any changes to the drainage of neighbouring sites will be subject to the same policy as this Proposal; therefore, for the majority of the surrounding area there is likely to be a beneficial cumulative impact from the implementation of policy.

4.6 Impact of Development on Flood Risk Elsewhere

A key requirement of this FRA, along with assessing flood risk to the Site, is to adequately assess the impact of the Proposal on flood risk elsewhere. This involves determining the source of risk (e.g. changes to the Site), the pathway of risk (e.g. re-direction of flow) and the receptors to the risk (e.g. nearby properties).

The building footprint is outside of the fluvial floodplain and so the development will not lead to a reduction in floodplain storage. Therefore, flood compensatory storage is not required.

The new development will not increase the impermeable area of the site, and so will not increase overland flow and surface water flood risk to downstream areas. However, planning authorities and regulatory bodies often require new development to actually have a positive (rather than neutral) impact on the downstream surface water drainage network where feasible. The proposed drainage strategy describes measures which can be implemented in order to achieve betterment on the existing situation.

4.7 Safe Access and Egress

The SFRA and NPPF stipulate that dry access is to be available in the 1 in 100 year event. For the more extreme 1 in 1000 year event, flood waters should not exceed 300mm.

The site is located within Flood Zone 1, with dry access/egress to and from the site to the wider road network via East Street for both the 1 in 100 year flood event and the more extreme 1 in 1000 year event.

4.8 Mitigation and Management Requirements

The SFRA and EA guidance dictate that the Finish Floor Level (FFL) of the ground floor should be 300mm above the 1 in 100 year river flood level accounting for climate change.

Comparison of the River Kennett flood level data with the topographic survey shows that the site is far above the 1 in 100 year plus climate change flood level which means no flood mitigation is required as part of the development design to protect against river flooding.

The historic boreholes suggest that the groundwater table is over 11m bgl with a slow rate of infiltration into the borehole excavation. However, it is recommended that the groundwater level and rate of water rise is assessed by additional borehole excavations to inform the likely mitigation required. If the groundwater table is likely to be encountered in the excavation of foundations and general earthworks, the following mitigation measures can be employed:

1. Excavating during the summer months when water table is likely to be lower
2. Lowering groundwater levels in advance of excavation e.g. by a deep well system
3. De-watering of excavation by pumping out any water which enters (sump pumping)

If a fast rate of infiltration into the boreholes is observed then the third mitigation option is not advised as significant groundwater seepage into the excavation can lead to instability.

The Drainage Strategy will ensure that flood risk to elsewhere from surface water runoff and sewer input is mitigated.

4.9 Summary Table

Flood Source	Current Level of Risk	Mitigation Required	Residual Risk
Fluvial/Tidal		None Required	
Ordinary Watercourse		None Required	
Groundwater		Excavating during the summer months when water table is likely to be lower Lowering groundwater levels in advance of excavation e.g. by a deep well system De-watering of excavation by pumping out any water which enters (sump pumping)	
Sewer		Drainage Strategy	
Surface Water		None Required	
Artificial Infrastructure			
Flood Risk to Elsewhere		Drainage Strategy	
Key		High Risk – Major constraint to development requiring active consideration in mitigation proposals	
		Moderate Risk – Issue requires consideration but not a significant constraint to development	
		Low – Issue requires some consideration and is not a significant constraint to development	
		Very Low - Issue requires little to no consideration and is not a significant constraint to development	
		Negligible Risk - No noticeable impact to site and not considered to be a constraint to development	

5 Drainage Strategy

5.1 General

As a minimum, the proposed on-site drainage will need to adhere to the guidance set out in the NPPF and best practice guidance which requires surface water to be managed so that flood risk (both on site and to third-parties) is not increased and where possible flood risk should be reduced from the existing situation.

Best-practice guidance has been followed to identify the most appropriate and sustainable method for managing surface water at this development. **Sections 5.3 and 5.4** constitute the outline surface water and foul drainage strategy which will form the basis of the detailed design work at a later date.

All private drainage should be constructed in accordance with Building Regulations and adoptable drainage constructed in accordance with the relevant Sewers for Adoption Guidance.

5.2 Guidance and Policy

5.2.1 Building Regulations Guidelines

General policy for sustainable drainage would follow the hierarchy as discussed in Part H of Building Regulations and Paragraph 080 (Reference ID: 7-080-20150323) of NPPG:

1. Infiltration to the ground using a sustainable drainage system.
2. If this is not feasible, discharge to a watercourse or river; generally at a controlled rate unless it does not affect flood risk e.g. if to the sea or an estuary.
3. Discharge at a controlled rate to a surface water sewer or drain.
4. Only if the above have all been investigated and it has been proved that none of these options are suitable will discharge at a controlled rate to a combined sewer system be considered and the approval for this can only be given by the Water Authority.

5.2.2 Sustainable urban Drainage Systems (SuDS)

SuDS seek to manage surface water as close to its source as possible, mimicking surface water flows arising from the site prior to the proposed development. Where possible, a SuDS technique should seek to contribute to each of the three goals identified below with the favoured system contributing significantly to each objective.

1. Reduce flood risk (to the site and neighbouring areas),
2. Reduce pollution, and,
3. Provide landscape and wildlife benefits.

There are various SuDS measures which can be adopted which can be designed to infiltrate runoff to reduce the overall volume of water leaving a site (Option 1 in drainage hierarchy) and/or attenuate (slow) runoff in order to reduce peak flows in a receiving watercourse/sewer (Options 2, 3 and 4 in drainage hierarchy).

Table 5 includes examples of commonly used components in a SuDS system. The proposed drainage strategy makes use of a number of these components, giving priority to measures which provide additional benefits to water quality/ecology/amenity whilst taking into account the various site constraints and design objectives.

Table 5: Examples of Sustainable urban Drainage Systems

SuDS Measure	Description	Source/Site Control?
Infiltration/attenuation basins, ponds and wetlands	Depressions in the ground that are utilised for surface runoff storage and also provide high potential for ecological, aesthetic and amenity benefits.	Site control
Swales	Vegetated channels used to convey rainwater, which remove pollutants and may permit infiltration in permeable soils.	Site control
Infiltration trenches	Gravel-filled channel which conveys flows, sometimes with a perforated pipe at the base to outfall to a receiving waterbody.	Site control
Soakaway	Gravel-filled pit which water is piped into so it drain slowly out into the surrounding permeable soil	Source control
Soft Landscaping	Planted vegetation and green space used to increase the permeable area of the site and promote infiltration and interception of rainfall.	Source control
Filter strips	Vegetated areas of gently sloping ground alongside impermeable areas which remove pollutants and promote infiltration/evaporation.	Site control
Permeable paving	Paving that allows infiltration of rainwater either to the underlying soil (permeable sites) or permeable sub-base (impermeable sites).	Source or site control depending on design
Green roofs	Vegetated roofs that reduce the volume and rate of runoff entering downpipes and remove pollution.	Source control
Rainwater Harvesting/Butts	Collects water from roof runoff for re-use in household appliances or gardens.	Source control
Attenuation tanks	Below-ground tanks used to store attenuated flows, to be gradually released into the sewer network.	Site control

5.3 Surface Water Strategy

5.3.1 Existing and Proposed Runoff Rates

Surface water runoff from the site should not exceed the discharge rate currently present on site, in accordance with the 'Non-Statutory Technical Standards for Sustainable Drainage Systems' (2015). The Site is predominantly impermeable and surface water on site is captured by the existing drainage system. Therefore post-development no additional runoff is envisaged from the Site. To ensure that flood risk is not increased elsewhere; surface water should ideally be directed in the same manner as in pre-development.

For previously developed sites, 30% betterment on the pre-development rates is generally requested. Existing rates for Brownfield Sites can be estimated using the following methods:

- Establish drainage connections and estimate full bore discharge using existing drainage details, i.e. gradient, pipe size.
- Modified Rational Method, which uses the following formula:

$$Q_p \text{ (l/s)} = 2.78CiA$$

Where:

Q_p = discharge rate

C = Coefficient where $C = C_v \times C_r$ (C_v = volumetric coefficient & C_r = routing coefficient) $C = 0.8 \times 1.3$

i = mean rainfall intensity (mm/hr)

A = Area (ha) drained hard surfaces

The Modified Rational Method will generally give the lower rate and so this is the method used here. The area of drained hard surfaces was conservatively estimated as 0.133ha and the mean rainfall intensity values were based on a 35 minute storm. The rainfall intensity values and estimated peak discharge rates are shown in **Table 6**.

Table 6: Rainfall Intensity Values and Existing Peak Discharge rates

Rainfall Event	Average Intensity for a 35 minute storm (mm/hr)	Surface Water Peak Discharge Rate (l/s)
Q1	17.616	6.77
Q30	52.038	20.01
Q100	76.355	29.36

It is proposed that runoff from the 1 in 30 year event is restricted to provide 30% betterment on the existing Brownfield discharge. Flows for the 1 in 100 year plus climate change event will also be restricted to the 1 in 100 year event in present day, assuming an increase in rainfall intensity of 30% over the 100 year lifetime of residential developments. So to summarise, off-site discharge for the 1 in 30yr event will be restricted to 70% of the 1 in 30 peak discharge rate and the 100yr +cc event restricted to 70% of the 1 in 100 yr peak discharge rate.

Based on the values in **Table 5**, runoff from up to the 1 in 30 year event (accounting for climate change) will be limited to 14.01 litres per second, which is 30% betterment on the estimated existing discharge rate of 20.01l/s. Flows which exceed the existing 30 year runoff will be limited to 29.36 litres per second up to the 1 in 100 year plus climate change event.

Runoff from events smaller than the 1 in 30 year will not be restricted, but the development should provide the same quantity of permeable area as the existing site (at least) to ensure runoff is not increased for these events.

It should be noted that this strategy was previously consented under the previous application for the Site (application ref: 170019) following the subsequent appeal.

5.3.2 Required Storage

Defra's non-statutory standards states that the drainage system must have the capacity to hold attenuated flows for the 1 in 30 year event and not cause flooding to vulnerable infrastructure or evacuation routes for the 1 in 100 year event accounting for climate change.

An assessment has been made of the onsite storage required for the 1 in 100 year plus climate change event using Windes Microdrainage Quick Storage Estimate. This indicated that a maximum storage volume of 28m³ would be required (Refer to calculations in **Appendix J**), assuming that the impermeable area will not increase as a result of the new development. The drainage strategy has shown that the majority of this volume could be accommodated by a SDS Geolite attenuation tank below the external courtyard, with anticipated dimensions of 10.8m x 4.2m x 0.5m. The remaining volume will be compensated by oversized pipes and inspection chambers/manholes.

It is to be noted that a full detailed design (supported by Windes network model files and including detailed calculations of runoff volumes for all return periods and events) will be provided for approval by the Local Planning Authority prior to work commencement.

5.3.3 Proposed Surface Water Strategy

The proposal is for private, surface water gravity sewers which will connect to the adopted surface water sewer to the north-east of the site via a new manhole (see **Appendix K**). This is subject to the agreement of flows with Thames Water and a Section 106 agreement. Invert levels were not available for the relevant manholes, so will need to be confirmed in a CCTV survey prior to detailed design.

The proposal is to limit flows using a complex flow control on the surface water pipe before it discharges into the public surface water sewer. The attenuated flows can be accommodated in a cellular tank beneath the patio area.

It should be noted that the principles of this strategy were previously consented under the previous application for the Site (application ref: 170019) following the subsequent appeal.

5.4 Proposed Foul Water Strategy

5.4.1 Foul Water Regulation

Under the Private Sewer transfer Regulations 2011; all new pipes which connect to the public sewer system and carry flow from more than one property will be adopted by a local Sewer Authority. Subsequently, they should be located in publicly accessible area and accord with the following principles:

- Pipes to have a minimum cover of 1.2m in trafficked areas and 0.6m elsewhere;
- All pipes to achieve a self-cleansing velocity of 0.75m/s at one-third design flow where possible;
- The minimum pipe size to be 100mm diameter, or 150mm diameter where presented for adoption;
- Roughness coefficient for all pipes (ks value) to be 1.5mm;
- Manholes to be placed at a maximum spacing of 150m centres.

5.4.2 The Proposed Strategy

The foul drainage strategy is shown in **Appendix L**. The Thames Water sewer map shows there is an adopted foul sewer to the east of the site. Although there are no manhole covers on Thames Water's records it is believed that there is a manhole for this sewer located just north of the site. We propose a connection for the foul drainage at this location subject to confirmation of its connection to the main sewer line and agreement of flows with Thames Water. Foul sewage will be discharged by gravity via new private sewers into the main foul sewer.

Based on the assumption of 4000 litres per dwelling per day (as quoted in Sewers for Adoption 7th Addition) and an estimated 108 no. units, the maximum peak foul flow rate from the

development is 5.00l/s. The final flow rates calculated at detailed design will need to be agreed with Thames Water.

The Thames Water sewer map shows that the nearest public sewer to the site is on East Street. The site boundary is outside of the easement requirement for this sewer which means there are no constraints to development in relation to the location of public sewers.

It should be noted that the principles of this drainage strategy were previously consented under the previous application for the Site (application ref: 170019) following the subsequent appeal.

5.5 Ownership and Maintenance

The details of the ownership and maintenance for all drainage on the site are required as part of the planning guidance. On this site it is proposed that the main foul and surface water run is adopted by Thames Water. The connections into the main runs and any SuDS elements will be owned and maintained by a private management company to be appointed by the developer.

6 Summary & Conclusion

The proposal is for minor material amendments to the extant permission ((APP/E0345/W/17/3190317) (as amended by 181629)) include for 5 additional student accommodation units (bringing to a total of 108), associated external alterations and changes to internal layout. This type of development is considered 'More Vulnerable' in accordance with Table 2 of NPPG.

The Site is entirely within Flood Zone 1 and the 0.1% annual exceedance probability event would not come close to the Site. This flood zone classification was also confirmed and upheld during the LPA Planning appeal (Appeal ref: APP/E0345/W/17/3190317).

The FRA which accompanied the planning appeal (Appeal ref: APP/E0345/W/17/3190317) concluded that the Sequential Test is deemed to have been passed as the site is located entirely within Flood Zone 1.

A sequential test document (dated 19th June 2018) was subsequently submitted at the request of Reading Borough Council. Below is an extract from Reading Borough Council's response:

"Having reviewed this document the LPA is now satisfied that the sequential test has been undertaken to appropriate standard. The sequential test report is considered to have demonstrated that there are no reasonably available sites entirely within flood zone 1 which could practicably accommodate the proposed development. Therefore, the LPA is satisfied that the sequential test has been passed."

The Site is not within the floodplain and so the Sequential Test is considered to be passed and the land use is compatible with the Flood Zone.

Safe access and egress is also possible in extreme fluvial and surface water flooding events. Therefore, no mitigation is required to protect against fluvial flooding.

The risk of groundwater flooding for the completed development was considered to be low but during the construction process, the risk of encountering groundwater was considered to be low to moderate. Further site investigation of groundwater levels is recommended due to the low level of confidence in the historic groundwater readings. Measures for managing groundwater in the construction phase are discussed in the report.

