

FLOOD RISK ASSESSMENT AND DRAINAGE STRATEGY

LAND EAST OF TYE LANE, WALBERTON

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EAST OF TYE LANE, WALBERTON, WEST SUSSEX FLOOD RISK ASSESSMENT AND DRAINAGE STRATEGY

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FLOOD RISK ASSESSMENT AND DRAINAGE STRATEGY

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1. INTRODUCTION

1.0.1 Ramboll UK Limited trading as Ramboll Environ (Ramboll) was appointed by Wates Developments (client) to undertake a Flood Risk Assessment (FRA) and develop an outline drainage design for the erection of up to 175 residential units at Walberton, West Sussex.

1.0.2 The key sources of information used to prepare this report include:

- Arun District Council – Level 1 and Level 2 Strategic Flood Risk Assessment (SFRA) (September 2016);
- Environment Agency's (EA) online database of indicative floodplain and hydrogeological maps;
- EA – Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities (last update published in March 2016);
- EA – Light Detection and Ranging (LiDAR) data (provided under the Open Government Licence v3.0);
- Sewers for Adoption – A Design and Construction Guide for Developers – Seventh Edition (August, 2012);
- CIRIA – C753 The SuDS Manual (2015);
- British Water – Code of Practice: Flows and Loads 4 (November, 2013);
- The British Geological Survey (BGS) Geology of Britain Viewer.
<http://www.bgs.ac.uk/data/mapViewers/home.html> (accessed January 2017);
- National Planning Policy Framework (NPPF);
- National Planning Practice Guidance (NPPG): Flood Risk and Coastal Change (April, 2015);
- Geo-Environmental – Ground Investigation (ongoing);
- K.A.Rylance Limited – 3D Topographic Survey (job no. 16:5125) (August 2016)

1.0.3 Ramboll cannot accept liability for the accuracy or otherwise of any information derived from third party sources.

1.1 Scope and Objectives

1.1.1 This document considers the risks of various sources of flooding to the application site and the consequent risk of flooding to downstream receptors (such as people, property, habitats, infrastructure and statutory sites) from the proposed development, as a result of surface water run-off. A comparison is made between the current situation and the proposed future development.

1.1.2 This FRA has been carried out in accordance with the National Planning Policy Framework (NPPF). It is to be used to assist the Local Planning Authority (LPA) and EA, when considering the flooding issues of the proposed development, as part of a planning application. An FRA is required for the application site as it is larger than one hectare of developable area.

1.1.3 This report provides the following information:

- i. An assessment of the flood risk to the site based upon flood data and the flood maps provided by the EA and SFRA and;
- ii. An assessment of the impact of the new development in terms of surface water run-off and foul water;
- iii. Proposals for measures to mitigate the generation of surface water run-off and foul water generated from the proposed development; and
- iv. Proposals to mitigate any residual flood risks to the development (if any).

2. SITE CONTEXT

2.1 Application Site Description

- 2.1.1 The application site area is approximately 11.3 ha (28 acres) and currently 100% greenfield. It is located in Walberton, West Sussex (NGR 497286 106211) 500 m south from A27 (Arundel Road). The development site is currently bordered by the Avisford Park Golf course to the north, Tye Lane to the west and residential dwellings to the south and east.
- 2.1.2 The application site location plan is provided in Figure 1, at the rear of this report.

2.2 Site Topography

- 2.2.1 A topographic survey was carried out by K.A.Rylance Limited in 2016. Based on the survey the site elevation varies from approximately 21.00 metres Above Ordnance Datum (mAOD) to 14.50 mAOD. Levels generally fall to a south and south westerly direction with an approximate 1:90 gradient. Contours indicate two natural low points within the boundary, at the southern edge as well as at the southwest corner.
- 2.2.2 The digital terrain model and topographic survey is provided in Figure 2, at the rear of this report.

2.3 Geological Setting

- 2.3.1 The British Geological Survey (BGS) map of the area, accessed via online digital mapping¹, indicates that the superficial deposits underlying the application site are River Terrace Deposits (sand, silt, and clay) of which beneath is London Clay Formation (clay, silt, and sand).
- 2.3.2 Available borehole record scans in the vicinity of the application boundary were reviewed accessed via www.bgs.ac.uk. The strata recorded at borehole log no. SU90NE39 located within the application site boundary is summarised in Table 2.1 below.

Table 2.1: BGS Borehole Records of SU90NE39

Strata	Description	Depth (mbgl)
1	Brickearth – silt, clayey, brown, with yellowish and dark brown mottling; discounting "pipes" of dark brown clay up to 1 cm diameter, containing abundant chalk pellets; scattered angular to subrounded white flint pebbles more common near the base	3.0
2	Head Gravel – silt, very chalky, pale brown, with abundant chalk granules, a few chalk pebbles and white subangular to rounded flint pebbles	4.1
3	'Very clayey' gravel. Gravel: coarse with fine, angular to subrounded; flint, some white and porous. Sand: coarse with medium and fine. Fines: clay, brown	7.2
4	Clay, silty, with fine sand, pale olive with mottling of orange-brown and dark brown (peat); a few angular flint pebbles	7.9
5	Raised Beach Deposits (younger) – Silt, brown, with fine sand, a few angular flint pebbles and some shell fragments	8.9
6	'Very clayey' sand. Sand: fine quarts. Fines: silt, brown to 10.6 m then grey	11.1
7	London Clay – clay, stiff, with pockets of silty and fine sandy clay; very fine mica flakes and rare rounded flint pebbles	11.5

¹ Refer to <http://mapapps.bgs.ac.uk/geologyofbritain/home.html> (accessed 30-01-2017)

- 2.3.3 According to borehole records groundwater was struck at 6.8 metres below ground level (mbgl).
- 2.3.4 Ground investigation work on site is currently being carried out by Geo-Environmental. Eight window sample (WS) locations were identified within the boundary (for the locations refer to Figure 2). All boreholes are 3 m deep. The summary of the encountered strata is provided in Table 2.2.

Table 2.2. Summary of Window Samples 1-8 (2017)

Strata	Description	Depth (mbgl)
1	Topsoil – Grass over dark brown slightly sandy clay with occasional rootlets (and flint gravel)	0.15 – 0.30
2	River Terrace Deposits – Firm dark brown orangish silty CLAY with rare fine to coarse angular flint gravel	0.80 – 2.20
3	River Terrace Deposits – Firm dark orangish brown gravelly silty CLAY with rare black specks. Gravel is fine to coarse angular flint	2.60 – 3.00
4	River Terrace Deposits – Firm dark orangish brown very gravelly silty CLAY with rare black specks. Gravel is fine to coarse angular flint	1.10 – 3.00

- 2.3.5 At locations WS5 and WS8 groundwater was encountered approximately 1 mbgl, however this is considered to be perched water.
- 2.4 Hydrological Setting**
- 2.4.1 There are two EA main rivers located at the east and west of the application site. The Barnham Rife flows north to south approximately 500 m west. This watercourse merges with Lidsey Rife 4 km downstream which subsequently discharges to the English Channel.
- 2.4.2 The Little Tortington Stream is located 250 m east at its nearest point to the site, flowing to the southeast direction. This watercourse merges with the River Arun approximately 3,600 m southeast from the application site which subsequently discharges to the sea at Littlehampton.
- 2.4.3 There are five man-made small lakes/ponds located on the golf course immediately north of the application site.
- 2.4.4 The development site is part of the South East River Basin District, Arun and Western Streams Management Catchment. In terms of operational catchments the application site is divided into two parts; approximately 95% is part of the Western Streams Operational/ Lidsey Rife River Waterbody Catchment and 5% is part of the Lower Arun Operational Catchment².
- 2.4.5 The Hydromorphological designation of Lidsey Rife Waterbody Catchment is not designated as artificial or heavily modified. The overall ecological status is moderate and chemical status good.
- 2.4.6 The sub-catchment of Lower Arun is a mix of urban concentrations and open agricultural land. The biggest pressure on the environment in this area is water quality, with impacts from Sewage Treatment Works and diffuse pollution from urban and rural sources. Furthermore, many of the waterbodies within this sub-catchment are small with many being field drains. The overall ecological status of surface water within this catchment is moderate and the chemical status is good.

² The Lower Arun Operational Catchment is not being classified as a separate River Waterbody Catchment at the location of the application site

- 2.4.7 The northwest extent of the application site is underlain by the Sussex Lambeth Group Groundwater Operational Catchment. The overall quantitative status is classified as poor and the chemical status of groundwater body as good in accordance with the water framework directive.

2.5 Hydrogeological Setting

- 2.5.1 The EA has developed Groundwater Source Protection Zones (SPZs) to assist in the assessment of risk to groundwater supplies taken from an abstraction point. The application site does not lie within a Groundwater Source Protection Zone.
- 2.5.2 The EA website shows aquifers and provides designations which are in line with the Water Framework Directive and are based on maps produced by the BGS. Definitions for the aquifer types are provided below based on the EA website:

Principal Aquifer: "layers of rock or drift deposits that have high intergranular and/ or fracture permeability – meaning they usually provide a high level of water storage. They may support water and/ or river base flow on a strategic scale."

Secondary A Aquifer: "permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers."

Secondary B Aquifer: "predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering."

Secondary Undifferentiated Aquifer: "assigned where it has not been possible to attribute either category A or B to a rock type. In most cases, this means that the layer in question has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the rock type."

- 2.5.3 The River Terrace Deposit underlying the application site is classified as a Secondary A aquifer.