The proposed foul and surface water drainage strategy is to discharge into the Thames Water sewers along East Street, subject to agreement with the Council and Thames Water. A CCTV survey is also required in order to confirm the connection location and manhole inverts. Surface water flows up to the 1 in 30 year event will be restricted to provide 30% betterment on the existing 1 in 30 year discharge; larger events will be restricted to the existing 1 in 100 year

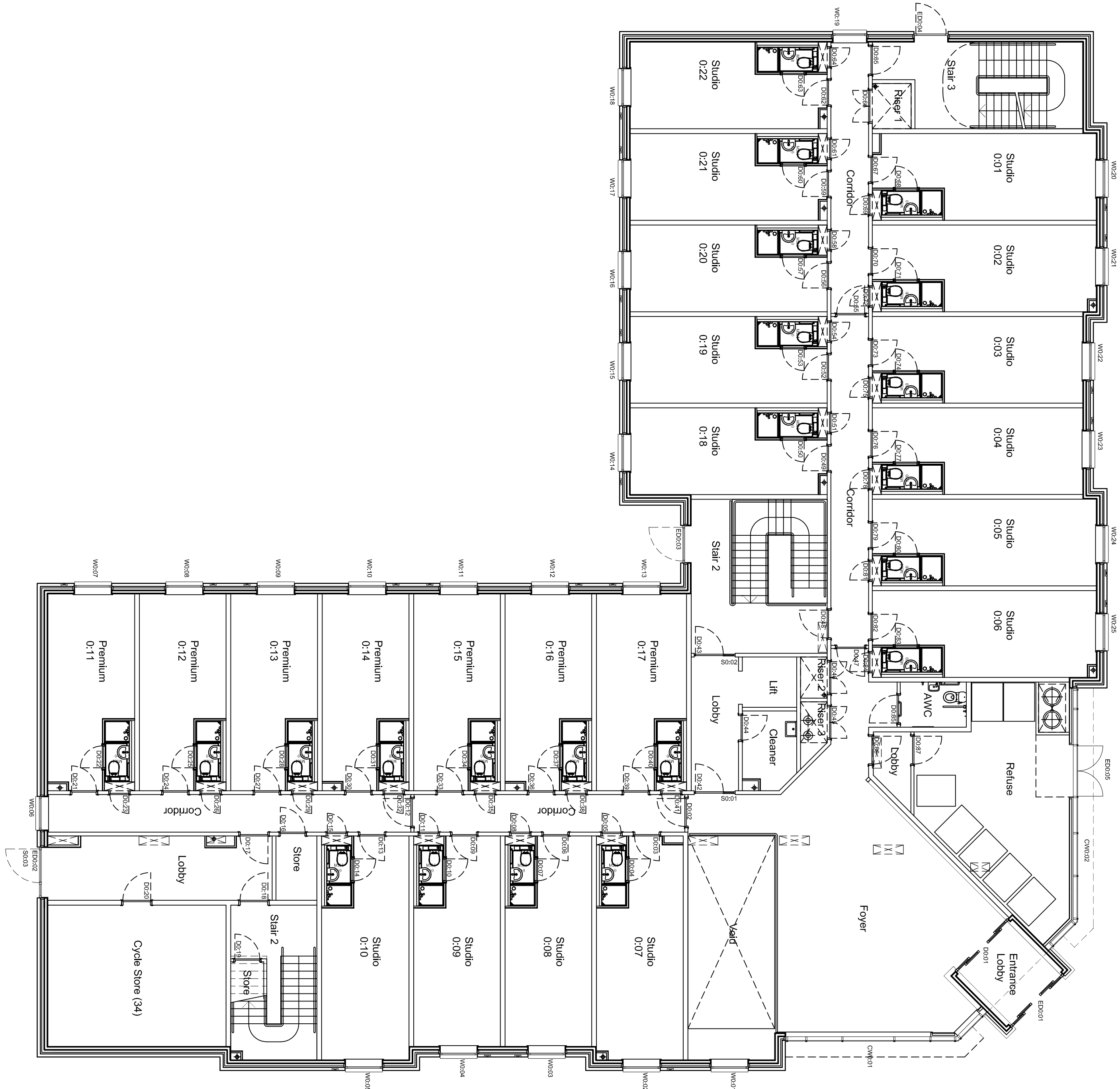
discharge. An attenuation tank is proposed below the external courtyard, which has capacity to store flows from the 1 in 100 year plus climate change event.

This FRA has demonstrated that the site is suitable for the proposed development and can be made safe from all sources of flooding.

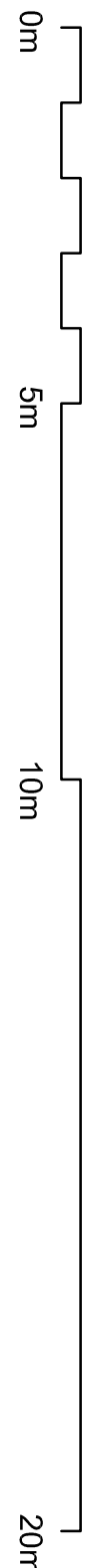
Appendix A – Proposed Basement & Ground Floor (x2)

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Drawing: PROPOSED LEVEL 0 FLOOR PLAN_PLANNING

Drawing No: 050		
Scale: 1:100	Job No: 18 053	Rev: 1
at size: A1	Status: Preliminary	B

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revision	notes	status	date	author	reviewer
B	3MKA Planning Issue	P	15/11/2018	MB	-
A	3MKA Planning Issue	P	15/11/2018	MB	-
-	First Issue	P	18/09/2018	MB/MB	MB

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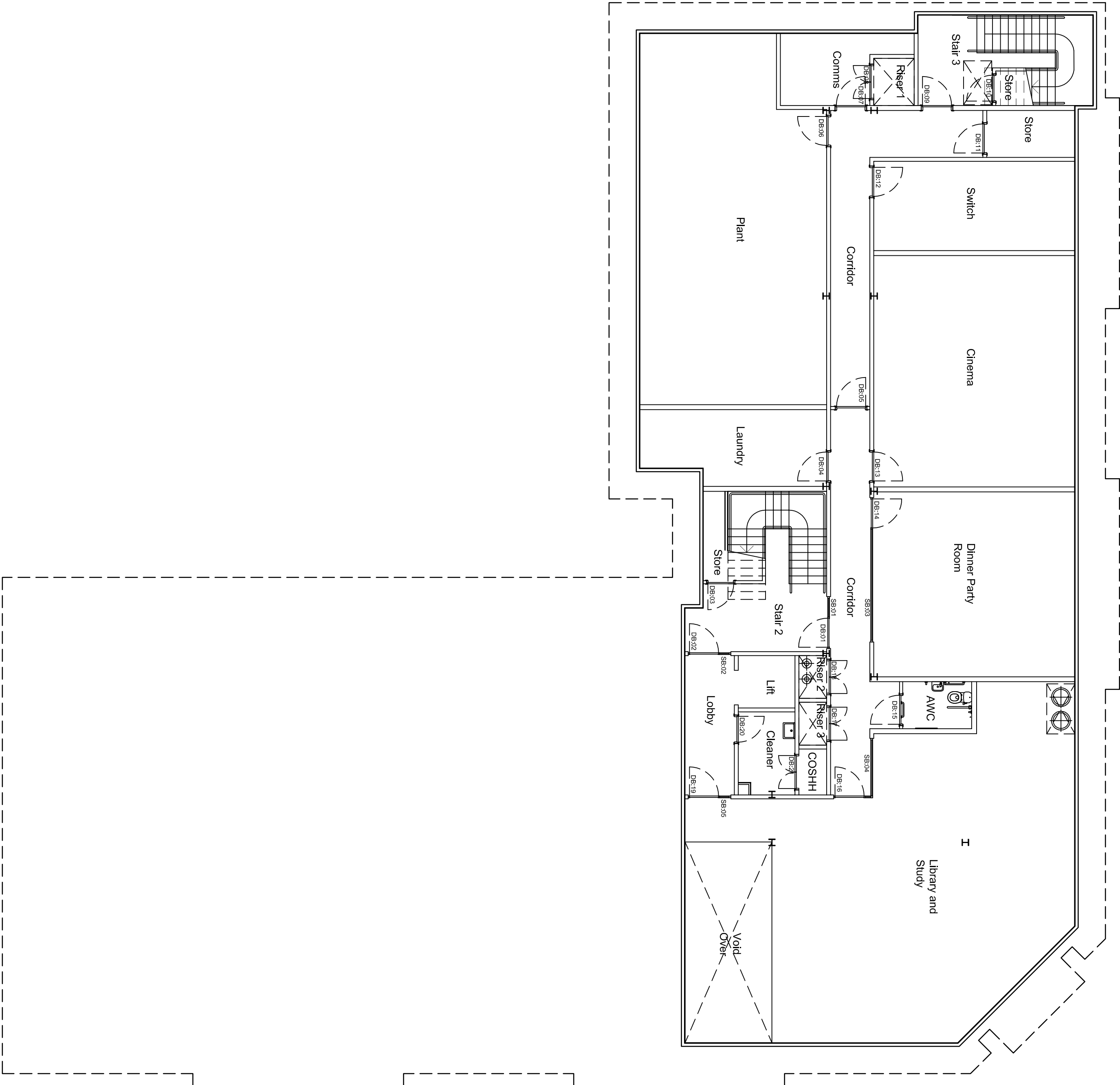
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18 053 049
BASEMENT LEVEL GENERAL ARRANGEMENT FLOOR PLAN
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0m 5m 10m 20m



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revision	notes	status	date	author	reviewer
-	MMA Planning Issue	P	15/11/2018	MB	-

Appendix B – Local Planning Policy (x4)

Core Strategy (2008):

Policy CS1: Sustainable Construction and Design

Proposals for new development, including the construction of new buildings and the redevelopment and refurbishment of existing building stock, will be acceptable where the design of buildings and site layouts use energy, water, minerals, materials and other natural resources appropriately, efficiently and with care and take account of the effects of climate change.

To meet these requirements: -

- All new housing is required to meet the most up to date Eco-Homes 'Very Good' as a minimum standard, and all new commercial developments are required to meet the most up to date BREEAM 'Very Good' as a minimum standard;
- On larger developments of more than 10 dwellings or 1,000 m2 of floorspace, ensure that 50% of the provision meets the most up to date Eco-Homes and BREEAM 'Excellent' standards;
- All new developments maximise the use of energy efficiency and energy conservation measures in their design, layout and orientation to reduce overall energy demand;
- All developments of more than 10 dwellings or 1000m2 floorspace incorporate on-site generation of energy from renewable sources and energy efficient design measures (including the use of CHP where appropriate) to off-set at least 20% of predicted carbon dioxide emissions from the estimated energy usage of the completed and occupied development;
- All developments reduce mains water use and demonstrate that water conservation measures are

incorporated so that predicted per capita consumption does not exceed the appropriate levels set out in the Code for Sustainable Homes or BREEAM Standards

- 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.

Policy CS34: Pollution and Water Resources

Development will only be permitted where it would not be damaging to the environment through air, land, noise or light pollution; where it would preserve or ideally enhance ground and surface water quality; and where existing water resources, sewerage and wastewater treatment infrastructure are adequate to support the proposed development.

Proposals for development that are sensitive to the effects of air, noise or light pollution will only be permitted in areas where they will not be subject to high levels of such pollution, unless adequate mitigation measures are provided to minimise the impact of such pollution.

Development will be permitted on land affected by contamination where it can be demonstrated, to the satisfaction of the LPA, that the contamination can be satisfactorily remediated so that it is suitable for the proposed end use.

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.

Level – 1 SFRA (2017)

Table 10.3: Peak River Flow Allowances – Flood Zone and Vulnerability 'Compatibility'

Vulnerability Classification	Flood Zone Classification		
	Flood Zone 2	Flood Zone 3a	Flood Zone 3b
Essential Infrastructure	Higher Central – Upper End	Upper End	Upper End
Highly Vulnerable	Higher Central – Upper End	<i>Not Appropriate</i>	<i>Not Appropriate</i>
More Vulnerable	Central – Higher Central	Higher Central – Upper End	<i>Not Appropriate</i>
Less Vulnerable	Central	Central – Higher Central	<i>Not Appropriate</i>
Water Compatible	No allowance applicable	Central	Central

Table 11.1: Summary of Flood Risk Vulnerability Classification

Classification	Forms of Development
Essential Infrastructure Highly Vulnerable More Vulnerable	Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk. Essential utility infrastructure which has to be located in a flood risk area for operational reasons, and water treatment works that need to remain operational in times of flood. Wind turbines.
	Police and ambulance stations; fire stations and command centres; Basement dwellings. Caravans, mobile homes and park homes intended for permanent residential use.
	Hospitals. Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels. Buildings used for dwelling houses, student halls of residence, drinking establishments, nightclubs and hotels. Non-residential uses for health services, nurseries and educational establishments. Sites used for holiday or short-let caravans and camping, subject to a specific warning and evacuation plan.

Figure 12.1: Extract of Table 4.1 from EA 'Supplementary Note on Flood Hazard Ratings'

Velocity (m/s)	Depth of flooding (m)												
	Debris Factor = 0.5				Debris Factor = 1								
	0.05	0.10	0.20	0.25	0.30	0.40	0.50	0.60	0.80	1.00	1.50	2.00	2.50
0.00													
0.10													
0.30													
0.50													
1.00													

 Danger for some

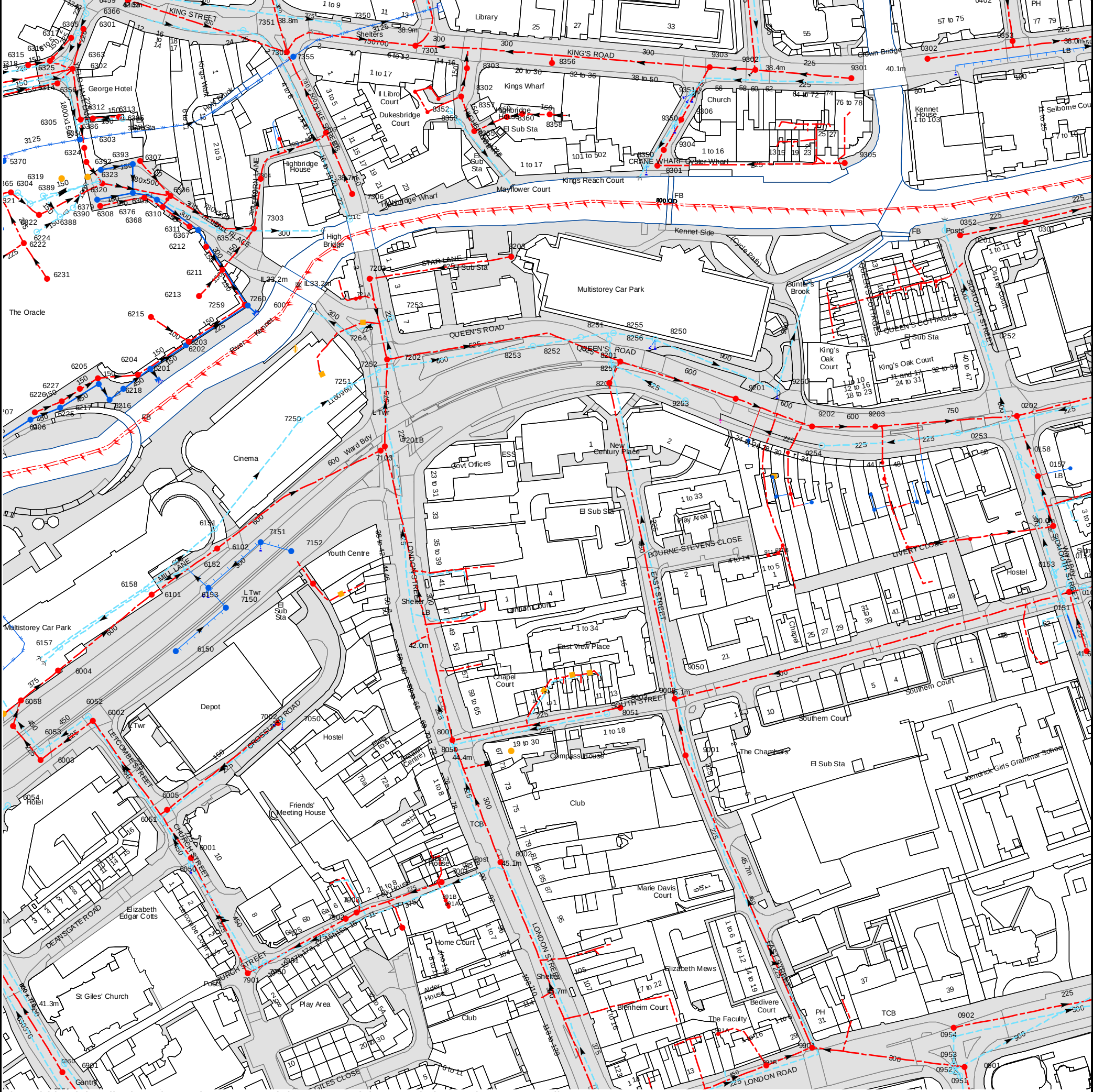
 Danger for most

 Danger for all

Appendix C – Topographic Survey (x1)

Appendix D – Thames Water Sewer Records (x5)

Asset Location Search Sewer Map - ALS/ALS Standard/2016 3412629



The width of the displayed area is 500 m and the centre of the map is located at OS coordinates 471848,173156
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
0154	40.48	37.23
0152	40.75	37.27
0102	40.88	38.01
011I	n/a	n/a
0156	40.72	37.35
0101	41.64	38.82
9050	44.24	42.8
9002	44.85	41.02
9001	45.8	41.54
991A	n/a	n/a
911A	n/a	n/a
911D	39.01	n/a
911E	39.04	n/a
911B	39.73	n/a
911C	39.52	n/a
911G	39.18	n/a
911F	38.97	n/a
911I	39.46	n/a
911J	39.12	n/a
011F	39.058	36.163
011E	37.17	n/a
011A	39.952	37.946
011D	38.99	n/a
011G	39.24	n/a
0954	45.91	n/a
0902	45.86	43.39
011B	39.887	37.188
0158	39.02	36.79
0157	39.31	n/a
011H	n/a	n/a
011C	39.901	36.458
0153	40.44	37.18
0151	40.94	38.85
0951	46.19	43.21
0952	46.07	41.64
0901	46.05	n/a
991B	n/a	n/a
0953	46.14	43.63
9901	45.99	42.55
6150	38.91	n/a
6152	38.4	36.16
6001	40.7	38.17
6050	40.75	39.43
6153	39.48	36.62
6151	38.19	n/a
6102	38.34	34.95
7150	38.74	n/a
7901	42.32	39.82
7950	42.27	40.5
7151	38.8	37.03
7951	42.35	40.67
7002	41.07	39.06
7050	41.06	39.62
7152	38.68	n/a
71YY	n/a	n/a
7902	43.4	40.93
7903	43.58	41.16
79ZV	n/a	n/a
7001	44.85	42.63
891B	n/a	n/a
891A	n/a	n/a
8050	44.16	42.19
8001	44.12	n/a
8002	45.3	42.15
8051	45.66	44.14
8003	45.56	42.4
6054	n/a	n/a
6057	38.9	35.58
6058	38.97	35.3
6053	39.07	36.94
6003	39.06	35.82
6004	38.67	n/a
6157	38.1	35.9
6052	39.21	37.32
6002	39.14	35.95
6158	38.2	36.05
6101	38.56	34.99
6051	40.17	39.04
6005	40.17	38.02
6206	38.2	36.93
6207	38.2	37.2
6225	39	36.9
6226	39	37.06
6227	39	36.95
6205	38.2	36.88
6231	n/a	n/a
6222	38.35	35.96
6901	41.96	38.37
6950	41.89	38.99
9306	37.67	35.58
9351	37.85	36.24

Manhole Reference	Manhole Cover Level	Manhole Invert Level
9301	39.82	37.11
9302	38.49	35.4
9303	38.13	35.28
0302	39.68	n/a
0353	n/a	n/a
911H	39.033	36.074
9254	38.69	n/a
921A	39.03	36.184
0253	38.89	37.2
9202	38.65	n/a
9203	38.9	n/a
0202	39.02	34.26
9253	n/a	n/a
9201	38.41	n/a
9250	38.74	36.05
8201	38.24	34.65
0252	38.41	36.35
8250	38.67	36.09
021A	n/a	n/a
0201	37.72	35.27
0352	37.46	35.76
0301	37.61	34.94
8350	37.17	35.99
8301	37.13	35.74
9305	37.08	n/a
9304	37.28	35.69
9350	37.68	36.03
7303	38.37	35.09
7304	38.52	35.09
731B	n/a	n/a
731A	n/a	n/a
7250	38.6	n/a
7305	38.56	34.77
7264	38.9	36.26
731C	n/a	n/a
7251	38.48	36.2
7306	38.77	35.77
721A	n/a	n/a
7203	38.52	n/a
7252	38.41	n/a
7103	n/a	n/a
7201B	38.96	n/a
7202	38.45	34.9
7253	37.92	36.99
8353	38.3	36.55
8355	38.03	36.39
8253	n/a	n/a
8203	37.29	35.95
8252	38.25	35.98
8251	38.26	36.28
8202	38.17	n/a
8256	n/a	n/a
8257	n/a	n/a
8255	n/a	n/a
6313	39.75	37.84
8357	38.01	37.05
8358	38.25	37.26
8360	n/a	n/a
731E	n/a	n/a
8352	38.3	36.71
73NF	n/a	n/a
8302	38.28	36.15
731D	n/a	n/a
73ME	n/a	n/a
8303	38.25	35.95
8356	n/a	n/a
7355	n/a	n/a
7302	39.32	n/a
7301	38.72	34.73
7351	39.88	39.05
7350	39.41	38.08
6403	42.39	38.45
6217	38.2	36.86
6308	38.2	36.59
6392	38.45	37.4
6323	38.4	35.25
6216	38.45	36.84
6385	39.75	38.85
6218	38.25	36.72
6393	38.45	37.22
6376	38.2	37.1
6204	38.2	36.75
6307	38.45	37.4
6309	38.2	36.4
6201	38	36.25
6215	37.5	36.43
6368	38.2	36.96
6310	38.2	36.33
6306	38.2	35.23
6202	38	37.01
6203	38	36.56
6311	38.2	36.53
6367	38.2	36.89

Manhole Reference	Manhole Cover Level	Manhole Invert Level
6213	37.5	36.43
6212	38.2	36.34
6352	38.09	36.23
6211	38.2	36.13
7259	39.6	36.36
7260	39	36.4
6314	41.4	40.2
6356	41.49	n/a
6325	41.2	40
6318	41.6	39.31
6302	41.09	37.7
6315	41.6	38.29
6316	41.8	38.2
6363	41.63	n/a
6317	42.2	39.55
6365	n/a	n/a
6301	42.29	39.18
6366	42.58	n/a
6459	42.8	n/a
6224	38.3	37.43
6388	38.3	37.32
6322	37.68	35.35
6390	38.3	37.18
6319	37.8	36.37
6379	38.2	37.4
6389	38.35	37.5
6304	38	36.38
6321	38	35.4
6320	38.4	36.3
6324	38.85	37
5370	39.25	37.75
6303	38.98	35.72
6350	39.11	n/a
6386	39.72	38.73
6305	39.75	37
6312	39.72	37.14
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

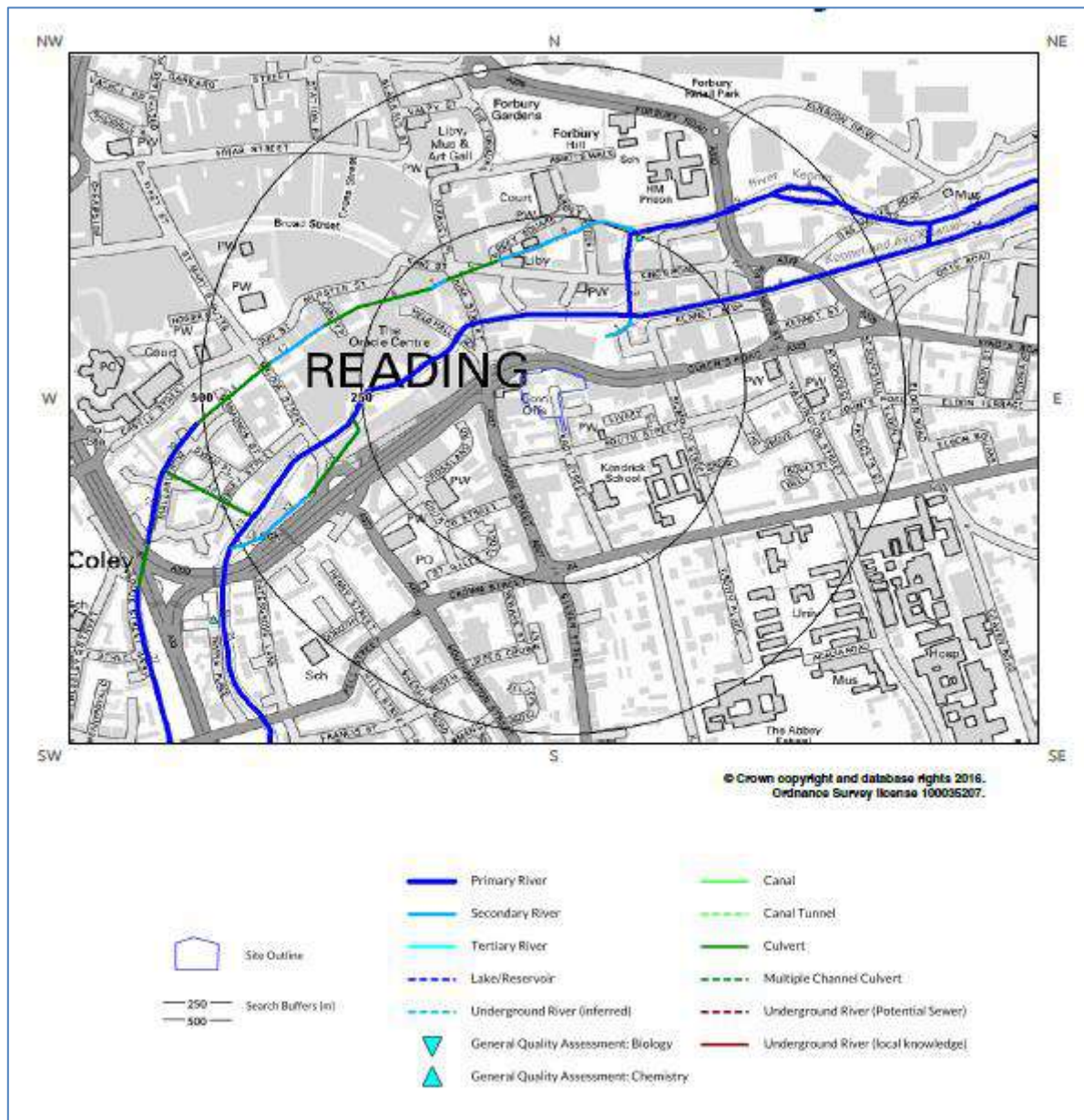
Other Sewer Types (Not Operated or Maintained by Thames Water)

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

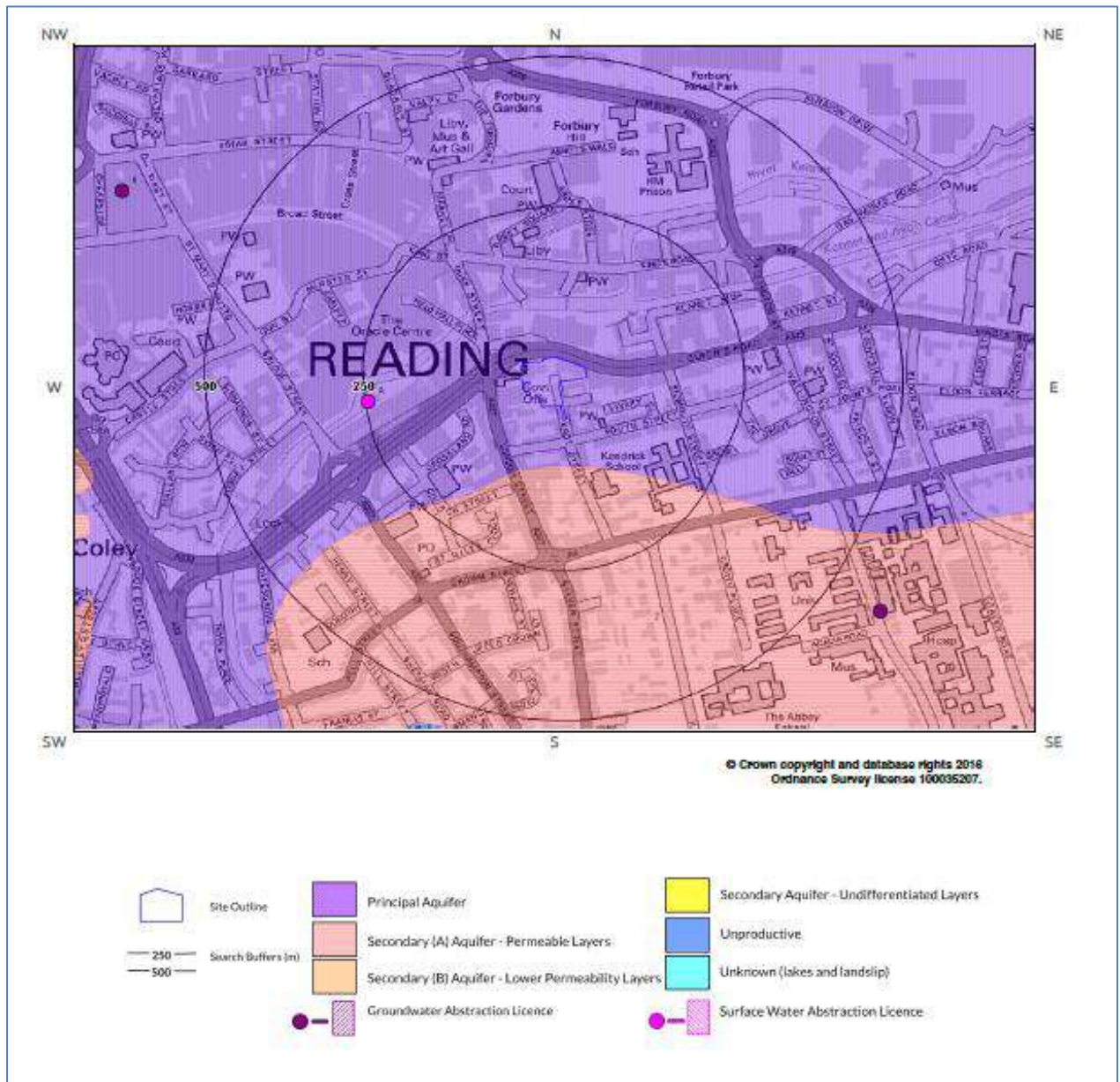
- 6) The text appearing alongside a sewer line indicates the internal diameter of the pipe in millimetres. Text next to a manhole indicates the manhole reference number and should not be taken as a measurement. If you are unsure about any text or symbology present on the plan, please contact a member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

Appendix E – Groundsure Maps (x3)

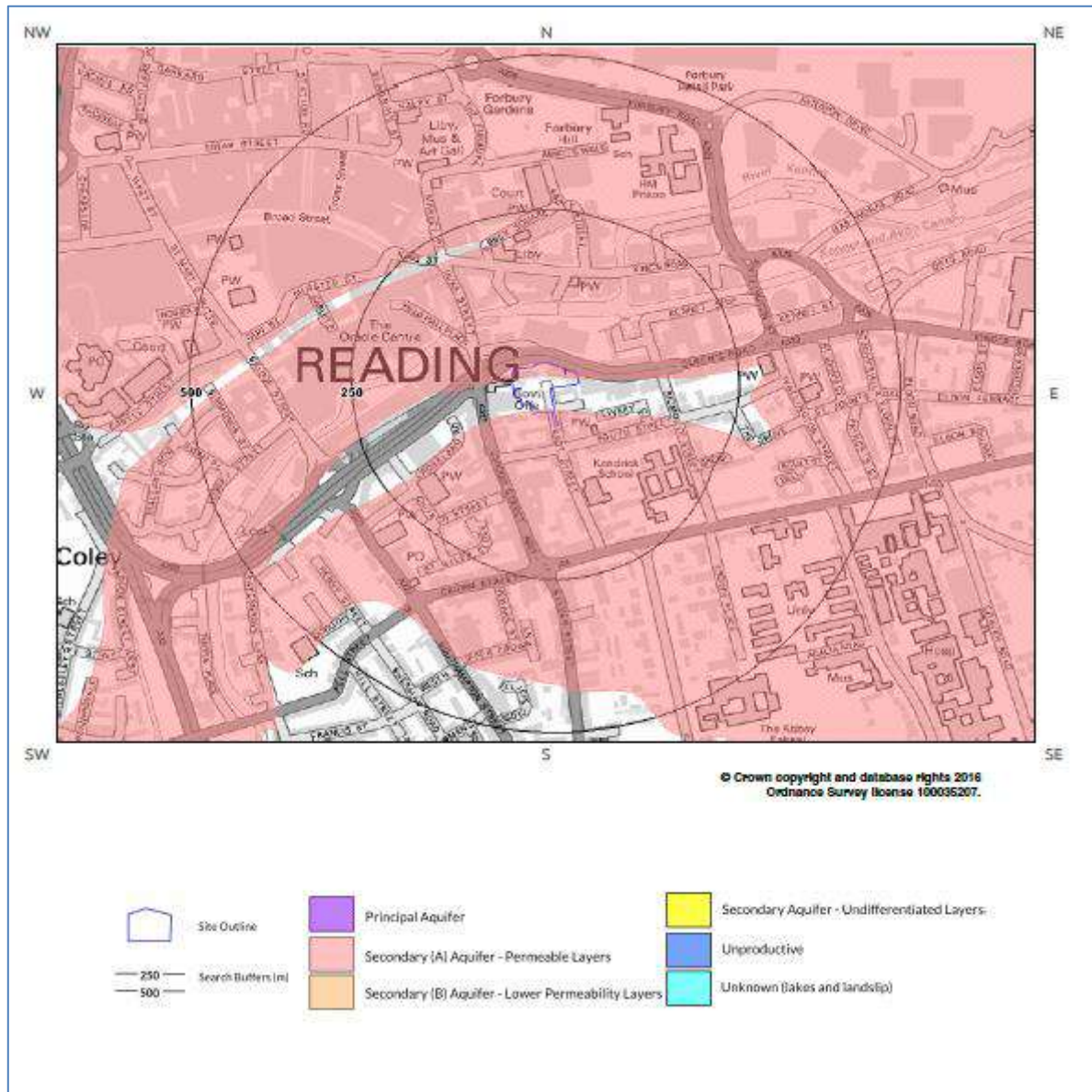
Map 1: Detailed River Network and River Quality