2.6 Existing Drainage Regime and Surface Water Runoff

- 2.6.1 The existing site is 100% greenfield. Runoff rates were calculated for the entire development site using the Interim Code of Practice for Sustainable Drainage Systems (ICP SuDS) method in MicroDrainage 2016. The results of the calculations are shown in Table 2.3, below. Detailed calculations are provided in Appendix A, at the rear of this report.

Table 2.3. Greenfield Runoff Rate Calculations

Return Period (years)	1-in-1	1-in-2	1-in-10	1-in-30	1-in-100
Greenfield run-off rates (l/s)	19.8	20.6	37.8	52.9	74.4

- 2.6.2 Southern Water asset records indicate that there are no public sewers located within the development site. Public foul sewers are located in Tye Lane, Avisford Park Road, and Yapton Lane. There are no surface water sewers within the close vicinity of the application site. The Southern Water asset records are provided in Appendix B, at the rear of this report.

2.7 Existing Flood Risk

Fluvial and Tidal Flood Risk

- 2.7.1 The EA's floodplain maps identify areas in England and Wales at risk of flooding by allocating them into flood risk zones.

- 2.7.2 The flood risk zones shown on the flood maps are defined in Table 1 (Flood Zones) of the Guidance (NPPG):

Zone 1: Low Probability

According to the NPPG, land in this zone is considered to have less than 1-in-1000 annual probability of river or sea flooding in any year. This is <0.1%.

Zone 2: Medium Probability

According to the NPPG, land in this zone is considered to have between a 1-in-100 and 1-in-1000 annual probability of river flooding in any year (between 1% and 0.1%) or between a 1-in-200 and 1-in-1000 annual probability of sea flooding in any year (0.5% to 0.1%).

Zone 3a: High Probability

According to the NPPG, land in this zone is considered to have a 1-in-100 or greater annual probability of river flooding in any year (>1%) or a 1-in-200 or greater annual probability of flooding from the sea in any year (>0.5%).

Zone 3b: The Functional Floodplain

According to the NPPG, land in this zone is used for water flow or storage in times of flood. This flood zone should be identified by a Strategic Flood Risk Assessment (SFRA). It is considered to have a 1-in-20 or greater chance of river flooding in any year which is >5%. Another probability, however, can also be agreed between the Local Planning Authority (LPA) and the EA.

- 2.7.3 Based on EA indicative mapping, the application site is located in Flood Zone 1, therefore the associated risk of flooding from rivers and sea is considered to be low. The extents of Flood Zones in the vicinity of the application site are provided in Figure 3, at the rear of this report.

Surface Water and Sewer Drainage Flood Risk

- 2.7.4 In accordance with the SFRA flooding from surface water runoff (or 'pluvial' flooding) is usually caused by intense rainfall that may only last a few hours and usually affects lower lying areas, often where the natural (or artificial) drainage system is unable to cope with the volume of water. Surface water flooding problems are inextricably linked to issues of poor drainage, or drainage blockage by debris, and sewer flooding.
- 2.7.5 The updated Flood Map for Surface Water (uFMfSW) provided by the EA shows predicted flood extents that predominantly follow topographical flow paths of existing watercourses or dry valleys with some isolated ponding location in low lying areas.
- 2.7.6 The EA indicative mapping indicates that the vast majority of the application site has a very low susceptibility to surface water flooding. A small part of the southwest corner is shown to have a high susceptibility to surface water flooding (1-in-30 year chance in every given year), however the spatial extent of predicted flooding is considered to be minimal. The uFMfSW shows an overland flood flow route following lower elevation contours on site flowing towards the ponding location. Such flooding is predicted to occur during very extreme rainfall events (1-in-1000 year chance in every given year), therefore the associated risk of flooding is very low.
- 2.7.7 The spatial extent of risk of flooding for surface water is provided in Figure 4, at the rear of this report.
- 2.7.8 Sewer flooding occurs when intense rainfall overloads the sewer system capacity (surface water, foul or combined), and/or when sewers cannot discharge properly to watercourses due to high water levels. Sewer flooding can also be caused when problems such as blockages, collapses or equipment (such as pumps) failure occur in the sewerage system. Surface water inundation of manhole openings,

entry of soil or groundwater into the sewer system via faults within the fabric of the sewerage system, is another cause of sewer flooding.

- 2.7.9 The Lidsey Surface Water Management Plan (SWMP) identified sewer flood based on information supplied by Southern Water. In the SWMP the main reason of surface water flooding in the Lidsey area was identified due to hydraulic overload of sewers as a result of infiltration assumed to be a result of land drainage seeping into the sewer via capillary cracks.
- 2.7.10 Historical incidents of flooding are detailed by Southern Water in their DG5 register. The database records incidents of flooding relating to public foul, combined or surface water sewers and identify which properties suffered flooding. For confidentiality reasons, this data has been supplied on a postcode basis from the Sewer Incident Report Form (SIRF³) hydraulic overload database. Table 5-2 of the SFRA indicates 20 recorded flood incidents with the BN18 0 postcode area⁴.
- 2.7.11 Historic flood incidents are also recorded by the EA. Based on their database it is understood that sewer flooding occurred in 1982 and 1987 along The Street, to the southwest of the site, as well as at the junction of Estergate Lane and Barnham Lane. The spatial extent of historic flooding is provided in Figure 5, at the rear of this report.
- 2.7.12 No historic sewer flooding was recorded within the application site however the above described flood incidents were within a 500 m radius from the southwest extent of the site. Considering the collated information above and the fact that no sewers situated beneath the application site or immediately upstream, the risk of drainage flooding is considered to be low, however consideration is to be given to the potential impact of the development site on downstream receptors and measures to be taken to minimise flood risk.

Groundwater Flood Risk

- 2.7.13 Compared with other sources, current understanding of the risks posed by groundwater flooding is limited and mapping of flood risk from groundwater sources is in its infancy. Under the Flood and Water Management Act (2010), LLFAs have powers to undertake risk management functions in relation to groundwater flood risk.
- 2.7.14 As part of the SFRA deliverables, mapping of the whole District has been provided showing the Areas Susceptible to Groundwater Flooding (AStGWF). The AStGWF is a strategic-scale map showing groundwater flood areas on a 1 km square grid. The data was produced to annotate indicative Flood Risk Areas for Preliminary Flood Risk Assessment (PFRA) studies and allow the LLFAs to determine whether they may be at risk of flooding from groundwater. This data shows the proportion of each 1km grid square, where geological and hydrogeological conditions indicate that groundwater might emerge. Appendix F, Sheet 43 of 46 of the SFRA indicates 25% to 50% susceptibility to groundwater flooding within the application site boundary.
- 2.7.15 Historic borehole records indicate that groundwater on site is in the order of 7 mbgl. Based on the ongoing ground investigation the top strata contain impermeable layers of silty clay the risk of flooding from groundwater within the application site boundary is considered to be low.

Risk from Reservoirs, Canal and Other Artificial Sources

- 2.7.16 Reservoirs are artificial bodies of water, where water is collected and stored behind a man-made structure (dam) and released under control either to reduce the flow magnitudes in downstream channels or to meet a requirement when needed for purposes such as irrigation, municipal needs or

³ Information provided by Southern Water on 25/02/2016

⁴ Nearest postcode to the site is BN18 0PF

hydroelectric power. Flooding from reservoirs occurs following partial or complete failure of the control structure designed to retain water in the artificial storage area or as a consequence of a flood which is much greater than that used for the purpose of designing the control and mitigation measures.

- 2.7.17 There are no large reservoirs within the Arun District and the indicative EA mapping shows no risk of flooding from reservoirs to the application site. The associated risk is therefore considered to be low.

Flood Risk Summary

- 2.7.18 Table 2.4 summarises the risk of flooding to the application site from all sources.

Table 2.4. Flooding Sources at the Proposed Development Site

Sources of Flooding	High	Medium	Low	Comments
Tidal/ fluvial			X	Site is located in Flood Zone 1
Surface water and drainage flood risk			X	Potential susceptibility to surface water flooding within the southwest corner of the site, although vast majority of site has very low risk. No recorded flooding occurred within the site boundary, however consideration to be given to the susceptibility of downstream receptors.
Groundwater			X	Groundwater table is predicted to be 7 mbgl with impermeable strata close to the surface.
Reservoirs, canals and other artificial sources			X	No reservoirs located in the vicinity of the site that could potentially pose risk of flooding to the site.

3. ASSESSMENT OF NEW DEVELOPMENT

3.1 Development Proposal

- 3.1.1 It is proposed to erect up to 175 residential mixed size dwellings with access road, parking and landscaping within the application site. Vehicular access to the site would be gained via B2132, Yapton Lane.
- 3.1.2 The proposed layout of the application site is provided in Appendix C, at the rear of this report.

3.2 Flood Risk Vulnerability

- 3.2.1 According to Table 2 (Flood Risk Vulnerability Classification) in the Planning Practice Guidance to NPPF, buildings used for residential dwellings are classified as "More Vulnerable".
- 3.2.2 Table 3 (Flood Risk Vulnerability and Flood Zone Compatibility) in the Planning Practice Guidance to NPPF, states that "More Vulnerable" developments are appropriate to locate in Flood Zones 1.

3.3 Sequential Test

- 3.3.1 The Sequential Test aims to steer development to areas with the lowest probability of flooding.
- 3.3.2 In accordance with the NPPF "More Vulnerable" developments are suitable for location in Flood Zone 1; therefore, the sequential test is deemed to have been passed and the Exception Test is not required for the proposed development.