Map 2: Bedrock Aquifer Designations



Map 3: Superficial Deposits Aquifer Designations



Appendix F – Borehole Logs and Map (x7)

BOREHOLE AND TRIAL PIT RECORDS

SYMBOLS AND ABBREVIATIONS

Samples

U ()	Undisturbed - standard open drive (blows) - 100mm dia in boreholes 38mm dia in trial pits and hand auger bores
T	Undisturbed - thin wall open drive
P	Undisturbed - piston
Cm	Undisturbed - CBR mould
D	Disturbed - small
B	Disturbed - bulk
W	Water

In Situ Tests

S []	Standard Penetration Test - open shoe [N-Value] * denotes extrapolated value
C []	Standard Penetration Test - solid cone
V ()	Vane Test (c_u kPa)
P ()	Hand Penetrometer (c_u kPa)
Mx	Mexe Probe
Mc	Mackintosh Probe

Water Levels

$\frac{z}{n}$	Depth and number of strike
$\frac{z}{n}$	Standing level related to strike number

Standpipes

	Simple Standpipe W denotes water monitoring G denotes gas monitoring
	Sealed Standpipe showing tip, upper and lower seals to scale

GROUND EXPLORATIONS LTD Tel:0895 231718 Fax:0895 239624 		Project BREWERY SITE, QUEENS ROAD, READING	BOREHOLE BH 4 1/3
Co-ordinates 471800 E 173200 N		Client FENCHURCH ESTATES LTD	Project No. 11459
Scale 1:50		Agent SCOTT-WHITE AND HOOKINS	Ground Level

Samples / Tests		(Date)	Inst.	Depth	Description of Strata (thickness)	Legend	Level
Type	Depth m	Casing					
		(01/07/94)		0.10	MADE GROUND: Tarmac (0.10) MADE GROUND: Brick rubble with some flint gravel and some ash. (1.70)		
C1 [15] B1	1.00 - 1.45 1.00 - 1.50	1.00		1.80	MADE GROUND; Soft dark brown silty sandy clay with some gravel and some ash. (0.90)		
U1 (55) D1	2.00 - 2.45 2.45	1.50		2.70	Medium dense brown, slightly clayey, silty sandy angular to rounded fine to coarse flint GRAVEL with occasional cobbles. (0.60)		
C2 [26] B2	3.00 - 3.45 3.00 - 3.50	3.00		3.30	Medium dense orange brown slightly sandy angular to rounded fine to coarse flint GRAVEL with occasional cobbles. (3.70)		
C3 [27] B3	4.00 - 4.45 4.00 - 4.50	4.00					
C4 [23] B4	5.00 - 5.45 5.00 - 5.50	5.00					
C5 [26] B5	6.50 - 6.95 6.50 - 7.00	6.00			From 6.50m, silty		
				7.00	White rubbly CHALK with much putty chalk matrix and some flints (8.50)		
S6 [16]	8.00 - 8.45	7.50					

Groundwater Strikes					Groundwater Observations					Chiselling		Percussive Boring	
Depth					Date	Time	Depth			Depth	Hours	Dia	Cased to
Struck	Rose to	Rate	Cased	Sealed			Bore	Casing	Water				
11.80	11.20	SLOW	10.50	NO	01/07/94		20.00	19.50	16.20			0.15	19.50
					01/07/94		20.00	0.00	15.40				

Remarks Large flint cobble pushed from 9.4m to 10.1m
 Excavating from 0m to 1m for 1 hour.
 Water added from 3.5m to 7m.

GROUND EXPLORATIONS LTD Tel: 0895 231718 Fax: 0895 239624 		Project BREWERY SITE, QUEENS ROAD, READING	BOREHOLE BH 4 2/3
Co-ordinates 471800 E 173200 N		Client FENCHURCH ESTATES LTD	Project No. 11459
Scale 1:50		Agent SCOTT-WHITE AND HOOKINS	Ground Level

Samples / Tests		(Date)	Inst.	Depth	Description of Strata (thickness)	Legend	Level
Type	Depth m	Casing					
S7 (66)	9.50 - 9.95	9.00			White rubbly CHALK with much putty chalk matrix and some flints		
S8 (22)	11.00 - 11.45	10.50					
W1	11.20						
S9 (29)	12.50 - 12.95	12.00					
S10 (14)	14.00 - 14.45	13.50					
S11 (31)	15.50 - 15.95	15.00		15.50	White rubbly to blocky CHALK with some flints (4.50)		

Groundwater Strikes					Groundwater Observations					Chiselling		Percussive Boring	
Depth					Date	Time	Depth			Depth	Hours	Dia	Cased to
Struck	Rose to	Rate	Cased	Sealed			Bore	Casing	Water				

Remarks

GROUND EXPLORATIONS LTD Tel: 0895 231718 Fax: 0895 239624 		Project BREWERY SITE, QUEENS ROAD, READING	BOREHOLE BH 4 3/3
Co-ordinates 471800 E 173200 N		Client FENCHURCH ESTATES LTD	Project No. 11459
Scale 1:50		Agent SCOTT-WHITE AND HOOKINS	Ground Level

Samples / Tests		(Date)	Inst.	Depth	Description of Strata (thickness)	Legend	Level
Type	Depth m	Casing					
S12[45]	17.00 - 17.45	16.50			White rubbly to blocky CHALK with some flints		
S13[48]	18.50 - 18.95	18.00					
S14[49]	19.50 - 19.95	19.50					
		(01/07/94)		20.00	END OF BOREHOLE		

Groundwater Strikes					Groundwater Observations					Chiselling		Percussive Boring	
Depth					Date	Time	Depth			Depth	Hours	Dia	Cased to
Struck	Rose to	Rate	Cased	Sealed			Bore	Casing	Water				

Remarks

SECTION THROUGH BOREHOLES - KEY TO LEGENDS



MADE GROUND



VALLEY GRAVEL



VALLEY GRAVEL



UPPER CHALK

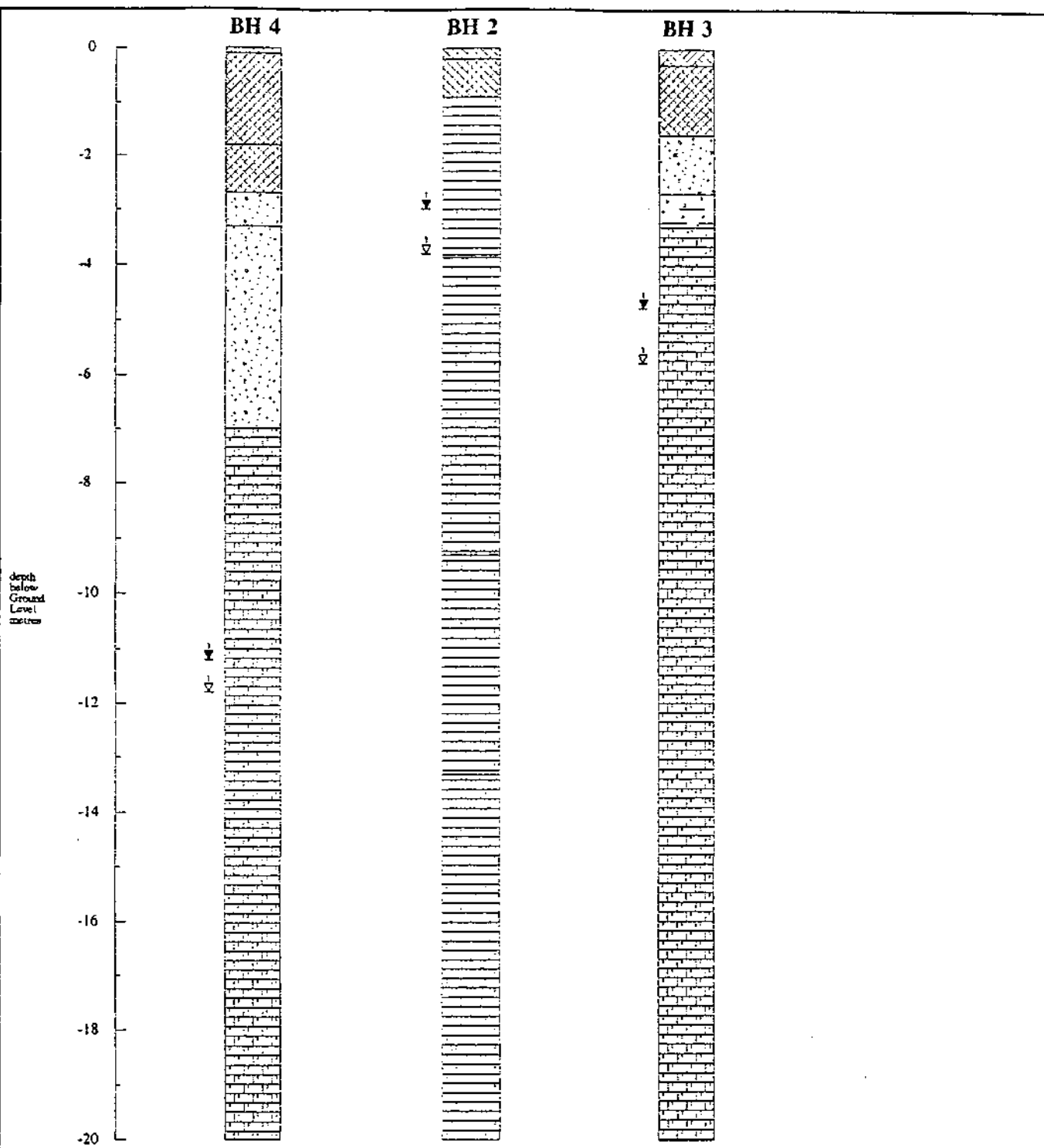


Groundwater Encountered

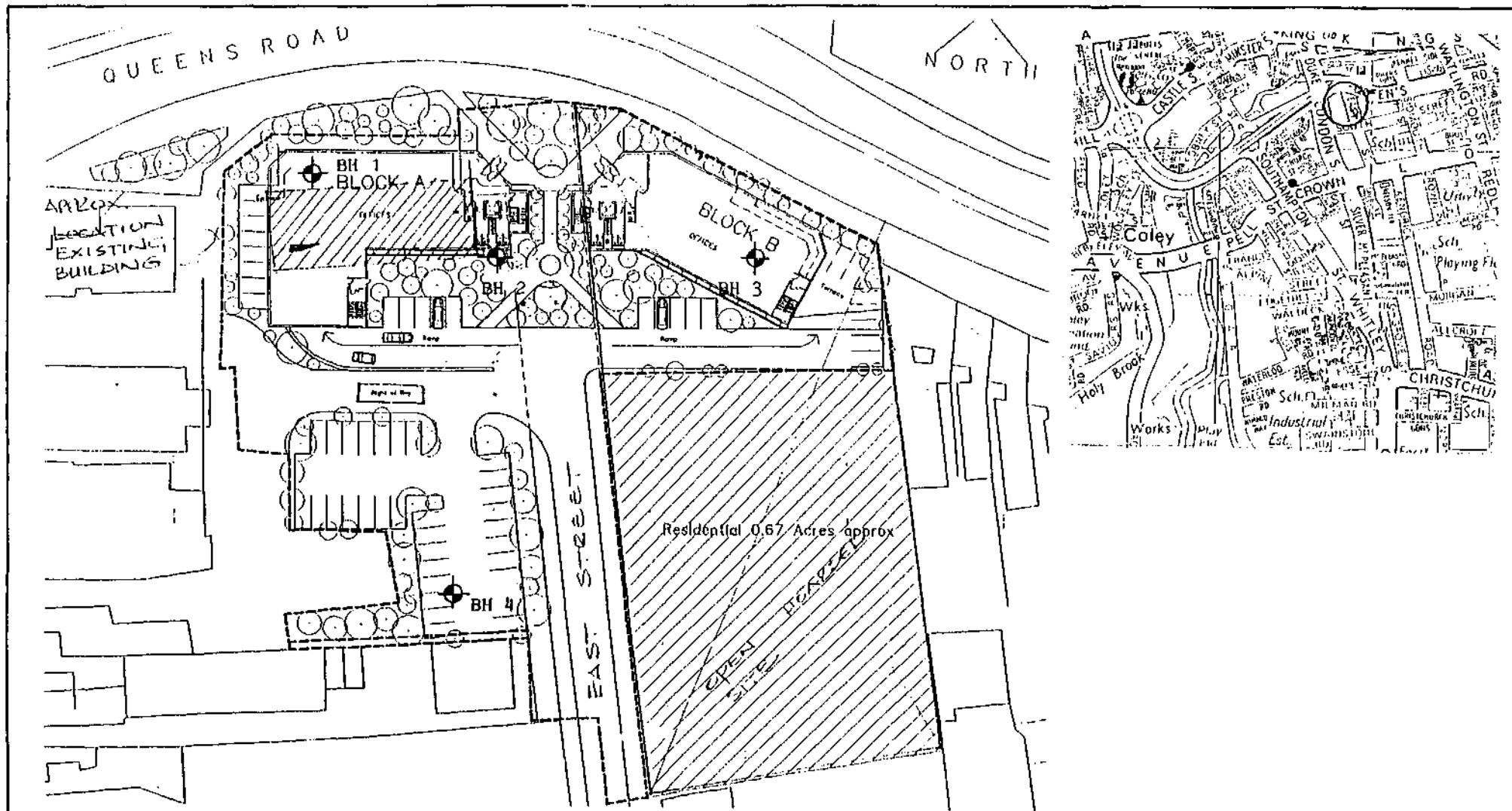


Standing Water Level

SITE	BREWERY SITE, QUEENS ROAD, READING	Project No.	11459
CLIENT	FENCHURCH ESTATES LTD	Vertical Scale	1:100
GROUND EXPLORATIONS LIMITED. Tel 0895 231718			



SITE	BREWERY SITE, QUEENS ROAD, READING	Project No.	11459
CLIENT	FENCHURCH ESTATES LTD	Vertical Scale	1:100
GROUND EXPLORATIONS LIMITED. Tel 0895 331718		Fig. No	2



Not to Scale

BREWERY SITE, QUEENS ROAD READING

GROUND EXPLORATIONS LIMITED	SITE PLAN	Report No: 11459
TELEPHONE: (0895) 231718	Date: July 1994	Figure No: 4

Appendix G – West Thames Area Guidance (x3)



Flood risk assessments: Climate change allowances

Application of the allowances and local considerations

West Thames Area

1) The climate change allowances

The [National Planning Practice Guidance](#) refers planners, developers and advisors to the Environment Agency guidance on considering climate change in Flood Risk Assessments (FRAs). This guidance was updated in February 2016 and is available on [Gov.uk](#) and should be read in conjunction with this document. The guidance can be used for planning applications, local plans, neighbourhood plans and other projects. It provides climate change allowances for peak river flow, peak rainfall, sea level rise, wind speed and wave height. The guidance provides a range of allowances to assess fluvial flooding, rather than a single national allowance. It advises on what allowances to use for assessment based on vulnerability classification, flood zone and development lifetime.

2) Assessment of climate change impacts on fluvial flooding

Table A below indicates the level of technical assessment of climate change impacts on fluvial flooding appropriate for new developments depending on their scale and location. This should be used as **a guide only**. Ultimately, the agreed approach should be based on expert local knowledge of flood risk conditions, local sensitivities and other influences. **For these reasons we recommend that applicants and / or their consultants should contact the Environment Agency at the pre-planning application stage to confirm the assessment approach, on a case by case basis.** **Table A** defines three possible approaches to account for flood risk impacts due to climate change, in new development proposals:

- **Basic:** Developer can add an allowance to the 'design flood' (i.e. 1% annual probability) peak levels to account for potential climate change impacts. The allowance should be derived and agreed locally by Environment Agency teams.
- **Intermediate:** Developer can use existing modelled flood and flow data to construct a stage-discharge rating curve, which can be used to interpolate a flood level based on the required peak flow allowance to apply to the 'design flood' flow.
- **Detailed:** Perform detailed hydraulic modelling, through either re-running Environment Agency hydraulic models (if available) or construction of a new model by the developer.

Table A – Indicative guide to assessment approach

VULNERABILITY CLASSIFICATION	FLOOD ZONE	DEVELOPMENT TYPE		
		MINOR	SMALL-MAJOR	LARGE-MAJOR
ESSENTIAL INFRASTRUCTURE	Zone 2	Detailed		
	Zone 3a	Detailed		
	Zone 3b	Detailed		
HIGHLY VULNERABLE	Zone 2	Intermediate/ Basic	Intermediate/ Basic	Detailed
	Zone 3a	Not appropriate development		
	Zone 3b	Not appropriate development		
MORE VULNERABLE	Zone 2	Basic	Basic	Intermediate/ Basic
	Zone 3a	Basic	Detailed	Detailed
	Zone 3b	Not appropriate development		
LESS VULNERABLE	Zone 2	Basic	Basic	Intermediate/ Basic
	Zone 3a	Basic	Basic	Detailed
	Zone 3b	Not appropriate development		
WATER COMPATIBLE	Zone 2	None		
	Zone 3a	Intermediate/ Basic		
	Zone 3b	Detailed		

NOTES:

- Minor: 1-9 dwellings/ less than 0.5 ha | Office / light industrial under 1ha | General industrial under 1 ha | Retail under 1 ha | Gypsy/traveller site between 0 and 9 pitches
- Small-Major: 10 to 30 dwellings | Office / light industrial 1ha to 5ha | General industrial 1ha to 5ha | Retail over 1ha to 5ha | Gypsy/traveller site over 10 to 30 pitches
- Large-Major: 30+ dwellings | Office / light industrial 5ha+ | General industrial 5ha+ | Retail 5ha+ | Gypsy/traveller site over 30+ pitches | any other development that creates a non residential building or development over 1000 sq m.

The assessment approach should be agreed with the Environment Agency as part of pre-planning application discussions to avoid abortive work.

3) Specific local considerations

Where the Environment Agency and the applicant and / or their consultant has agreed that a 'basic' level of assessment is appropriate the figures in Table B below can be used as a allowance for potential climate change impacts on peak 'design' (i.e. 1% annual probability) fluvial flood level rather than undertaking detailed modelling.

Table B – Local allowances for potential climate change impacts

Watercourse	Central	Higher Central	Upper
Thames	500mm	700mm	1000mm

Use of these allowances will only be accepted after discussion with the Environment Agency.

4) Fluvial flood risk mitigation

Read the guidance on [Gov.uk](https://www.gov.uk) to find out which allowances to use to **assess** the impact of climate change on flood risk.

For planning consultations where we are a statutory consultee and our [Flood risk standing advice](#) **does not** apply we use the following benchmarks to inform flood risk **mitigation** for different vulnerability classifications. **These are a guide only. We strongly recommend you contact us at the pre-planning application stage to confirm this on a case by case basis. Please note you may be charged for this advice.** For planning consultations where we are not a statutory consultee or our [Flood risk Standing advice](#) applies we recommend local planning authorities and developers use these benchmarks but we do not expect to be consulted.

- For development classed as '[Essential Infrastructure](#)' our benchmark for flood risk mitigation is for it to be designed to the '**upper end**' climate change allowance for the epoch that most closely represents the lifetime of the development, including decommissioning.
- For [highly vulnerable](#) in flood zone 2, the '**higher central**' climate change allowance is our minimum benchmark for flood risk mitigation. In sensitive locations it may be necessary to use the **upper end** allowance.
- For [more vulnerable developments](#) in flood zone 2, the '**central**' climate change allowance is our minimum benchmark for flood risk mitigation, and in flood zone 3 the '**higher central**' climate change allowance is our minimum benchmark for flood risk mitigation. In sensitive locations it may be necessary to use the **higher central** (in flood zone 2) and the **upper end** allowance (in flood zone 3).

- For [water compatible](#) or [less vulnerable](#) development (e.g. commercial), the ‘central’ climate change allowance for the epoch that most closely represents the lifetime of the development is our minimum benchmark for flood risk mitigation. In sensitive locations it may be necessary to use the **higher central** (particularly in flood zone 3) to inform built in resilience.

There may be circumstances where local evidence supports the use of other data or allowances. Where you think this is the case we may want to check this data and how you propose to use it.

Appendix H – EA Product 4 Data (x7)

Product 4 (Detailed Flood Risk) for New Century Place, Reading, RG1 4QJ

Our Ref: BE_1399_01

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

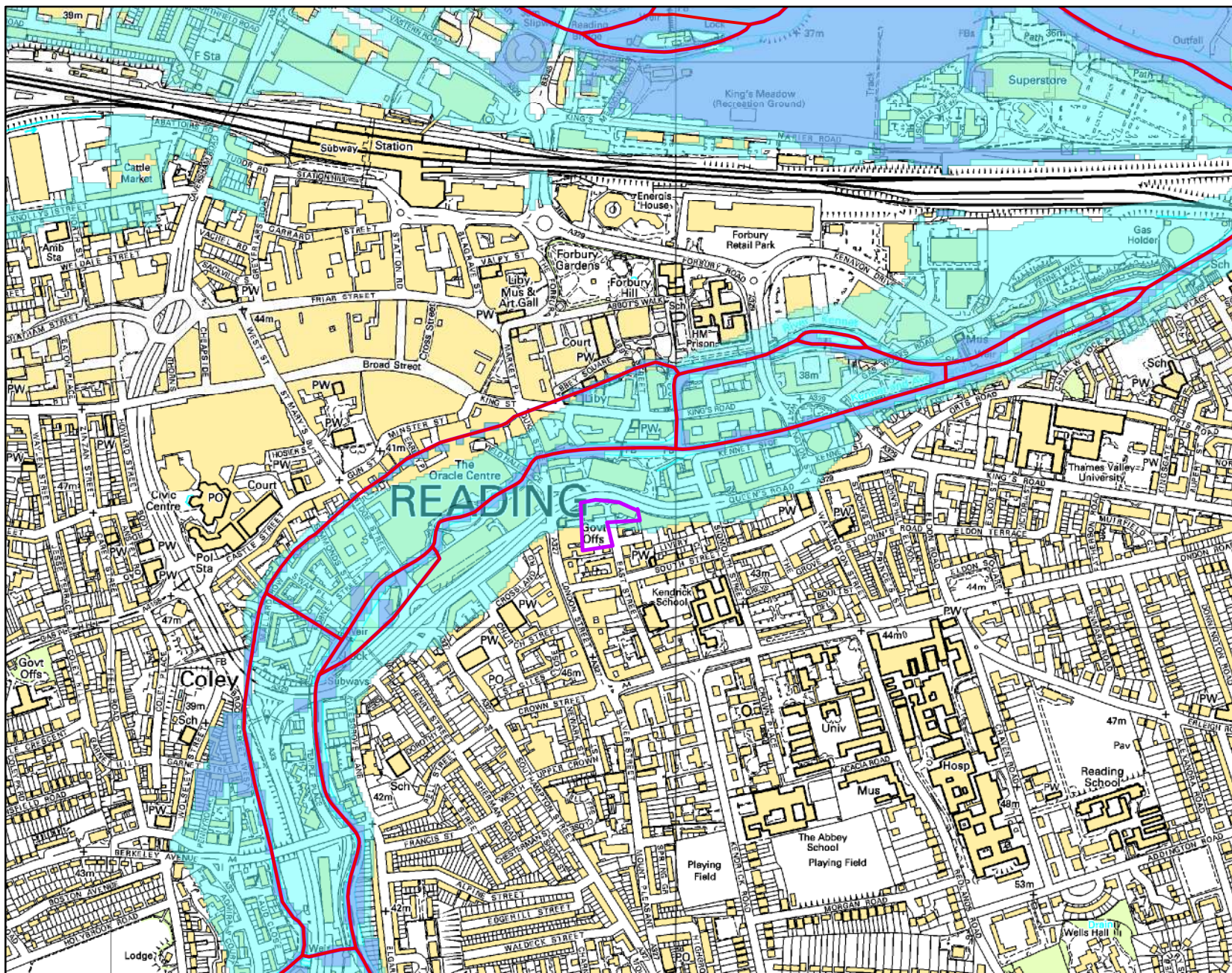
<http://www.environment-agency.gov.uk/research/planning/82584.aspx>

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: New Century Place, Reading, RG1 4QJ

Created on 31/09/2016 REF: BE_1399_01



Kilometres

0 0.1 0.2

Legend

- 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

BE_1399_01

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

BE_1399_01

Model: Kennet (Tyle Mill to Thames Confluence) 2007

Description: The information provided is taken from the Kennet (Tyle Mill to Thames confluence) 2007. 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 100 / 1% AEP and 1 in 100+20% / 1% AEP with climate change

Mapped Outputs:

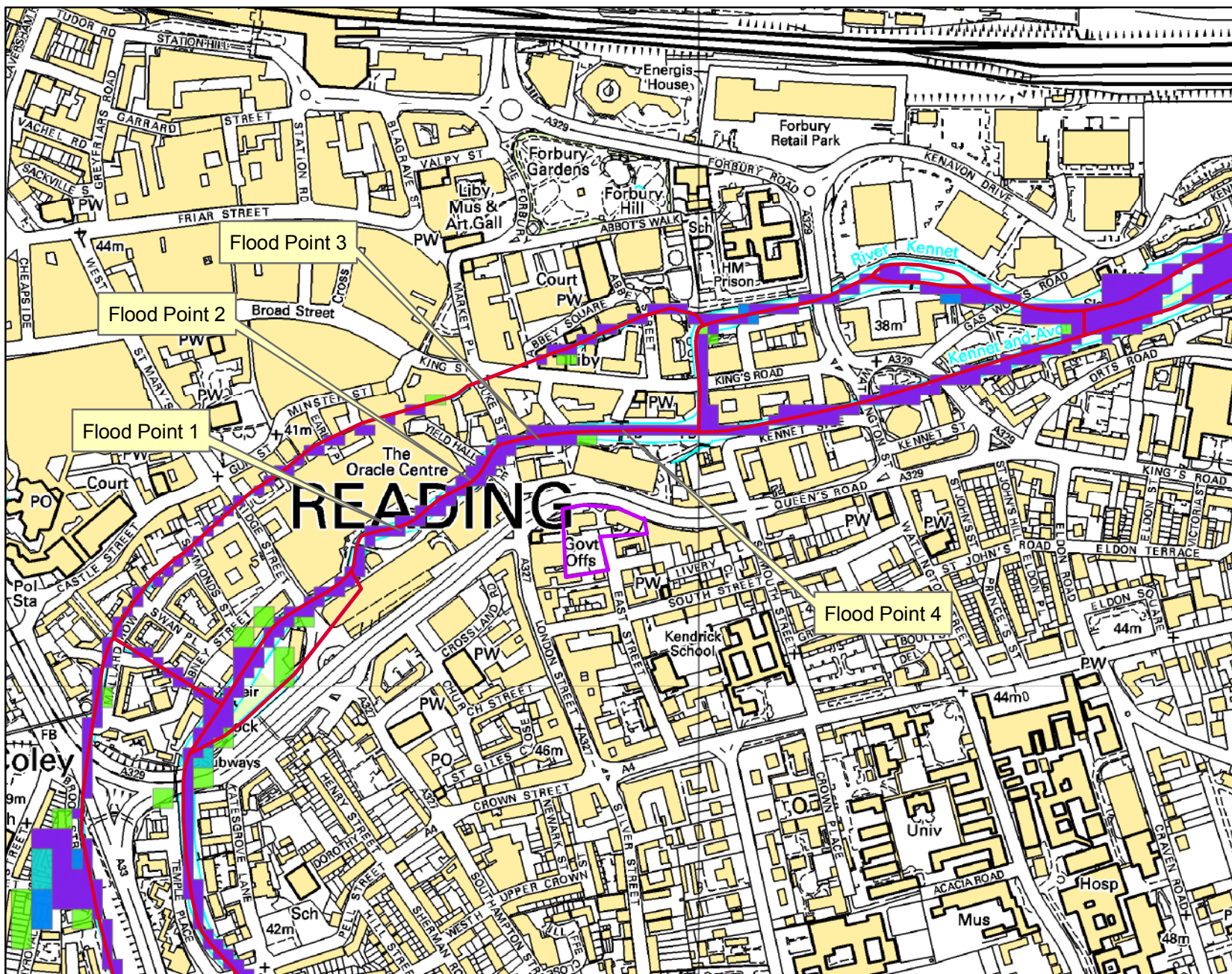
1 in 5 / 20% AEP; 1 in 20 / 5% AEP; 1 in 100 / 1% AEP and 1 in 100+20% / 1% AEP with climate change

Model accuracy:

Levels $\pm$ 250mm

Detailed FRA Map centred on: New Century Place, Reading, RG1 4QJ

Created on 31/09/2016 REF: BE_1399_01



Kilometres

0 0.07 0.14

Legend

- Main River
- 20% AEP Flood Extent
- 10% AEP Flood Extent
- 5% AEP Flood Extent
- 1% AEP Flood Extent

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 floodplain flood levels

BE_1399_01

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	10% AEP	5% AEP	1% AEP	1% AEP (+20% on river flows)	0.1% AEP
Flood Point 1	Kennet (Tyle Mill to Thames Confluence) 2007	471,628	73,189	37.47	37.60	37.72	37.94	No Data	No Data
Flood Point 2	Kennet (Tyle Mill to Thames Confluence) 2007	417,717	173,254	37.42	37.55	37.65	37.88	No Data	No Data
Flood Point 3	Kennet (Tyle Mill to Thames Confluence) 2007	471,807	173,304	37.14	37.26	37.35	37.58	No Data	No Data
Flood Point 4	Kennet (Tyle Mill to Thames Confluence) 2007	471,913	173,315	37.05	37.17	37.26	37.50	No Data	No Data

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

Historic flood data

BE_1399_01

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:

Flood Event Code	Flood Event Name	Start Date	End Date	Source of Flooding	Cause of Flooding
	No Historic Data Available At The Time				

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.

Appendix I – Modelling Report (x14)

TECHNICAL NOTE

Project: **Land at East Street, Reading**
Subject: Flow Estimation for input to Hydraulic Model
Client: Studios Building (Reading) Ltd.
Prepared by: Gemma Goodmore (Project Engineer)
Approved by: Seymour D'Oyley (Associate Director)

WB04333 - FR08

Revision: V2

Issue date: 05-10-2017

1.0 Introduction

- 1.1 Clarkebond (UK) Ltd (Clarkebond) were appointed by Studios Building (Reading) Ltd. to undertake hydraulic modelling of the River Kennet in order to accurately demonstrate the extent of the 1 in 1000 year flood event and thus confirm whether the development site, known as Land at East Street, is within Flood Zone 1.
- 1.2 This technical note discusses the methods used to calculate the flows which were input into the hydraulic model and any assumptions made in process. It should be read in conjunction with the hydraulic modelling report produced by Edenvale Young Associates Ltd (ref: EVY647_East Street_Report).
- 1.3 The outputs from both reports are solely to inform the requirements for the development proposed by the client under the planning application submitted in 2017. No reliance on the report should be made by third parties for informing future modelling. Clarkebond also accepts no liability for any inaccurate conclusions, assumptions or actions taken resulting from any inaccurate information supplied to Clarkebond from others.

2.0 Background

- 2.1 Figure 1 (Section 7) shows an aerial view of the existing site. The site is currently a car park, classified as 'Brownfield' land and covers an area of approximately 1520m² (0.152ha). It is located by National Grid Reference SU 71870 73168 or postcode RG1 4QJ. East Street forms the eastern boundary of the site and the River Kennet is located approximately 130m to the north.
- 2.2 A hydraulic model 'Kennet (Tyle Mill to Thames Confluence) 2007' exists for the River Kennet adjacent to the site and was provided to Clarkebond by the Environment Agency (EA). This model has been used to define Flood Zone 3, but the EA confirmed that the 1 in 1000 year flows were not estimated and, therefore, no model run was undertaken for this event. The current Flood Zone 2 shown on the flood map for planning is therefore based on broad-scale JFlow hydraulic modelling.
- 2.3 The JFlow model output is expected to be an inaccurate representation of the floodplain as it indicates that Flood Zone 2 extends out to the site, even though the lowest point on site (40.37m AOD) is considerably above the 1 in 100 year flood level (37.58m AOD) in a relatively unconfined catchment.