3.4 Surface Water Runoff

- 3.4.1 The existing site is currently 100% greenfield. As a result of the proposed development, the extent of impermeable areas will increase to approximately 3.75 ha⁵ (33% of total site area), including the access road, parking areas, footways and roof areas.
- 3.4.2 The NPPF identifies that rainfall intensities will increase in the future as a result of climate change (CC), thereby increasing surface water runoff rates and volumes. The updated EA CC allowance guidance (2016) shows the recommended national precautionary sensitivity ranges for various parameters including peak rainfall intensity. The design life of the new development is considered to be 100 years; the recommended allowance for CC has a range between 20% (central) and 40% (upper end). This therefore needs to be accounted for when designing the new drainage systems. Due to the compliance with the requirements set by the SFRA a 40% CC allowance was applied throughout the surface water drainage design.
- 3.4.3 Table 3.1 summarises the predicted change in peak flow as a result of the development considering 40% allowance for CC. The critical storm duration for runoff is 15 minutes. Detailed calculations are provided in Appendix D, at the rear of this report.

Table 3.1: Post-Development Surface Water Runoff

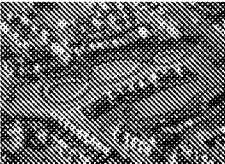
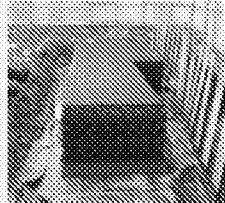
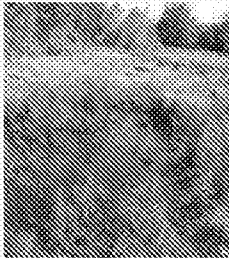
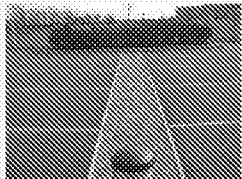
Return Period (years)	1-in-1	1-in-2	1-in-10	1-in-30	1-in-100
Post-development runoff rates (l/s) including 40% CC	435	558	861	1063	1390

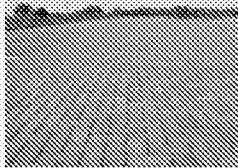
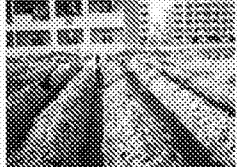
3.5 Assessment of Sustainable Drainage Options

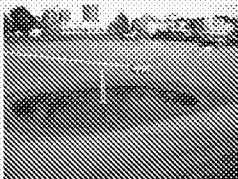
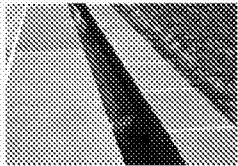
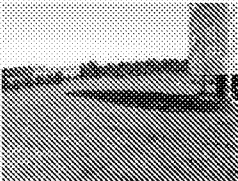
- 3.5.1 The SFRA states that in accordance with the Flood Risk Management Hierarchy, mitigation measures should be seen as a last resort to address flood risk issues. Once risk has been minimised as far as possible, only then should mitigation measures be considered.
- 3.5.2 Chapter 2 of the FRA demonstrates that the application site is located within Flood Zone 1 and at low overall risk from all other sources of flooding. Although a minor low point within the site is identified to have a high susceptibility to surface water flooding, this part of the site is not allocated for housing, therefore the proposed development is considered to be compliant with the Flood Risk Management Hierarchy. The topographic profile indicates that the receptors downstream of the application site are residential dwellings; therefore considerations to the outline drainage strategy are to be given to ensure that flood risk is not increased beyond the boundaries.
- 3.5.3 It is understood that the SFRA requires new developments to consider for making space for water and such approach to be applied to surface water generated by impermeable surfaces. All new developments should aim to incorporate SuDS to minimise the amount of surface water that is generated. Through a sequential design, known areas of flood risk from surface water can be set aside as open space to ensure flow routes are not blocked, preventing water from building up to potentially dangerous depths. The provision of SuDS also allows water related features to become part of the landscape, offering improved aesthetics to a development and removing the need for underground storage or culverting. The practical feasibility and suitability of different SuDS features are assessed in Table 3.2 below.

⁵ The approximate extent of impermeable areas were calculated in GIS based on indicative site layout provided in Appendix C. Approximate roof are 14,451 m² and other hard surfaces including roads, footways and parking is 23,072 m²

Table 3.2: Sustainable Drainage System Options

SUDS Group	Technique	Image	Description	Advantages	Disadvantages	Suitable for Use at Site?
Retention	Balancing pond		Provides both storm water attenuation and treatment. Run-off from each rain event is detained and treated in the pool. The retention time promotes pollutant removal through sedimentation.	Good removal of pollutants, can be used where groundwater is vulnerable, good community acceptability, high ecological, and amenity benefits	No reduction in run-off volume, land take may limit use in high density sites	✓ Considered suitable, however land take and safety implications to be considered.
	Sub-surface storage		Oversized pipes, tank systems and modular geocellular systems that can be used to create a below ground storage structure.	Modular and flexible, dual usage (infiltration/storage, high void ratios), can be installed beneath trafficked and soft landscaped areas.	No water quality treatment	✓ Sub-surface storage with infiltration is suitable for the site; however it is likely that more cost effective solutions are achievable.
Wetland	Shallow wetland		Wetlands provide stormwater attenuation and treatment. They comprise shallow ponds and marshy areas, covered in aquatic vegetation. Wetlands detain flows for an extended period to allow sediments to settle and to remove contaminants. They can provide significant ecological benefits.	Good pollutant removal and if lined can be used where groundwater is vulnerable. Good community acceptability, ecological and amenity benefits.	Land take is high, requires baseflow, little reduction in run-off volume, not suitable for steep sites	✓ Wetlands areas are considered to be suitable within the southwest corner of the application site.
	Extended detention wetland					
	Pond wetland					
	Pocket wetland					
	Submerged gravel wetland					
	Wetland channel					
Infiltration	Infiltration trench		Surface water run-off can be discharged directly to ground for infiltration by soakaways, basins, or trenches. A prerequisite is that both groundwater and ground conditions are appropriate to receive the quality and quantity of water generated.	Reduces the volume of run-off, effective at pollutant removal, contributes to groundwater recharge, simple and cost-effective, easy performance observation	Requires appropriate pre-treatment, basins require a large flat area, offset from foundations	✓ Underlying geology is considered to be suitable for infiltration. Land take allows adequate space for an infiltration basin.
	Infiltration basin					
	Soakaway					

SUDS Group	Technique	Image	Description	Advantages	Disadvantages	Suitable for Use at Site?
Filtration	Porous paving		Block or porous paving allows run-off to infiltrate through to sub base layer. Water can then be infiltrated into ground or conveyed into storage or drainage systems.	Reduces the volume of run-off and if designed for infiltration contributes towards groundwater recharge. Easy to install and retrofit. Simple to manage. If lined can be used where groundwater is sensitive.	Not suitable for heavily trafficked areas or adoptable roads. Requires regular sweeping to prevent clogging with dirt	✓ Permeable paving could be utilised on the site for access routes or any car parking areas. Due to the depth of potential impermeable strata perforated pipes are required to convey runoff water.
	Permeable paving					
	Surface sand filter		Structures designed to treat surface water run-off through filtration using a sand bed filter medium. The filters can be designed with or without infiltration. Temporary storage of run-off is achieved through ponding above the filter layer. They are used where particularly high pollutant removal is required.	Flexibility of design, efficient in removing pollutants, suitable for retrofits and in tightly constrained urban locations.	Not for high sediment content, detention times can support algae growth, minimum hydraulic head of 1.2m required, possible odour problems, high capital and maintenance cost	✗ There is no requirement for high pollution reduction.
	Sub-surface sand filter					
	Perimeter sand filter					
	Bioretention /filter swale		Vegetated strips of land designed to accept run-off as overland sheet flow between a hard-surfaced area and a receiving system.	Landscaping features, effective in removing pollutants, flexible layout to fit into landscape, suited for highly impervious areas, good retrofit capability, effective pre-treatment option	Requires landscaping and management, large land requirement, not suitable for steep sites; no significant attenuation or reduction of flows.	✗ Lack of land take along the proposed access road.
	Filter trench /drain		Shallow excavations filled with rubble or stone that create temporary subsurface storage for filtration of storm water run-off. Receive lateral inflow from an adjacent impermeable surface.	Hydraulic benefits achieved with filter trenches, trenches can be incorporated into site landscaping and fit well beside roads and car parks.	High clogging potential without effective pre-treatment, limited to small catchments, high cost of replacing filter material.	✓ Filter trenches may be suitable but maintenance costs and suitability needs to be considered.

SUDS Group	Technique	Image	Description	Advantages	Disadvantages	Suitable for Use at Site?
Detention	Detention basin		Surface storage basins that provide flow control through attenuation. Normally dry and in certain situations the land may also function as a recreational facility.	Cater for a wide range of rainfall events, can be used where groundwater is vulnerable, potential for dual land use, easy to maintain.	Land take, little reduction in run-off volume, detention depths constrained by levels.	Underlying geology is considered to be suitable for infiltration. Land take allows adequate space for
	Enhanced dry swale		Swales are linear vegetated drainage features in which surface water can be stored or conveyed. They can be designed to allow infiltration, where appropriate.	Incorporate into landscaping, good removal of pollutants, reduces run-off rates and volumes, low cost.	Not suitable for steep areas, significant land take, not suitable in areas with roadside parking.	Could be suitable for certain locations. However there is lack of land take along the proposed access road.
	Enhanced wet swale					
Conveyance	Conveyance swales		Formal linear drainage features in which surface water can be stored or conveyed. They can be incorporated with water features such as ponds or waterfalls where appropriate.	Negate the need for underground pipework. Can provide some attenuation. Possible reduction in run-off volume via plant uptake and infiltration.	Potential trip/wheel hazard, disabled access issues.	Conveyance swale could be utilised along the access road eliminating the need for perforated pipes associated with permeable paving. However, safety implication and trip hazard to be considered in context of proposed use.
	Rills					
Source control	Green/brown roof		Multi-layered system that covers the roof of a building with vegetation cover/landscaping over a drainage layer. Designed to intercept and retain precipitation, reducing the volume of run-off and attenuating peak flows.	Mimics greenfield state of building footprint for high density developments, good removal of pollutants, ecological benefits, insulates buildings, sound absorption.	Additional weight, not appropriate for steep roofs, maintenance of roof vegetation.	Not considered to be suitable for steep roofs associated with residential dwellings.