3.0 Selection of Inflow Nodes

- 3.1 Seven inflow nodes were selected in FEH Web Service for which peak flows and hydrographs were estimated. Figure 2 shows the location of the nodes calculated and Figures 3a-3g show the catchments of each node (see Section 7).
- 3.2 To ensure a consistent approach with the original model, the location of the nodes were selected to match the inflow nodes calculated for the original hydraulic modelling as indicated by the green stars in the drawing in Appendix A.
- 3.3 The inflow nodes 'Drain to Holy Brook' and 'I4' indicated in the previous modelling are located on small catchments (tributaries of the Kennet) which were not recognised in the FEH Web Service. Therefore, the updated flow nodes (Node 3 and 7 respectively) were calculated at the downstream confluence of the tributaries with the River Kennet to better represent the incoming catchment. These were then input into the model hydrograph at the location where the original flows were calculated.
- 3.4 The catchment of the inflow node 'Green Park Stream' (a tributary of Foudry Brook) was also not clearly represented in FEH Web Service. Therefore, to capture the incoming flows from this tributary, Node 6 was calculated, which is the downstream extent of Foudry Brook. The flows calculated at Node 6 were then input into the model at the location of 'Inflow Foudry', replacing the flows calculated at Node 5. Edenvale Young confirmed that although this would not give an accurate representation of the flood extent at that particular location, this method gives the most accurate representation of the flood extent at the site which is some distance downstream (refer to Figure 2, Section 8). Therefore, the model would not be suitable for use in areas further upstream, but is suitable for the purpose of this exercise.

4.0 Peak Flow Data

- 4.1 Table 1a (Section 8) shows the peak flows for Nodes 1-7 estimated using the FEH statistical method. The QMED was calculated using the data transfer method (see Table 1b). Three donor catchments were selected for each node based on the closeness of the catchment centroids and catchment area, as recommended in the EA Science Report SC0500050 (2008). The pooling groups and peak flows were calculated in WINFAP-FEH V3.
- 4.2 Peak flows estimated using the ReFH rainfall-runoff method (ReFH 2) are shown in Table 2 (Section 8). The 1 in 5 year flows are in general accordance with the FEH flows but for the larger magnitude events (1 in 100 year and 1 in 1000 year) the ReFH method generally estimates higher flows.
- 4.3 The FEH statistical method is considered to be the preferred method of peak flow estimation where the following cases apply:
 - there are more than two or three years of flood peak data on the watercourse (even if not at the sites of interest), from a gauging station suitable for high flow measurement;

- the catchment is larger than 1000 km²;
- Rainfall-runoff approaches assume a catchment-wide design storm, which is less realistic for large catchments.
- the catchment is highly permeable (approximately BFIHOST>0.65).

4.4 All of the above apply to the site of interest and so there is highest confidence in this method and this has been selected for the site. However, this method is generally not recommended for estimating the 1 in 1000 year flow and so these flows were scaled using the FEH/ReFH 100 year to 1000 year ratios (refer to Table 3). The final peak flows which were used in the modelling (accounting for the scaled 1 in 1000 year flows) are given in Table 4 (Section 8).

4.5 Comparison of these peak flows and the peak flows in the previous modelling for the 1 in 100 year event is shown in Table 5 (Section 8). The first thing to note is that the peak flows on the main River Kennet (Inflow Kennet / Node 1) are nearly 10 cumecs lower with the updated modelling approach. This is considered to be attributable to improvements in flow modelling methods which have brought flow estimates down in certain areas of the country, particularly permeable catchments such as the River Kennet.

4.6 The other notably lower flow in the updated calculations is the Clay Brook inflow (Node 2) which is shown to be 18.909 cumecs in the previous calculations and 3.072 in the current calculations. This was investigated and can be attributed to the upstream catchment not being picked up in FEH Web Service, instead this part of the catchment is attributed to the main River Kennet catchment covered within Node 1 (Inflow Kennet) (refer to Figures 4a and 4b). This would have little effect on the flood extent at the site of interest as the overall flow which reaches the site will be represented.

5.0 Hydrographs

Hydrographs were estimated by Edenvale Young using the FEH Rainfall Runoff Method scaled by the final peak flows provided by Clarkebond.

6.0 Summary of Hydraulic Modelling

Full details on the modelling undertaken, including flood maps for the 1 in 100, 1 in 100 plus climate change and 1 in 1000 year events, is given in the report produced by Edenvale Young (ref: EVY647_East Street_Report). The report demonstrates the site would not be flooded in the 1 in 1000 year event and therefore can be considered to be within Flood Zone 1, automatically passing the Sequential Test.

7.0 Figures

Figure 1 - Aerial View of Site

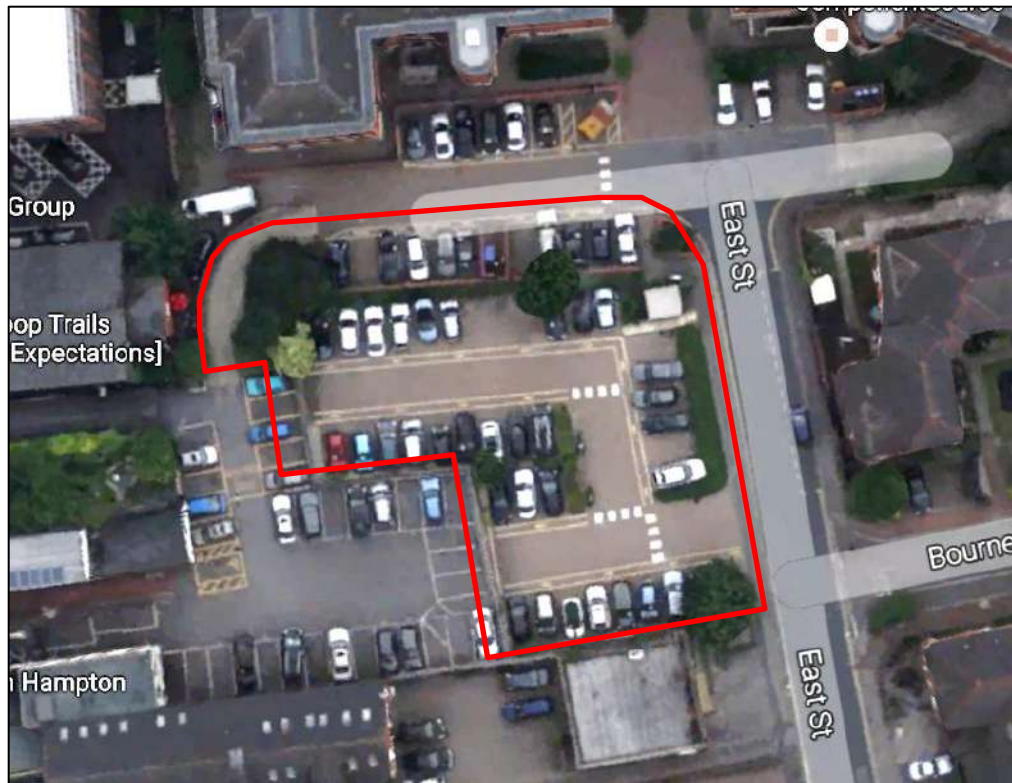


Figure 2 – Node Location Map

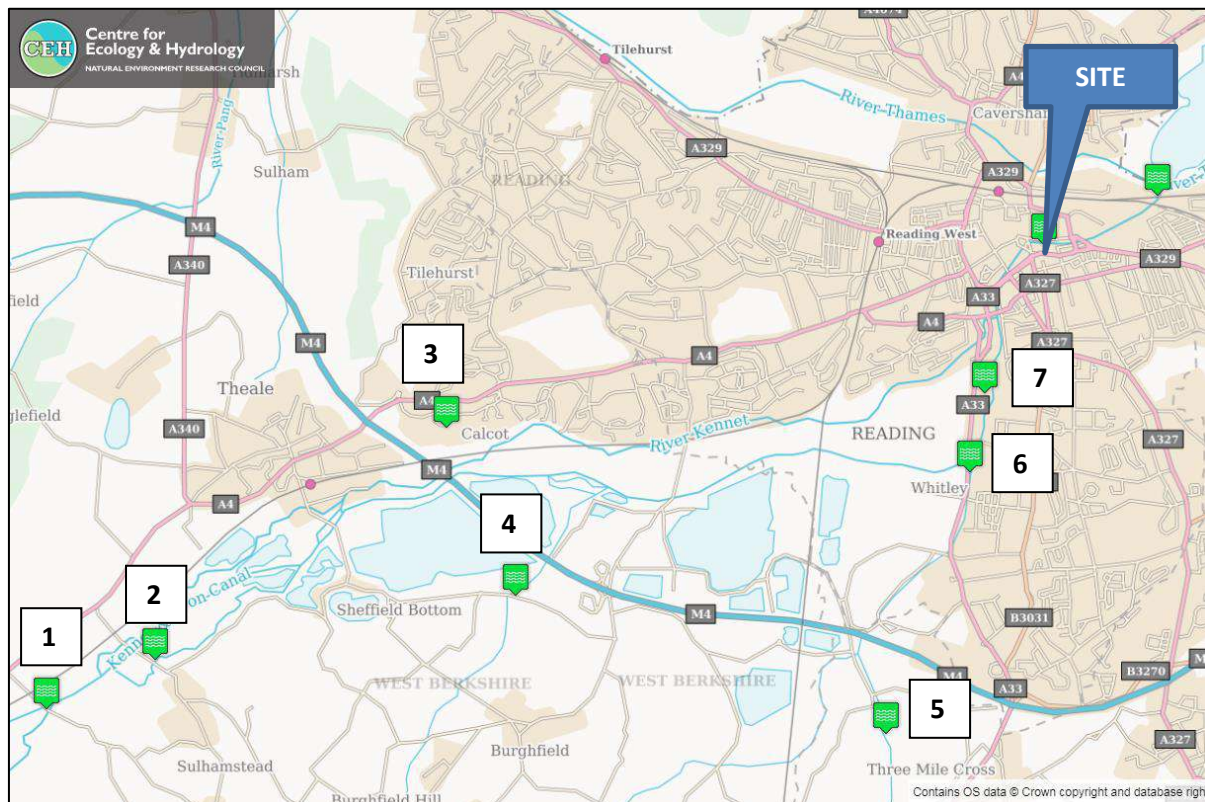


Figure 3a – Catchment of Node 1



Figure 3b – Catchment of Node 2

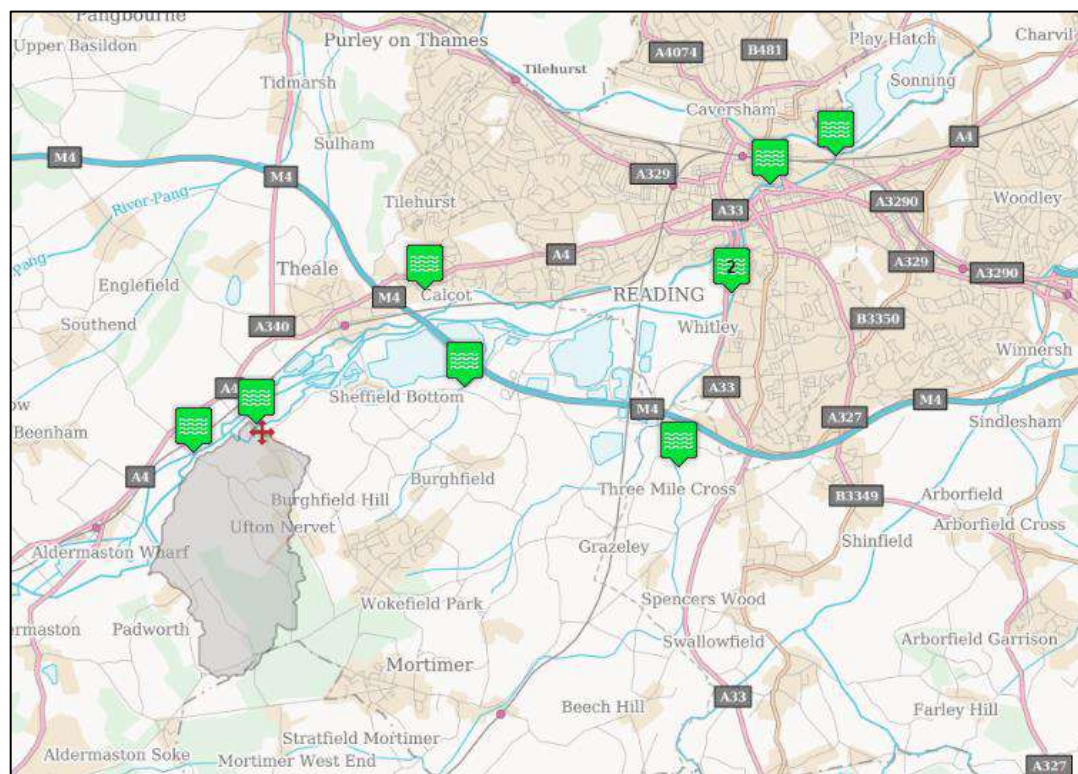


Figure 3c – Catchment of Node 3

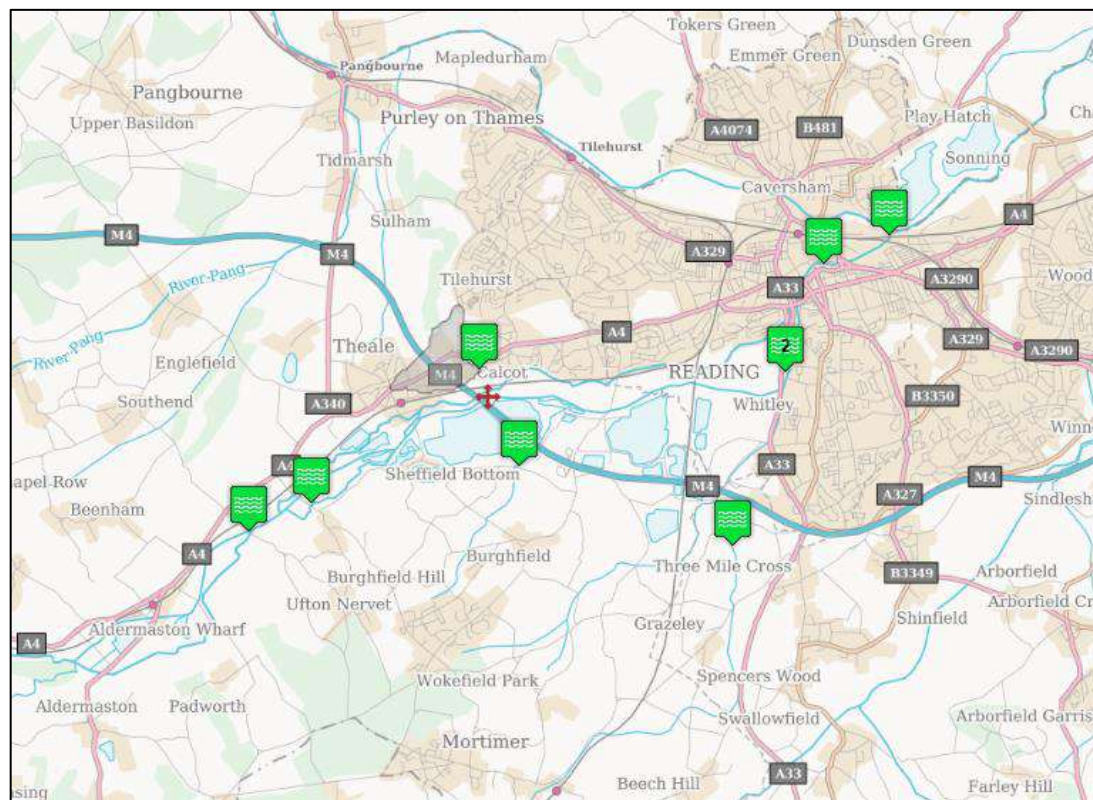


Figure 3d – Catchment of Node 4

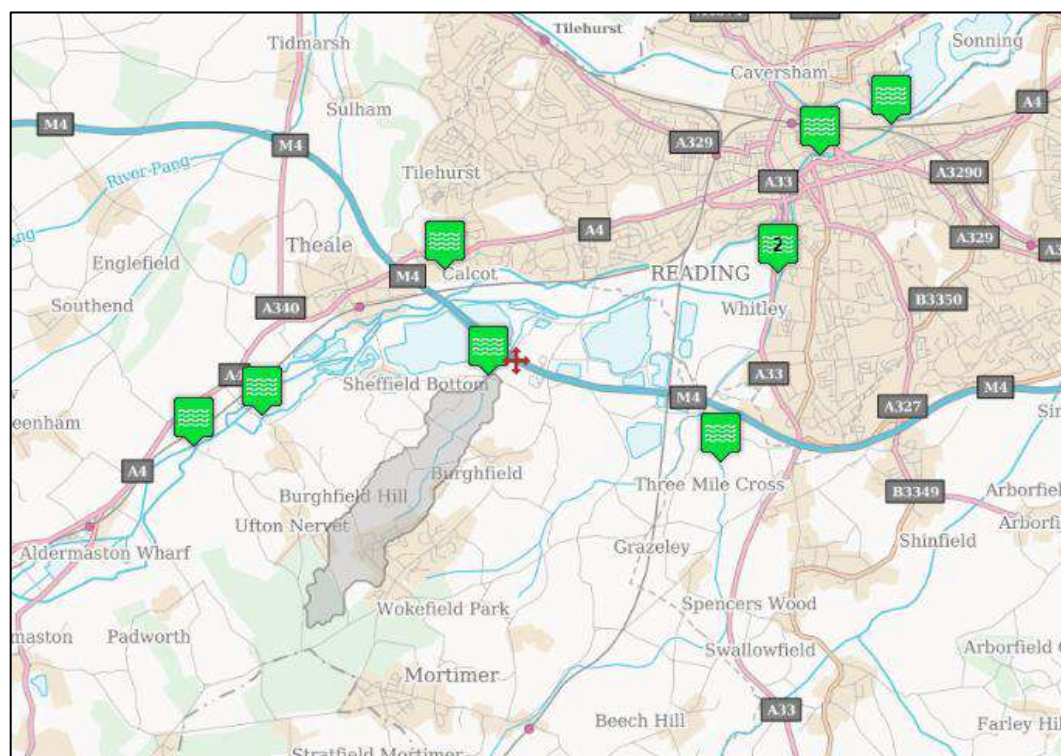


Figure 3e – Catchment of Node 5

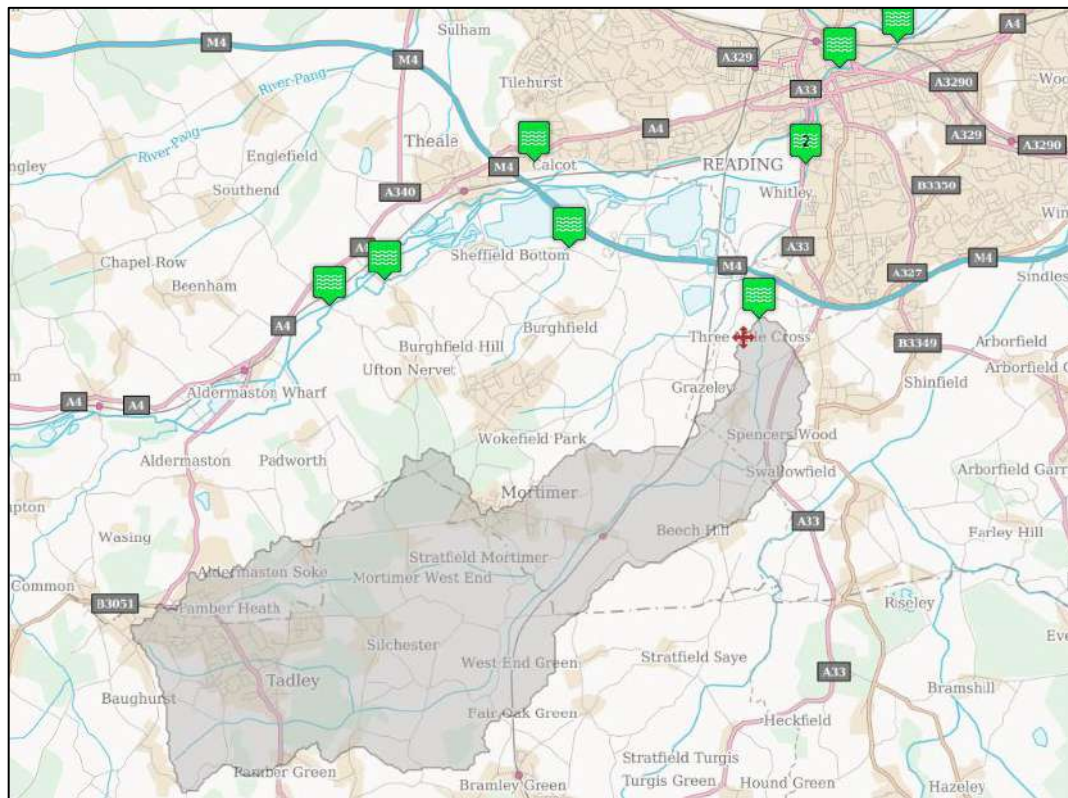


Figure 3f – Catchment of Node 6

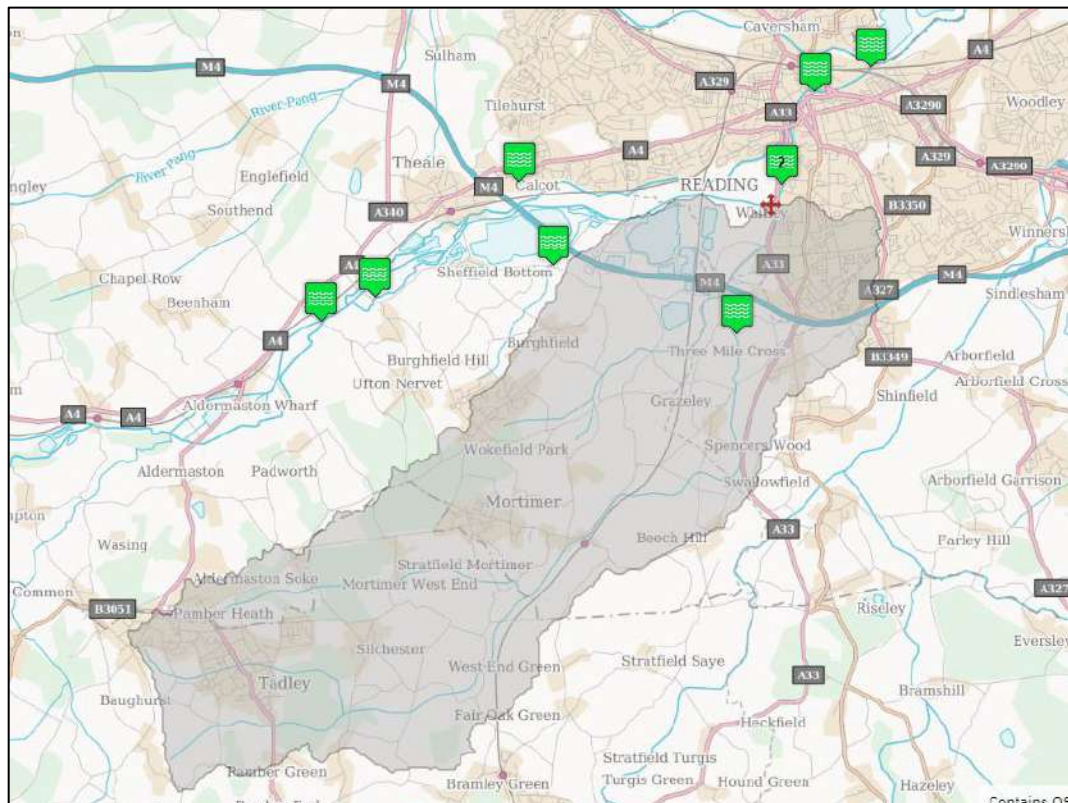


Figure 3g – Catchment of Node 7

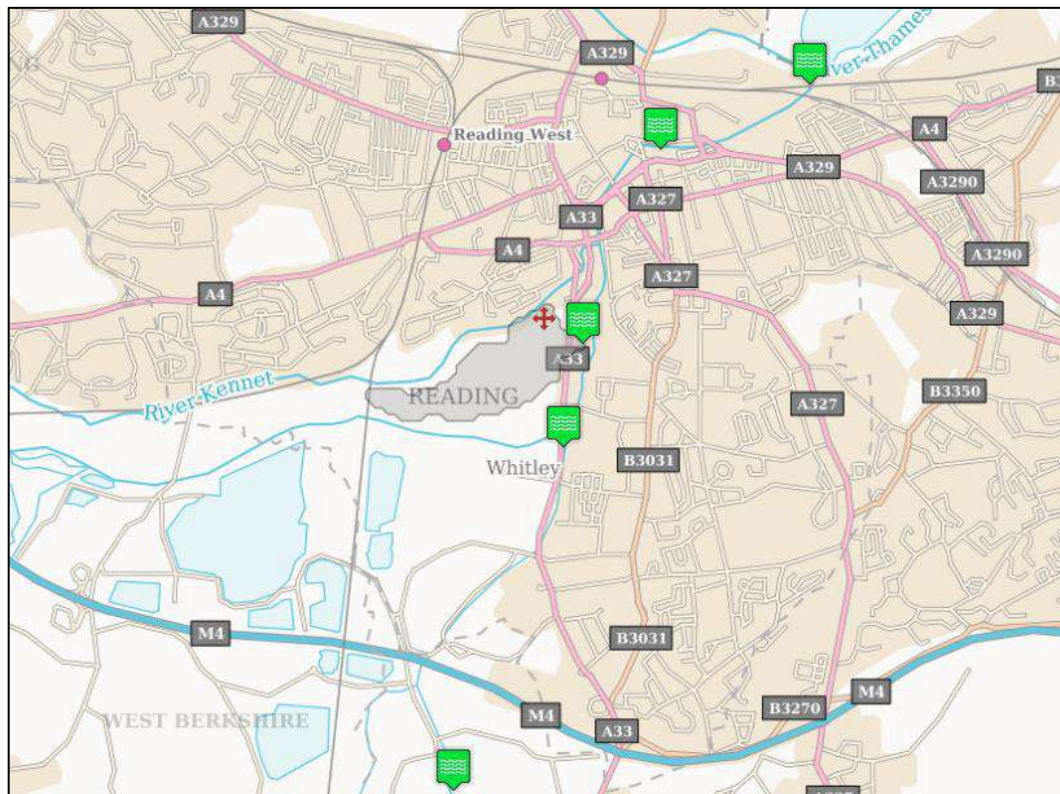


Figure 4a – Close up of Node 2

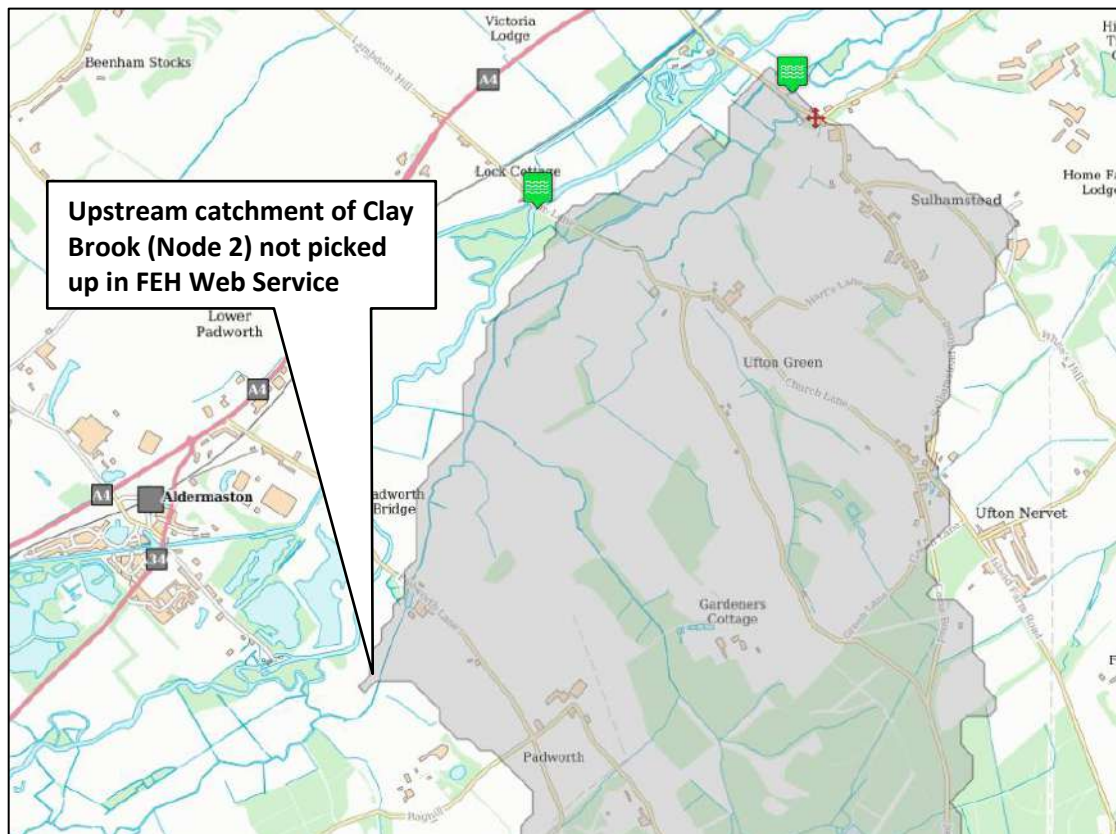
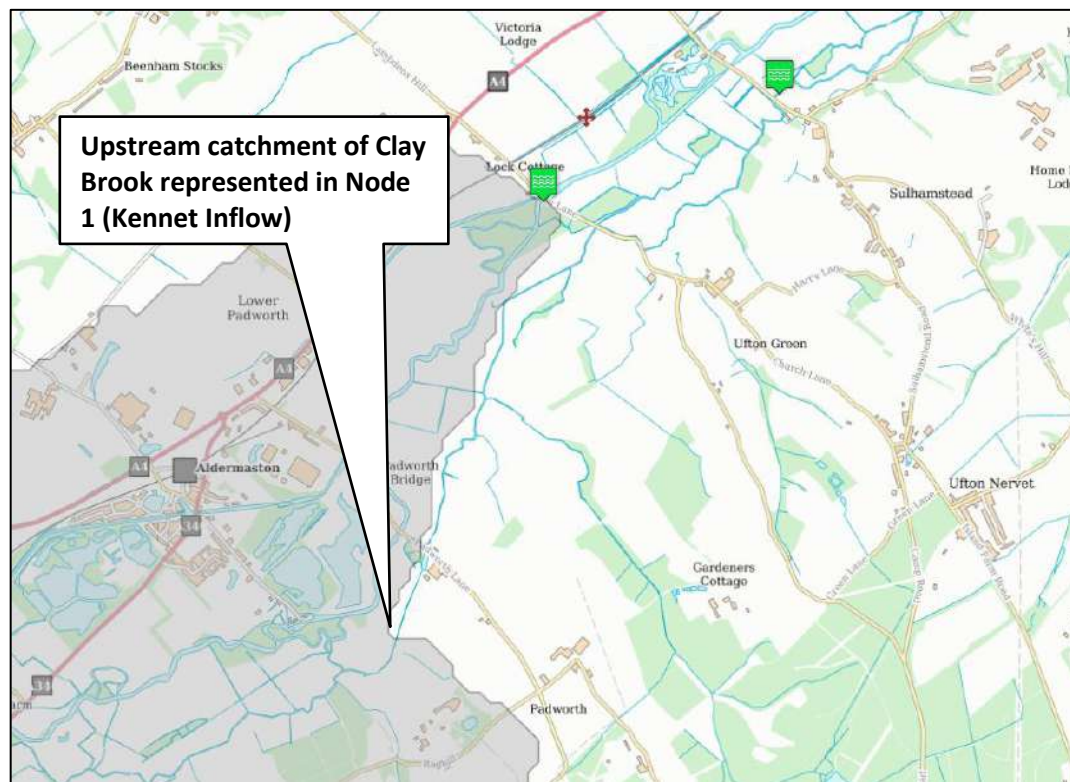