3.6 Surface Water Drainage Strategy

- 3.6.1 Arun District Council has specific guidance with regards to the implementation of SuDS into new developments. The SuDS hierarchy is to be considered throughout the design of new drainage systems. The considerations given to the hierarchy is summarised in Table 3.3 below.

Table 3.3: Considerations to the SuDS Hierarchy

SuDS Hierarchy	Comments
Discharge into the ground	Ground conditions (refer to Chapter 2.3) are likely to be suitable for infiltration within Strata 2 and 3
Controlled discharge to a surface water	No open watercourses are located in the close proximity of the site boundary. Ditches are located both side of Tye Lane, along the western edge of the site. Discharging to the ditch closest to the site might be feasible. However the exact route beyond the site boundary is unknown, therefore it is difficult to assess the impact on downstream receptors if additional flow is being discharged to the ditch
Controlled discharge to surface water sewer	No surface water sewer is located in the proximity to the site, therefore this option is being discounted

- 3.6.2 Taking into account the findings of the ground investigation by Geo-Environmental, full infiltration is deemed to be achievable on site below Strata 1 and 2; however it is recommended to carry out BRE Digest 365 testing in order to confirm the exact rate of infiltration at detailed design stage.
- 3.6.3 Window sample results show that the total depth of underlying impermeable layers (Strata 1 and 2) varies between 0.8 and 2.2 mbgl across the application site, which was taken into account throughout the design process.
- 3.6.4 On the above basis, it is proposed that surface water runoff from roof areas generated by the 1-in-100 year event (including 40% allowance for CC) is to be discharged to private drainage and infiltrate directly into the ground via a combination of infiltration trenches and soakaways. Infiltration trenches are to be utilised at locations where the depth of Strata 1 and 2 is less than 1 mbgl and soakaways for all other locations.
- 3.6.5 Surface water runoff from hard paved areas is proposed to laterally feed the swales constructed along the main access road. Due the varying depth of permeable strata underlying the application site the swales located on the eastern side to be constructed at shallow depth only providing conveyance of runoff water towards a detention basin located at the localised low point on the south edge. Runoff water is to be collected by road gullies along the lateral roads and discharge to the nearest conveyance swale. Within the western part of the site the permeable layer is located at a shallower depth therefore direct infiltration is considered to be achievable via infiltration trenches incorporated in the swale design.
- 3.6.6 All swales to form an interconnected drainage network that provides conveyance for excess runoff during extreme rainfall events (beyond a 1-in-100 plus 40% CC) discharging to the detention basin on the eastern side and to a wetland that is proposed to be located at the southwest corner of the application site. Both the detention basin and the wetland allows water to be infiltrated in at a lower rate therefore providing temporary attenuation.
- 3.6.7 Further to the proposed SuDS network, the existing tree belt located along the southern edge of the application site ensures that any additional runoff water from the development will be intercepted within the application boundary.

- 3.6.8 The indicative layout of the surface water drainage strategy is provided in Figure 6⁶, at the rear of this report. The surface water drainage strategy will need to be developed further at the appropriate design stage however on the basis of the above, there will be no increase in flood risk to downstream receptors following development. In addition to this, the introduction of SuDS as part of the proposals will reduce the susceptibility of surface water flooding within the application site compared to the existing situation.

3.7 Foul Water Drainage Strategy

- 3.7.1 Southern Water asset records (see Appendix B) indicate that there are public foul sewers located in close proximity to the application site. A 225 mm diameter vitrified clay (VC) pipe runs from north to south in Tye Lane and discharging to the main 300 mm diameter pipe in The Street. The second sewer is located in Avisford Park Road. It is a 175 mm diameter VC pipe which represents the head of the run and assumed to discharge to the main run in The Street flowing to a westerly direction. There is a lateral 150 mm diameter public sewer located in Manser Road that discharges to the run located in Yapton Lane (B2132) flowing north to south. This pipe has a 175 mm diameter at its length adjacent to the site boundary. It is understood that all sewers surrounding the application site discharge to the Lidsey Wastewater Treatment Works (WTW) which is located approximately 3.9 km southwest of the proposed development site.
- 3.7.2 Based on the proposed number and size of residential dwellings peak⁷ foul flows have been calculated using the British Water Code of Practice. As a result of the proposed development the additional flows to be connected to public network will be in the order of 11.1 l/s. Detailed Calculations are provided in Appendix E, at the rear of the report.
- 3.7.3 It is proposed to collect foul water from the dwellings via private gravity drains. Due to the local topography residential units within the eastern extent of the site to be connected to the public network at manhole no. 4901 (approximately 40% of predicted flows) and properties within the western extent to manhole no. 9101 (approximately 60% of predicted flows). Before any connections are made to the foul sewerage network an S106 application is to be submitted and approved by Southern Water.
- 3.7.4 The indicative layout of the foul drainage strategy is provided in Figure 7, at the rear of this report.

4. SUMMARY

- i. The application site has an approximate total area of 11.3 ha and is currently 100% greenfield. It is located in Walberton, West Sussex (NGR 497286 106211) 500 m south from A27 (Arundel Road). The development site is currently bordered by the Avisford Park Golf course to the north, Tye lane to the west and residential dwellings to the south and east.
- ii. Ground investigation undertaken within the application site indicates the presence of River Terrace Deposits. According to historic borehole records groundwater level is at 6.8 mbgl.
- iii. Risk of flooding from all sources to the application site is considered to be low.

⁶ The layout of the outline surface water drainage strategy is shown indicatively for illustrative purposes only and subject to the final proposed masterplan and associated levels design.

⁷ At the time of the calculation performed provision was made for 200 residential units. It is understood that application is to be submitted to 175 units, therefore the predicted peak flow rate from the development is deemed to be lower than 11.1 l/s.

- iv. According to NPPF the proposed development is classified "More Vulnerable" which is appropriate to be located in Flood Zone 1. The sequential test is deemed to have been passed and the Exception Test is not required for the proposed development.
- v. As a result of the proposed development, the extent of impermeable areas will increase to approximately 3.75 ha (33% of total site area), including the access road, parking areas, footways and roof areas.
- vi. Based on the ground investigation results full infiltration is deemed to be achievable on site below Strata 1 and 2; however it is recommended to carry out BRE Digest 365 testing in order to confirm the exact rate of infiltration at detailed design stage.
- vii. It is proposed that surface water runoff from roof areas generated by the 1-in-100 year event (including 40% allowance for CC) is to be discharged to private drainage and infiltrate directly into the ground via a combination of infiltration trenches and soakaways. Infiltration trenches are to be utilised at locations where the depth of Strata 1 and 2 is less than 1 mbgl and soakaways for all other locations.
- viii. Surface water runoff from hard paved areas is proposed to laterally feed the swales constructed along the main access road. Due the varying depth of permeable strata underlying the application site the swales located on the eastern side to be constructed at shallow depth only providing conveyance of runoff water towards a detention basin located at the localised low point on the south edge. Runoff water is to be collected by road gullies along the lateral roads and discharge to the nearest conveyance swale. Within the western part of the site the permeable layer is located at a shallower depth therefore direct infiltration is considered to be achievable via infiltration trenches incorporated in the swale design.
- ix. All swales to form an interconnected drainage network that provides conveyance for excess runoff during extreme rainfall events (beyond a 1-in-100 plus 40% CC) discharging to the detention basin on the eastern side and to a wetland that is proposed to be located at the southwest corner of the application site. Both the detention basin and the wetland allows water to be infiltrated in at a lower rate therefore providing temporary attenuation.
- x. Foul water from the dwellings is proposed to be collected by private gravity drains. Due to the local topography residential units within the eastern extent of the site to be connected to the public network at manhole no. 4901 (approximately 40% of predicted flows) and properties within the western extent to manhole no. 9101 (approximately 60% of predicted flows). Before any connections are made to the foul sewerage network an S106 application is to be submitted and approved by Southern Water to ensure that there is no increase in sewer flood risk.

FIGURES

FIGURE 1	SITE LOCATION PLAN
FIGURE 2	EXISTING SITE LAYOUT
FIGURE 3	TOPOGRAPHIC SURVEY AND DIGITAL TERRAIN MODEL
FIGURE 4	BGS BEDROCK GEOLOGY
FIGURE 5	EA RISK OF FLOODING FROM RIVERS AND SEA
FIGURE 6	OUTLINE SURFACE WATER DRAINAGE STRATEGY
FIGURE 7	OUTLINE FOUL DRAINAGE STRATEGY

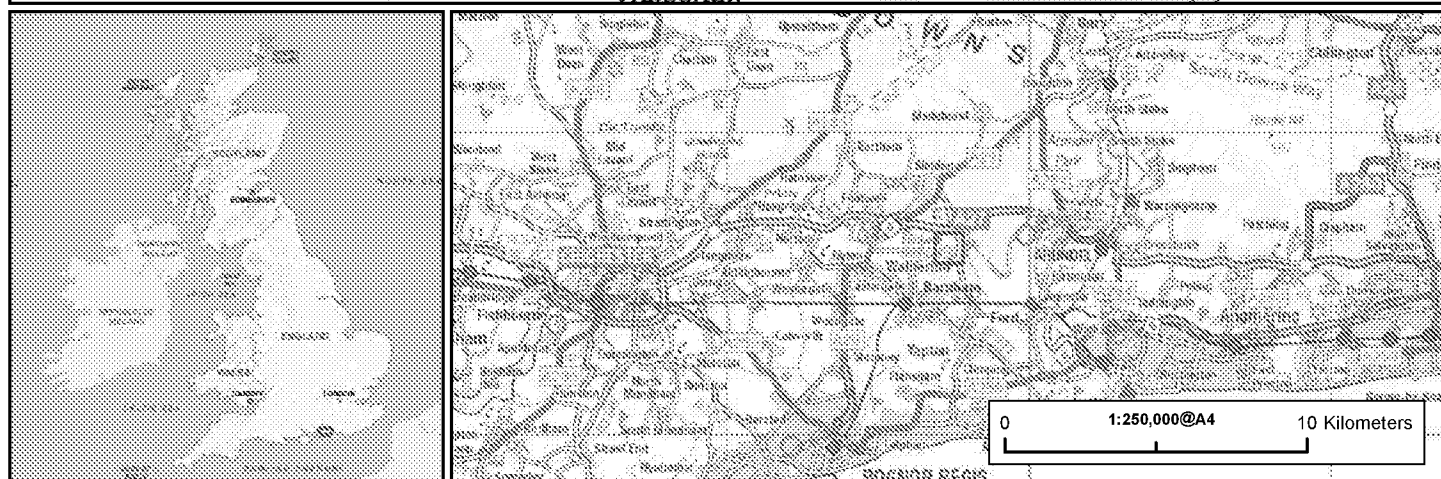
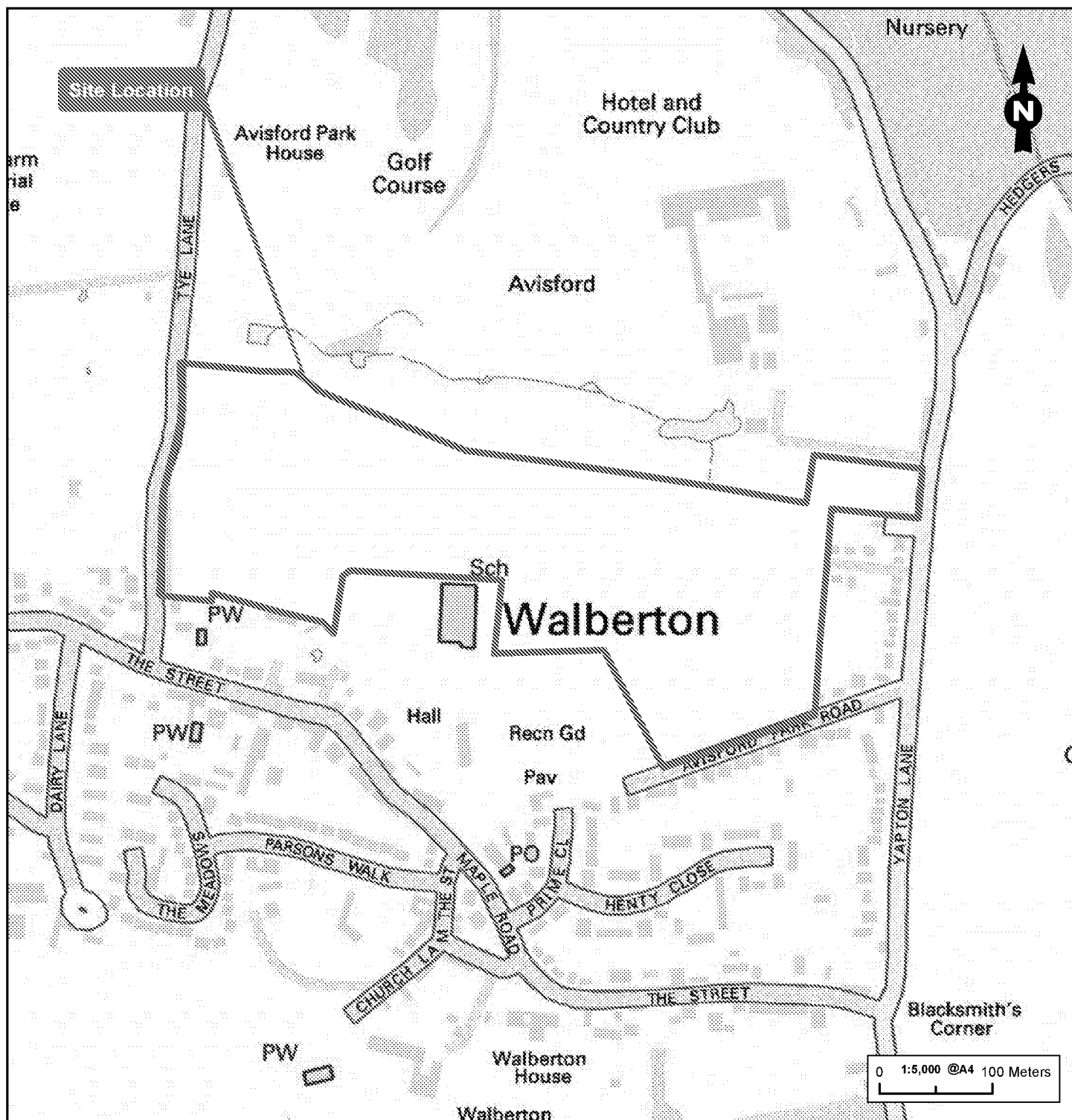


Figure Title Figure 1: Site Location	Project Name Walberton, West Sussex	Date June 2017	
Project Number 1620003639	Client Wates Developments Ltd	Scale As shown	
		Issue 1	



Legend

Application Site Boundary

Environment Agency Main Rivers

Walberton Topographic Survey (2016)

Contours

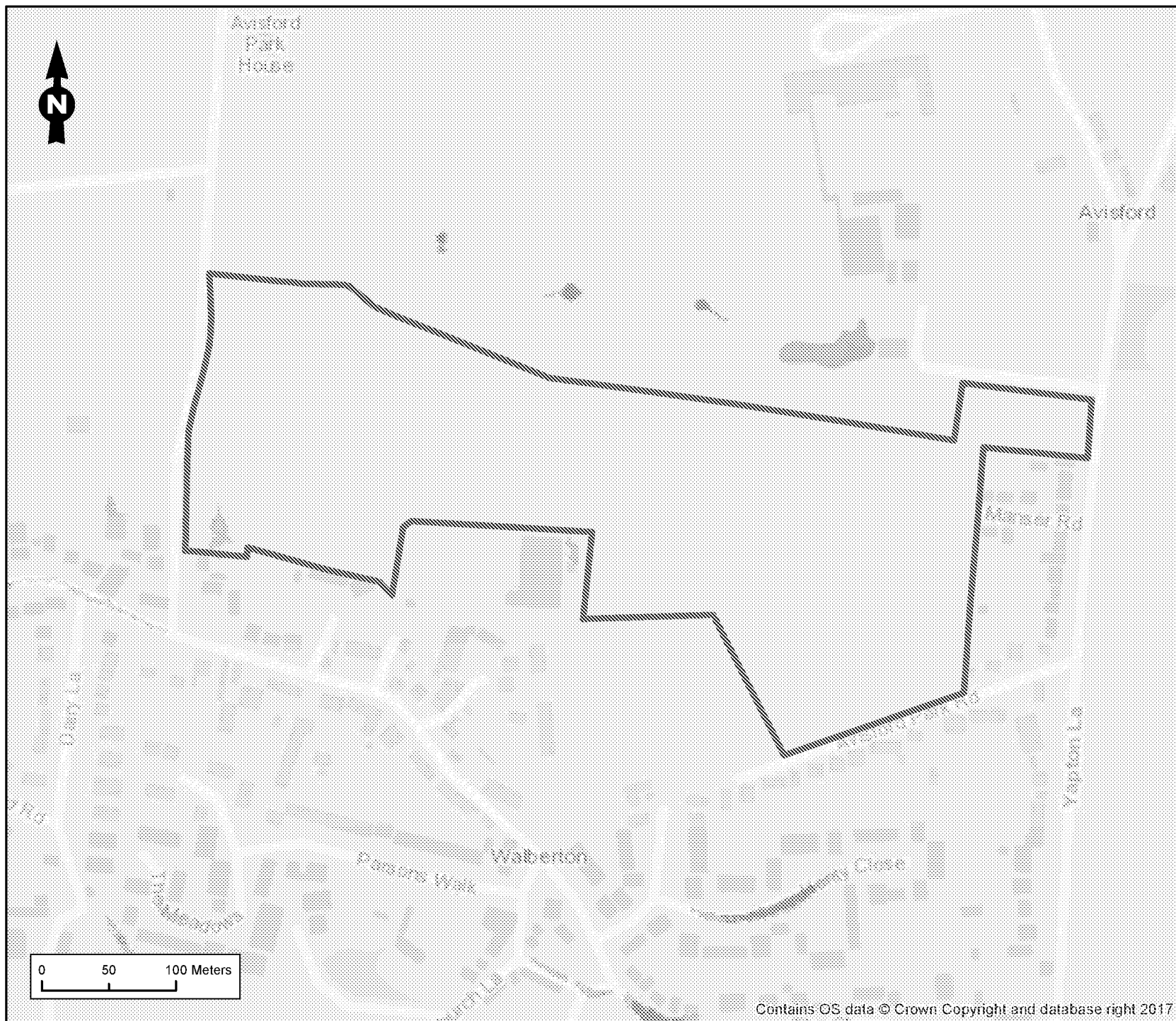
Digital Terrain Model (2011)

22 mAOD or higher

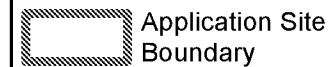
14 mAOD or lower

Window Sample (refer to ongoing ground investigation by Geo-Environmental)

Figure Title	
Digital Terrain Model and Topographic Survey	
Project Name	
Walberton, West Sussex	
Project Number	Figure No.
1620003639	2
Date	Prepared By
June 2017	RH
Scale	Issue
1:5,000 @A3	1
Client	
Wates	
RAMBOLL ENVIRON	



Legend



Risk of Flooding from Surface Water Depth: 3.3 percent annual chance

DEPTH (Six bands)

- Below 150mm
- 150-300mm
- 300-600mm
- 600-900mm
- 900-1200mm
- Over 1200mm

Figure Title

Environment Agency - Risk of Flooding from Surface Water 1-in-30 year event

Project Name

Walberton, West Sussex

Project Number

1620003639

Figure No.