Figure 4b – Close up of Node 1



8.0 Tables

Table 1a – Estimated peak flows using FEH statistical method

	Peak Flows (m ³ /s)					
Return Period	QMED	5 year	100 year	100 year plus 35%	100 year plus 70%	1000 year
Node 1 (Inflow Kennet)	36.531	46.890	76.852	103.750	130.648	104.901
Node 2 (Inflow Clay Brook)	1.014	1.466	3.072	4.147	5.222	4.970
Node 3 (Inflow drain to HolyBrook)	0.305	0.410	0.871	1.1759	1.481	1.554
Node 4 (Inflow Clayhill Brook)	0.849	1.192	2.562	3.459	4.355	4.399
Node 5 (Inflow foudry)	7.269	10.352	19.414	26.209	33.004	28.053
Node 6	9.342	12.512	19.619	26.4857	33.352	24.546
Node 7 (Inflow I4)	0.066	0.093	0.185	0.2498	0.315	0.287

Table 1b – Estimation of QMED

		Donor Station				
Site code	Initial estimate of QMED (from catchment descriptors)	Donor Station Number	Donor Station QMED (from catchment descriptors)	Distance between centroids d _{ij} (km)	Donor Station QMED (from observed data)	Final estimate of QMED (m ³ /s)
Node 1	36.473	39016	37.554	0.656	37.624	36.531
Node 2	1.116	39025	22.513	14.98	17	1.014
Node 3	0.333	39025	22.513	19.51	17	0.305
Node 4	0.93	39025	22.513	17.64	17	0.849
Node 5	7.992	39025	22.513	15.52	17	7.269
Node 6	9.211	39007	21.475	17.28	22.43	9.342
Node 7	0.065	39007	21.475	19.32	22.43	0.066

Table 2 – Estimated peak flows using ReFH rainfall runoff method

	Peak Flows (m3/s)					
Return Period	2 year	5 year	100 year	100 year plus 35%	100 year plus 70%	1000 year
Node 1 (Inflow Kennet)	35.17	45.60	84.63	114.2505	143.871	141.20
Node 2 (Inflow Clay Brook)	1.07	1.42	2.61	3.5235	4.437	4.45
Node 3 (Inflow drain to HolyBrook)	0.53	0.71	1.34	1.809	2.278	2.20
Node 4 (Inflow Clayhill Brook)	0.98	1.28	2.36	3.186	4.012	3.98
Node 5 (Inflow foudry)	7.33	9.38	16.42	22.167	27.914	27.15
Node 6	11.41	14.59	25.41	34.3035	43.197	42.04
Node 7 (Inflow I4)	0.06	0.08	0.15	0.2025	0.255	0.27

Table 3 – Ratio of ReFH 100 year and 1000 year flows

Return Period	100 year	1000 year	100 year to 1000 year ratio (1:X)
Node 1 (Inflow Kennet)	84.63	141.20	1.668
Node 2 (Inflow Clay Brook)	2.61	4.45	1.705
Node 3 (Inflow drain to HolyBrook)	1.34	2.20	1.641791
Node 4 (Inflow Clayhill Brook)	2.36	3.98	1.686441
Node 5 (Inflow foudry)	16.42	27.15	1.653471
Node 6	25.41	42.04	1.654467
Node 7 (Inflow I4)	0.15	0.27	1.8

Table 4 – Final peak flows used

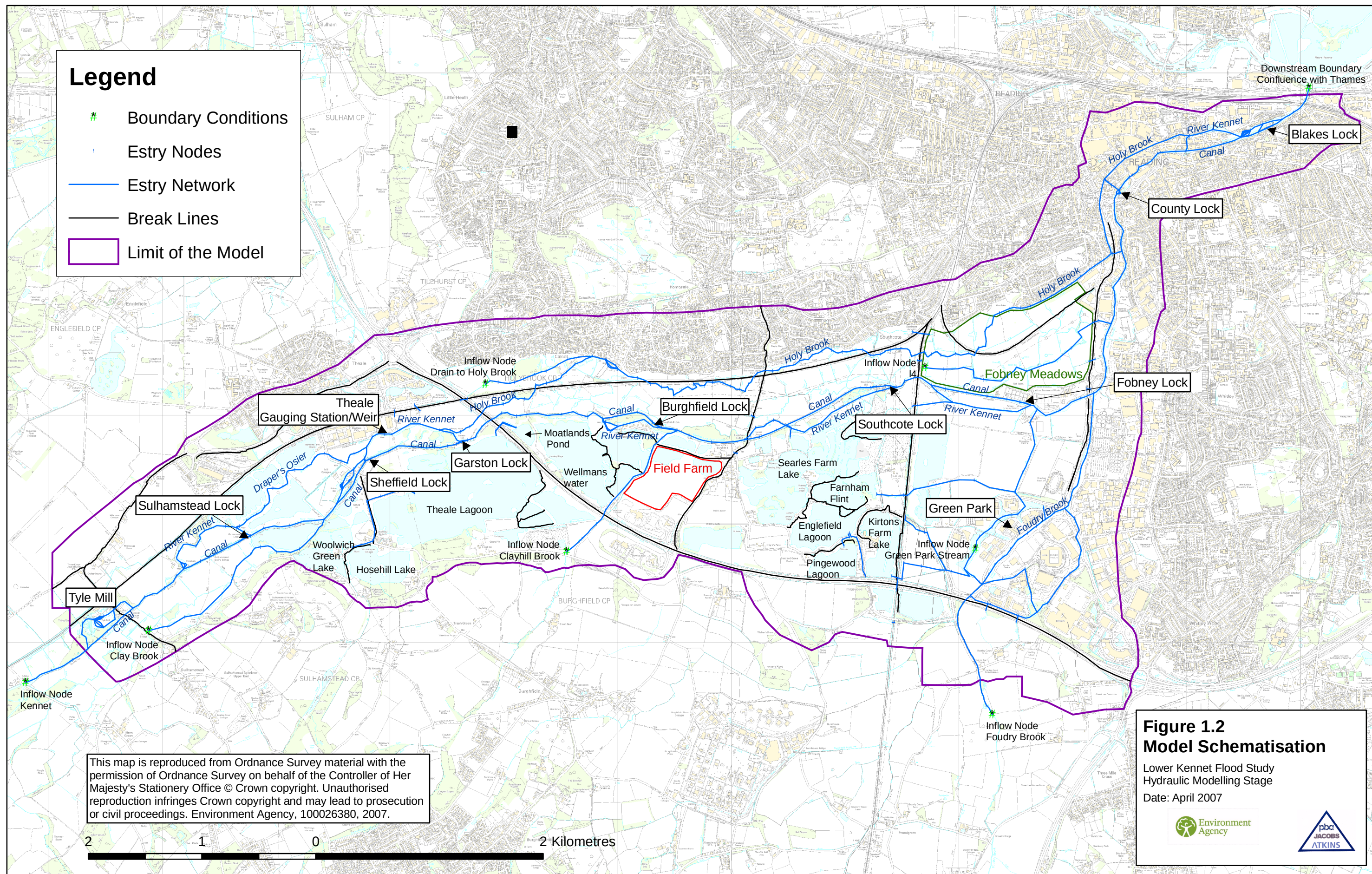
	Peak Flows (m3/s)					
Return Period	QMED	5 year	100 year	100 year plus 35%	100 year plus 70%	1000 year*
Node 1 (461800, 168600)	36.531	46.890	76.852	103.750	130.648	128.1891
Node 2 (462900, 169100)	1.014	1.466	3.072	4.147	5.222	5.23776
Node 3 (465850, 171450)	0.305	0.410	0.871	1.1759	1.481	1.43
Node 4 (466550, 169750)	0.849	1.192	2.562	3.459	4.355	4.320662
Node 5 (470300, 168350)	7.269	10.352	19.414	26.209	33.004	32.10049
Node 6 (471150, 171000)	9.342	12.512	19.619	26.4857	33.352	32.45899
Node 7 (471399, 171800)	0.066	0.093	0.185	0.2498	0.315	0.333

*calculated using FEH Statistical/ReFH Ratio method

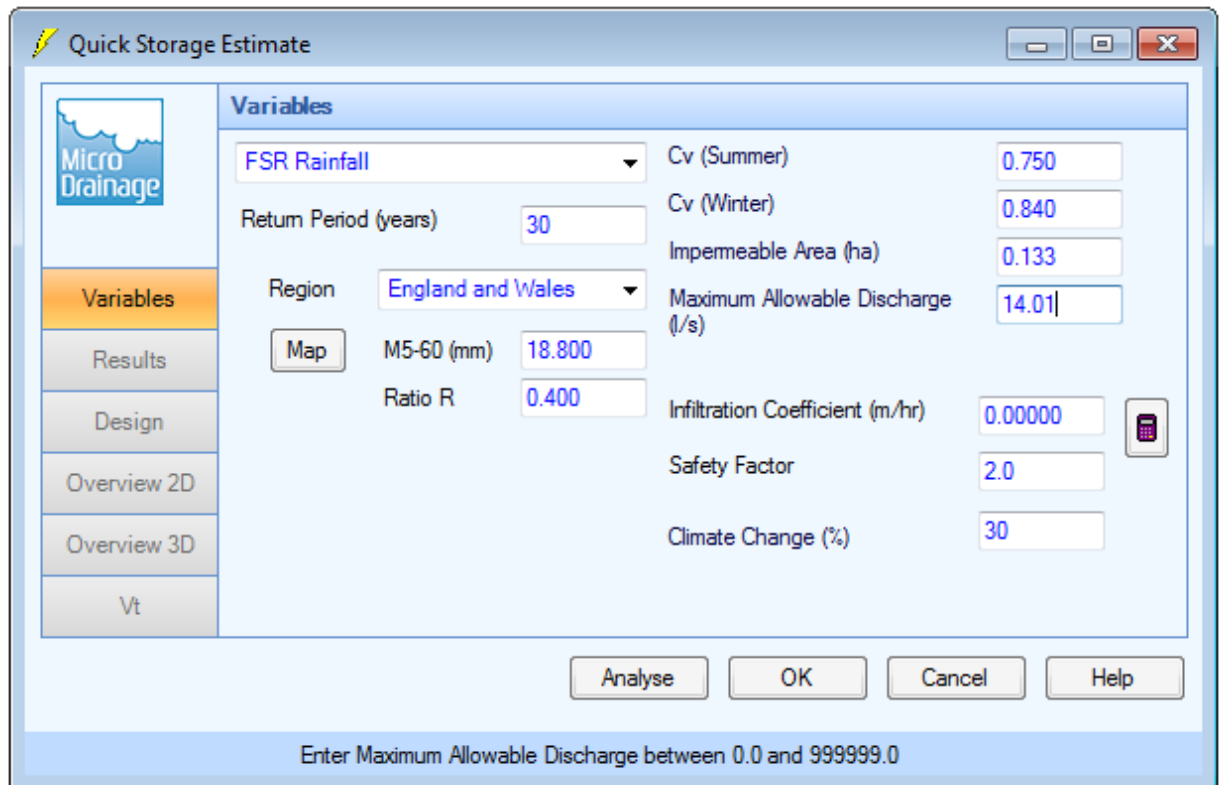
Table 5 – Comparison of Previous and Updated Flows

	Peak Flows (m3/s) in 1 in 100 year event	
Return Period	Previous	Updated (Clarkebond)
Node 1 (Inflow Kennet)	86.727	76.852
Node 2 (Inflow Clay Brook)	18.909	3.072
Node 3 (Inflow drain to Holy Brook)	0.1	0.871
Node 4 (Inflow Clayhill Brook)	0.1	2.562
Node 5 (Inflow foudry)	20.04	19.414
Node 6	n/a	19.619
Node 7 (Inflow I4)	0.4	0.185

9.0 Appendix A – Inflow Nodes in Previous Model



Appendix J – MicroDrainage Quick Storage Estimates (x2)



Quick Storage Estimate

Variables

FSR Rainfall

Return Period (years): 30

Region: England and Wales

Map

M5-60 (mm): 18.800

Ratio R: 0.400

Cv (Summer): 0.750

Cv (Winter): 0.840

Impervious Area (ha): 0.133

Maximum Allowable Discharge (l/s): 14.01

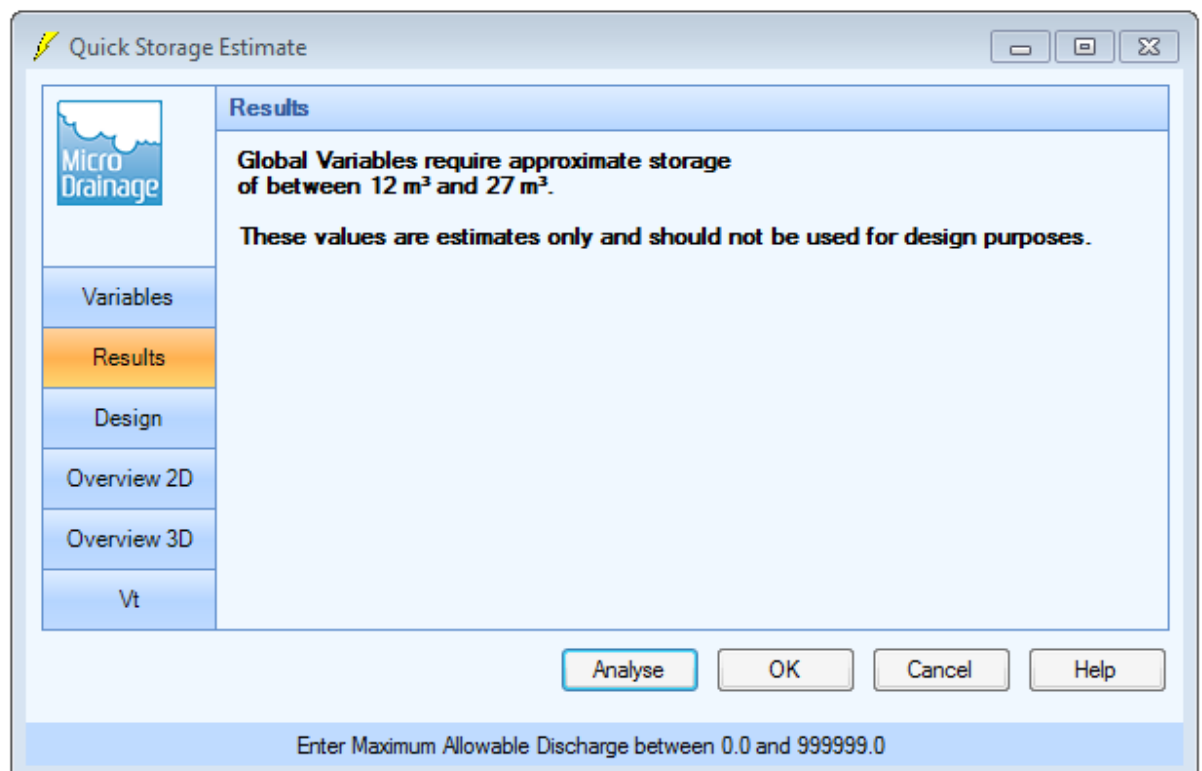
Infiltration Coefficient (m/hr): 0.00000

Safety Factor: 2.0

Climate Change (%): 30

Analyse OK Cancel Help

Enter Maximum Allowable Discharge between 0.0 and 999999.0



Quick Storage Estimate

Results

Global Variables require approximate storage of between 12 m³ and 27 m³.

These values are estimates only and should not be used for design purposes.

Analyse OK Cancel Help

Enter Maximum Allowable Discharge between 0.0 and 999999.0

Quick Storage Estimate

Micro Drainage

Variables

FSR Rainfall

Return Period (years) 100

Region England and Wales

Map

M5-60 (mm) 18.800

Ratio R 0.400

Cv (Summer) 0.750

Cv (Winter) 0.840

Impervious Area (ha) 0.133

Maximum Allowable Discharge (l/s) 29.36

Infiltration Coefficient (m/hr) 0.00000

Safety Factor 2.0

Climate Change (%) 30

Analyse OK Cancel Help

Enter Maximum Allowable Discharge between 0.0 and 999999.0

Quick Storage Estimate

Micro Drainage

Results

Global Variables require approximate storage of between 6.6 m³ and 28 m³.

These values are estimates only and should not be used for design purposes.

Analyse OK Cancel Help

Enter Maximum Allowable Discharge between 0.0 and 999999.0

Appendix K – Drainage Strategy (x1)



clarkebond

MULTIDISCIPLINARY ENGINEERING CONSULTANTS

The Cocoa House
129 Cumberland Road
Bristol
BS1 6UY

tel: +44 (0)117 929 2244

GF Suite
Bickleigh House
Park Five Buisness Centre
Exeter EX2 7HU

tel: +44 (0)1392 369098

Unit 17.1
The Leathermarket
11-13 Weston Street
London SE1 3ER

tel: +44(0)20 7939 0959

www.clarkebond.com