4a

Date

June 2017

Prepared By

RH

Scale

1:4,000 @A4

Issue

1

Client

Wates

PAMBOLL ENVIRON

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Legend



Risk of Flooding from Surface Water Depth: 1 percent annual chance

DEPTH (Six bands)

- Below 150mm
- 150-300mm
- 300-600mm
- 600-900mm
- 900-1200mm
- Over 1200mm

Figure Title

Environment Agency - Risk of Flooding from Surface Water 1-in-100 year event

Project Name

Walberton, West Sussex

Project Number

1620003639

Figure No.

4b

Date

June 2017

Prepared By

RH

Scale

1:4,000 @A4

Issue

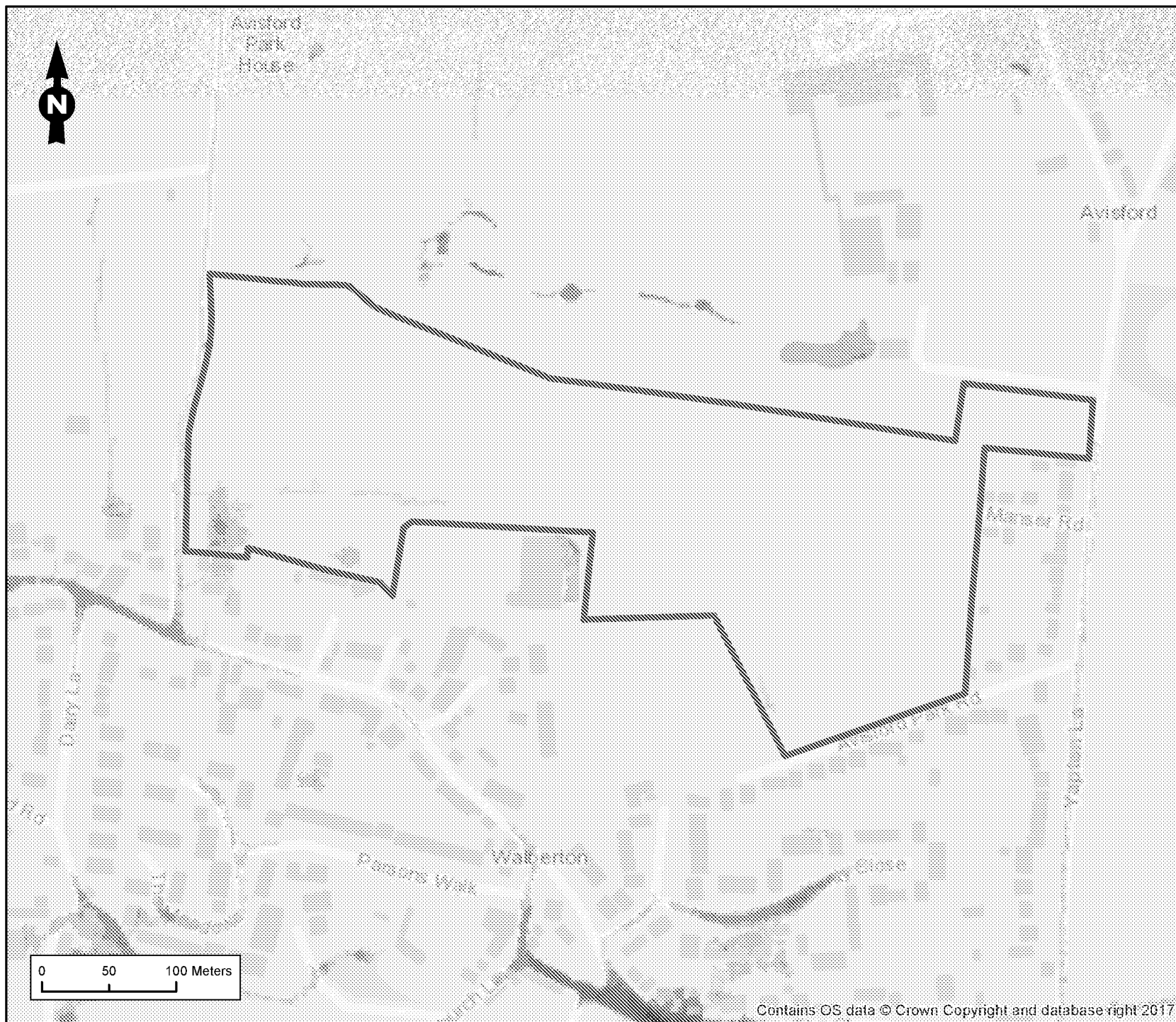
1

Client

Wates

PAMBOLL ENVIRON

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Legend

 Application Site Boundary

Risk of Flooding from Surface Water Depth: 0.1 percent annual chance

DEPTH (Six bands)

 Below 150mm
 150-300mm
 300-600mm
 600-900mm
 900-1200mm
 Over 1200mm

Figure Title

Environment Agency - Risk of Flooding from Surface Water 1-in-1000 year event

Project Name

Walberton, West Sussex

Project Number

1620003639

Figure No.

4c

Date

June 2017

Prepared By

RH

Scale

1:4,000 @A4

Issue

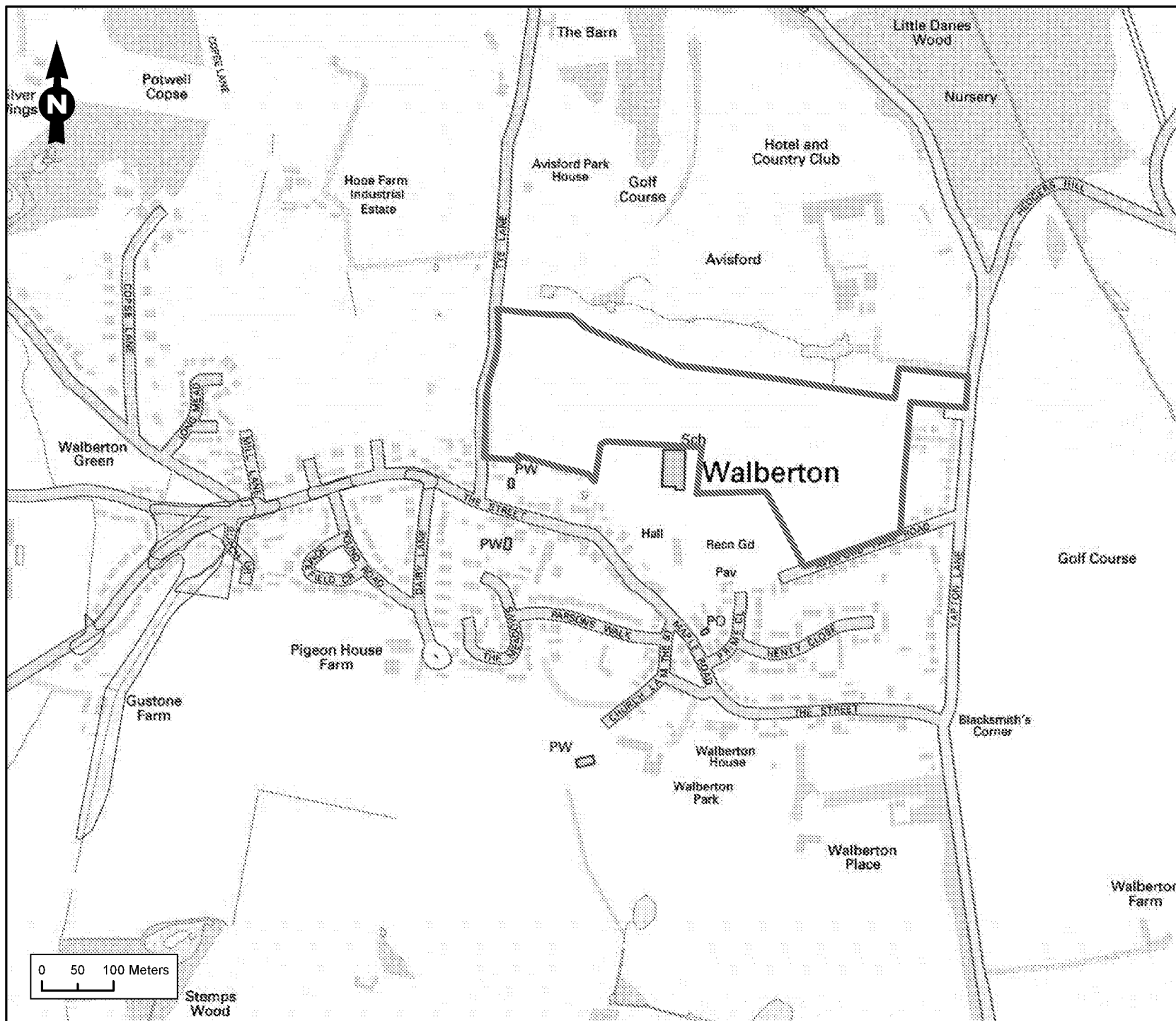
1

Client

Wates

 ENVIRON

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Legend

 Application Site Boundary

Recorded Flood Outlines

 Recorded Flood Outlines

Figure Title

Environment Agency - Historic Flood Map

Project Name

Walberton, West Sussex

Project Number

1620003639

Figure No.

5

Date

June 2017

Prepared By

RH

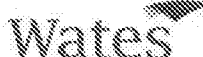
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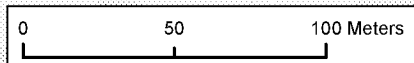
Issue

1

Client

 Wates

 PAMBOLL ENVIRON



Legend

 Application Site Boundary

 Road gully

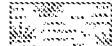
Proposed SuDS features

 Conveyance swale

 Pipe connection

 Swale with infiltration trench

 Dry detention basin

 Wetland

Propert level drainage design

 Properties with infiltration trenches

 Properties with soakaways

 Window Samples

WS	Depth to permeable layer
1	1.1
2	0.9
3	2.2
4	2.1
5	0.8
6	1.2
7	0.9
8	0.9

Figure Title

Outline Surface Water Drainage Strategy

Project Name

Walberton, West Sussex

Project Number

1620003639

Figure No.

6

Date

June 2017

Prepared By

RH

Scale

1:2,500 @A3

Issue

1

Client

Wates



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APPENDIX A GREENFIELD RUNOFF CALCULATIONS

Ramboll UK Ltd		Page 1
60 Newman Street London W1T 3DA		
Date 01/06/2017 14:37	Designed by RHEGE	
File WALBERTON - GREENFIELD ...	Checked by	
Micro Drainage		Source Control 2016.1
<u>ICP SUDS Mean Annual Flood</u> Input Return Period (years) 2 Soil 0.300 Area (ha) 11.300 Urban 0.000 SAAR (mm) 779 Region Number Region 7 Results l/s QBAR Rural 23.3 QBAR Urban 23.3 Q2 years 20.6 Q1 year 19.8 Q30 years 52.9 Q100 years 74.4		
©1982-2016 XP Solutions		

Ramboll UK Ltd		Page 1																								
60 Newman Street London W1T 3DA																										
Date 01/06/2017 14:38	Designed by RHEGE																									
File WALBERTON - GREENFIELD ...	Checked by																									
Micro Drainage		Source Control 2016.1																								
<u>ICP SUDS Mean Annual Flood</u> Input <table><tr><td>Return Period (years)</td><td>10</td><td>Soil</td><td>0.300</td></tr><tr><td>Area (ha)</td><td>11.300</td><td>Urban</td><td>0.000</td></tr><tr><td>SAAR (mm)</td><td>779</td><td>Region Number</td><td>Region 7</td></tr></table> Results l/s <table><tr><td>QBAR Rural</td><td>23.3</td></tr><tr><td>QBAR Urban</td><td>23.3</td></tr><tr><td>Q10 years</td><td>37.8</td></tr><tr><td>Q1 year</td><td>19.8</td></tr><tr><td>Q30 years</td><td>52.9</td></tr><tr><td>Q100 years</td><td>74.4</td></tr></table>			Return Period (years)	10	Soil	0.300	Area (ha)	11.300	Urban	0.000	SAAR (mm)	779	Region Number	Region 7	QBAR Rural	23.3	QBAR Urban	23.3	Q10 years	37.8	Q1 year	19.8	Q30 years	52.9	Q100 years	74.4
Return Period (years)	10	Soil	0.300																							
Area (ha)	11.300	Urban	0.000																							
SAAR (mm)	779	Region Number	Region 7																							
QBAR Rural	23.3																									
QBAR Urban	23.3																									
Q10 years	37.8																									
Q1 year	19.8																									
Q30 years	52.9																									
Q100 years	74.4																									
©1982-2016 XP Solutions																										

APPENDIX B SOUTHERN WATER ASSET RECORDS

SEWER RECORDS PAGE 1 OF 2

106529



105951

496827	O.S. REF. SU9706SW	Drawn by: kumaria	The positions of pipes shown on this plan are believed to be correct, but Southern Water Services Ltd accept no responsibility in the event of inaccuracy. The actual positions should be determined on site. WARNING: BAC pipes are constructed of Bonded Asbestos Cement WARNING: Unknown (UNK) materials may include Bonded Asbestos Cement		
	Title: 239336_Walberton Greenfield, T	Scale: 1:2500			
		Date: 29/03/2017	Based upon Ordnance Survey Digital Data with the permission of the controller of H.M.S.O. Crown Copyright Reserved Licence No. WU 298530.		

497769

SEWER RECORDS PAGE 2 OF 2

Node	Cover	Invert	Size	Material	Shape	Node	Cover	Invert	Size	Material	Shape	Node	Cover	Invert	Size	Material	Shape	Node	Cover	Invert	Size	Material	Shape
0001X	13.75	10.7	175	VC	CIRC																		
0201X	14.74	12.66	225	VC	CIRC																		
0301X	17.04	15.59	225	VC	CIRC																		
0401X	22.08	20.58	225	VC	CIRC																		
0501X	24.85	22.87	225	VC	CIRC																		
1001X	15.06	11.3	175	VC	CIRC																		
1002X	14.79	11.03	175	VC	CIRC																		
1003X	14.61	10.99	175	VC	CIRC																		
1004X	14.13	10.88	175	VC	CIRC																		
2903X	14.61	11.5	175	VC	CIRC																		
2904X	15.13	11.33	175	VC	CIRC																		
2905X	14.94		175	VC	CIRC																		
3901X	16.57	14.92	175	VC	CIRC																		
3902X	16.4	14.77	175	VC	CIRC																		
4001X	17.03	15.39	175	VC	CIRC																		
4901X	16.63	15.12	175	VC	CIRC																		
5001X	17.55	15.7	175	VC	CIRC																		
6001X	17.3	15.67	175	VC	CIRC																		
6002X	16.47	14.75	175	VC	CIRC																		
6003X	18.03	16.51	175	VC	CIRC																		
6101X	18.24	16.47	175	VC	CIRC																		
6102X	19.14		150	VC	CIRC																		
6201X	18.85	17.19	175	VC	CIRC																		
8001X	12.6	11.42	150	VC	CIRC																		
8002X	12.62	11.7	150	VC	CIRC																		
8003X		-0.01	150	VC	CIRC																		
8004X			150	VC	CIRC																		
8005X	13.61		150	VC	CIRC																		
8006X	13.1	11.25	150	VC	CIRC																		
8008X	13.38	11.4	150	VC	CIRC																		
8009X	12.58	11.78	150	VC	CIRC																		
8101X	11.74	9.9	300	VC	CIRC																		
8102X	11.54	9.69	300	VC	CIRC																		
8103X	13.3	11.83	150	VC	CIRC																		
8902X	13.64	11.99	150	VC	CIRC																		
9001X	13.09	10.99	175	VC	CIRC																		
9002X	12.46	10.32	300	VC	CIRC																		
9101X	13.67	11.8	225	VC	CIRC																		
9103X	12.21	10.49	175	VC	CIRC																		
9104X	11.96	10	300	VC	CIRC																		
9902X	13.06	11.18	175	VC	CIRC																		
9903X	13.75	13.03	100	VC	CIRC																		

LINE STYLES / COLOURS

Brown	-----	Foul
	-----	Foul Siphon Sewer
	-----	Foul Vacuum Main
	-----	Foul Rising Main
Red	-----	Combined
	-----	Combined Siphon Sewer
	-----	Combined Rising Main
Orange	-----	Lateral Drain
	-----	Building Over Agreement Area
Dark Blue	-----	Treated Effluent
Purple	-----	Sludge
	-----	Sewer Catchment
	-----	Section 104 Area
Light Blue	-----	Surface Water
	-----	Surface Water Rising Main
Yellow	-----	Private
Green	-----	Access Shaft
	-----	Decommissioned

MATERIALS

AK	Alkaline
BAC	Bonded Asbestos Cement
BRD	Brick (Common)
BRE	Brick (Engineering)
CC	Concrete Box Culvert
CI	Cast Iron
CO	Concrete (In-Situ)
CP	Concrete (Pre-Cast)
CSB	Concrete Segments (bolted)
CSU	Concrete Segments (unbolted)
DI	Ductile Iron
GRG	Glass Reinforced Concrete
GRP	Glass Reinforced Plastic
MAC	Masonry In regular Courses
MAR	Masonry In random Courses
PE	Polyethylene
PF	Pitch Fibre
PP	Polypropylene
PVC	Polyvinyl Chloride
RFW	Reinforced Plastic Matrix
SI	Spun Iron
ST	Steel
VC	Verified Clay
XXX	Other
ZZZ	Unknown

Manhole (SW)
Manhole (F&C)
Lamp hole (SW)
Lamp hole (F&C)
Pumping Station (SW)
Pumping Station (F&C)
Side entry manhole (SW)
Side entry manhole (F&C)
Blind shaft (SW)
Blind shaft (F&C)
Ejector station (SW)
Ejector station (F&C)
Watertight door (SW)
Watertight door (F&C)
Flushing ch. Min-e (SW)
Flushing ch. Min-e (F&C)
Flushing ch. No-e (SW)
Flushing ch. No-e (F&C)
Demonstration Chamber

LEGEND - SEWERS

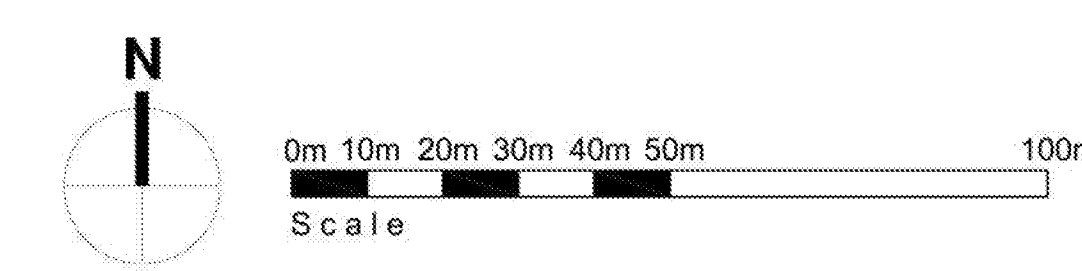
Washout (SW)
Washout (F&C)
Rodding Eye (SW)
Rodding Eye (F&C)
Gauging point (SW)
Gauging point (F&C)
Intercept chamber (SW)
Intercept chamber (F&C)
Storm Tank (SW)
Storm Tank (F&C)
Vortex chamber (SW)
Vortex chamber (F&C)
Label ellipse
Dummy/S24 manhole
Outfall
Penstock chamber
Demiboards
Storm Overflow
Backdrop manhole
Other (s)
Other
Change In sewer (s)
Change In sewer
Rafflux valve
Flap valve
Cascade
Anode
Valve
Closed Valve
Air Valve
Hatch box (SW)
Hatch box (F&C)
Direction arrow
Emptying valve
Catchpit
Soakaway
Inlet
Balancing Pond

Wastewater treatment works
Marine treatment works
Outfall headworks
Vent
Vent column
Tidal storage tank
Blank end
Head of Public Sewer
Micro Pumping Station
SHAPES (S)
A Arched
B Barrel
C Circular
E Egg
H Horseshoe
R Rectangular
S Square
T Trapezoidal
U U Shape
X Other

NODE REFERENCING SYSTEM
1st digit: hundred metre easting identifier
2nd digit: hundred metre northing identifier
sewer type identifier
3rd digit: 0-4 = Foul/Combined
5-9 = Surface Water
4th digit: next sequential node

Drawn by:	kumaria	
Title:	239336_Walberton Greenfield, T	
Date:	29/03/2017	

APPENDIX C PROPOSED SITE LAYOUT



APPENDIX D POST-DEVELOPMENT RUNOFF RATES

 Tekla Tedds Ramboll UK Ltd. Carlton House, Ringwood Road Southampton SO40 7HT	Project				Job no.	
	Walberton, West Sussex				1620003639	
	Calcs for				Start page no./Revision	
	Wates Developments Ltd				1	
	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
	RH	01/06/2017	SA	01/06/2017	AG	02/06/2017

POST-DEVELOPMENT DESIGN RAINFALL

In accordance with the Wallingford Procedure

Tedds calculation version 2.0.00

Design rainfall intensity

Location of catchment area	Other
Storm duration	D = 15 min
Return period	Period = 1 yr
Ratio 60 min to 2 day rainfall of 5 yr return period	r = 0.325
5-year return period rainfall of 60 minutes duration	M5_60min = 19.6 mm
Increase of rainfall intensity due to global warming	p _{climate} = 40 %
Factor Z1 (Wallingford procedure)	Z1 = 0.61
Rainfall for 15min storm with 5 year return period	M5_15min _i = Z1 × M5_60min × (1 + p _{climate}) = 16.6 mm
Factor Z2 (Wallingford procedure)	Z2 = 0.63
Rainfall for 15min storm with 1 year return period	M1_15min = Z2 × M5_15min _i = 10.4 mm
Design rainfall intensity	I _{max} = M1_15min / D = 41.7 mm/hr

Maximum surface water runoff

Catchment area	A _{catch} = 37523 m ²
Percentage of area that is impermeable	p = 100 %
Maximum surface water runoff	Q _{max} = A _{catch} × p × I _{max} = 434.9 l/s

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POST-DEVELOPMENT DESIGN RAINFALL

In accordance with the Wallingford Procedure

Tedds calculation version 2.0.00

Design rainfall intensity

Location of catchment area	Other
Storm duration	D = 15 min
Return period	Period = 2 yr
Ratio 60 min to 2 day rainfall of 5 yr return period	r = 0.325
5-year return period rainfall of 60 minutes duration	M5_60min = 19.6 mm
Increase of rainfall intensity due to global warming	p _{climate} = 40 %
Factor Z1 (Wallingford procedure)	Z1 = 0.61
Rainfall for 15min storm with 5 year return period	M5_15min _i = Z1 × M5_60min × (1 + p _{climate}) = 16.6 mm
Factor Z2 (Wallingford procedure)	Z2 = 0.80
Rainfall for 15min storm with 2 year return period	M2_15min = Z2 × M5_15min _i = 13.4 mm
Design rainfall intensity	I _{max} = M2_15min / D = 53.5 mm/hr

Maximum surface water runoff

Catchment area	A _{catch} = 37523 m ²
Percentage of area that is impermeable	p = 100 %
Maximum surface water runoff	Q _{max} = A _{catch} × p × I _{max} = 557.5 l/s

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POST-DEVELOPMENT DESIGN RAINFALL

In accordance with the Wallingford Procedure

Tedds calculation version 2.0.00

Design rainfall intensity

Location of catchment area	Other
Storm duration	D = 15 min
Return period	Period = 10 yr
Ratio 60 min to 2 day rainfall of 5 yr return period	r = 0.325
5-year return period rainfall of 60 minutes duration	M5_60min = 19.6 mm
Increase of rainfall intensity due to global warming	p _{climate} = 40 %
Factor Z1 (Wallingford procedure)	Z1 = 0.61
Rainfall for 15min storm with 5 year return period	M5_15min _i = Z1 × M5_60min × (1 + p _{climate}) = 16.6 mm
Factor Z2 (Wallingford procedure)	Z2 = 1.24
Rainfall for 15min storm with 10 year return period	M10_15min = Z2 × M5_15min _i = 20.6 mm
Design rainfall intensity	I _{max} = M10_15min / D = 82.6 mm/hr

Maximum surface water runoff

Catchment area	A _{catch} = 37523 m ²
Percentage of area that is impermeable	p = 100 %
Maximum surface water runoff	Q _{max} = A _{catch} × p × I _{max} = 860.6 l/s

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POST-DEVELOPMENT DESIGN RAINFALL

In accordance with the Wallingford Procedure

Tedds calculation version 2.0.00

Design rainfall intensity

Location of catchment area	Other
Storm duration	D = 15 min
Return period	Period = 30 yr
Ratio 60 min to 2 day rainfall of 5 yr return period	r = 0.325
5-year return period rainfall of 60 minutes duration	M5_60min = 19.6 mm
Increase of rainfall intensity due to global warming	p _{climate} = 40 %
Factor Z1 (Wallingford procedure)	Z1 = 0.61
Rainfall for 15min storm with 5 year return period	M5_15min _i = Z1 × M5_60min × (1 + p _{climate}) = 16.6 mm
Factor Z2 (Wallingford procedure)	Z2 = 1.53
Rainfall for 15min storm with 30 year return period	M30_15min = Z2 × M5_15min _i = 25.5 mm
Design rainfall intensity	I _{max} = M30_15min / D = 102.0 mm/hr

Maximum surface water runoff

Catchment area	A _{catch} = 37523 m²
Percentage of area that is impermeable	p = 100 %
Maximum surface water runoff	Q _{max} = A _{catch} × p × I _{max} = 1063.4 l/s

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POST-DEVELOPMENT DESIGN RAINFALL

In accordance with the Wallingford Procedure

Tedds calculation version 2.0.00

Design rainfall intensity

Location of catchment area	Other
Storm duration	D = 15 min
Return period	Period = 100 yr
Ratio 60 min to 2 day rainfall of 5 yr return period	r = 0.325
5-year return period rainfall of 60 minutes duration	M5_60min = 19.6 mm
Increase of rainfall intensity due to global warming	p _{climate} = 40 %
Factor Z1 (Wallingford procedure)	Z1 = 0.61
Rainfall for 15min storm with 5 year return period	M5_15min _i = Z1 × M5_60min × (1 + p _{climate}) = 16.6 mm
Factor Z2 (Wallingford procedure)	Z2 = 2.00
Rainfall for 15min storm with 100 year return period	M100_15min = Z2 × M5_15min _i = 33.3 mm
Design rainfall intensity	I _{max} = M100_15min / D = 133.4 mm/hr

Maximum surface water runoff

Catchment area	A _{catch} = 37523 m²
Percentage of area that is impermeable	p = 100 %
Maximum surface water runoff	Q _{max} = A _{catch} × p × I _{max} = 1390.3 l/s

APPENDIX E FOUL FLOW CALCULATIONS

Using *British Water Code of Practice 4*
Calculation based on population numbers

Source	No. of Persons	Per Person Flow (Lt/day)	BOD (Grams)	Ammonia N (Grams)	Per Site Flow (Lt/day)
10 no. 1 bed house (3P system)	30	150			4500
70 no. 2 bed house (4P system)	280	150			42000
70 no. 3 bed house (5P system)	350	150			52500
40 no. 4 bed house (6P system)	240	150			36000
10 no. 5 bed house (7P system)	70	150			10500
		Total	0	0	145.50 m³/day
		Dry Weather Flow			1.68 l/s
		Infiltration Factor		10%	1.85 l/s
		Peak Flow			11.11 l/s

Multiplied by 6 if it's a 24hour
 application or 3 if 12hour,
 basically 1DWF = 4hours

