PROPOSED DEVELOPMENT ACROSS LAND OFF KELVEDON ROAD, TIPTREE, ESSEX

FLOOD RISK ASSESSMENT AND SURFACE WATER DRAINAGE/SUDS STRATEGY

JANUARY 2019

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CONTRACT

Evans Rivers and Coastal Ltd has been commissioned by Marden Homes to carry out a Flood Risk Assessment and Surface Water Drainage/SUDS Strategy for a proposed development across land off Kelvedon Road, Tiptree, Essex.

QUALITY ASSURANCE, ENVIRONMENT AND HEALTH AND SAFETY

Evans Rivers and Coastal Ltd operates a Quality Assurance, Environmental, and Health and Safety Policy.

This project comprises various stages including data collection; hydrological and hydrogeological assessments; surface water drainage designs; and reporting. Quality will be maintained throughout the project by producing specific methodologies for each work stage. Quality will also be maintained by initiating internal quality procedures including the validation of third party deliverables; creation of an audit trail to record any changes made; and document control using a database and correspondence log file system.

To adhere to the Environmental Policy, data will be obtained and issued in electronic format and alternatively by post. Paper use will also be minimised by communicating via email or telephone where possible. Documents and drawings will be transferred in electronic format where possible and all waste paper will be recycled. Meetings away from the office of Evans Rivers and Coastal Ltd will be minimised to prevent unnecessary travel, however for those meetings deemed essential, public transport will be used in preference to car journeys.

The project will follow the commitment and objectives outlined in the Health and Safety Policy operated by Evans Rivers and Coastal Ltd. All employees will be equipped with suitable personal protective equipment prior to any site visits and a risk assessment will be completed and checked before any site visit. Other factors which have been taken into consideration are the wider safety of the public whilst operating on site, and the importance of safety when working close to a water source and highway. Any designs resulting from this project and directly created by Evans Rivers and Coastal Ltd will also take into account safety measures within a “designers risk assessment”.

Report carried out by:

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1. INTRODUCTION

1.1 Project Scope

1.1.1 Evans Rivers and Coastal Ltd has been commissioned by Marden Homes to carry out a Flood Risk Assessment and Surface Water Drainage/SUDS Strategy for a proposed development across land off Kelvedon Road, Tiptree, Essex.

1.1.2 It is understood that this assessment will be submitted to the Planning Authority as part of a planning application. Specifically, this assessment intends to:

1) Carry out an assessment of the practical use of sustainable drainage (SUDS) measures using the relevant soil maps, software and other literature;

2) Determine the existing surface water drainage regime across the site using appropriate methods;

3) Develop a post-development management plan/drainage strategy for surface water across the site, which considers the use of SUDS and alternative methods of surface water disposal;

4) Make an assessment of the flood risk to the site during return period events up to the climate change enhanced 1 in 100 year storm event and recommend mitigation measures accordingly;

5) Carry out an appraisal of flood risk from any other sources such as groundwater as required by NPPF;

6) Report findings and recommendations.

1.1.3 This assessment is carried out in accordance with the requirements of the National Planning Policy Framework (NPPF) dated 2018. Other documents which have been consulted include:

- Woods-Ballard., et al. 2015. *The SUDS Manual, Report C753*. London: CIRIA.
- Woods-Ballard., et al. 2007. *The SUDS Manual, Report C697*. London: CIRIA.
- BS8582:2013 entitled *Code of practice for surface water management for development sites*.
- DEFRA document entitled *Sustainable Drainage Systems – Non statutory technical standards for sustainable drainage systems* dated March 2015.
- LASOO document entitled *Non statutory technical standards for sustainable drainage systems – Best Practice Guidance* dated 2015.
- DEFRA/EA document entitled *Rainfall runoff management for developments* dated 2013.
- Communities and Local Government 2007. *Improving the Flood Performance of New Buildings*. HMSO.
- DEFRA/EA document entitled *The flood risks to people methodology (FD2321/TR1),* 2006;

- EA *Supplementary Note on Flood Hazard Ratings and Thresholds for Development Planning and Control Purpose*, 2008;
- National Planning Practice Guidance – Flood Risk and Coastal Change.
- Essex County Council's SUDS Design Guide dated 2014.
- Essex County Council Local Flood Risk Management Strategy (LFRMS) dated 2013.
- Essex County Council Preliminary Flood Risk Assessment dated 2011 (PFRA).
- Colchester Borough Council Strategic Flood Risk Assessment (SFRA) Appendix C Colchester Supplementary Report dated 2008.
- Colchester Borough Council Strategic Flood Risk Assessment (SFRA) Level 1 Update dated 2016.
- Colchester Town Surface Water Management Plan (SWMP) dated 2013.

2. DATA COLLECTION

2.1 To assist with this report, the data collected included:

- Ordnance Survey 1:10,000 street view map obtained via Promap (Evans Rivers and Coastal Ltd OS licence number 100049458).
- British Geological Survey, *Online Geology of Britain Viewer*.
- British Geological Survey, *Groundwater flooding susceptibility map.*
- British Geological Society, *BGS SuDS detailed data*.
- 1:250,000 *Soil Map of Eastern England* (Sheet 4) published by Cranfield University and Soil Survey of England and Wales 1983.
- 1:625,000 *Hydrogeological Map of England and Wales*, published in 1977 by the Institute of Geological Sciences (now the British Geological Survey).
- Topographical survey carried out by J Taylor Ltd (shown at the end of this report).

3. SITE CHARACTERISTICS

3.1 Existing Site Characteristics and Location

3.1.1 The site is located across land off Kelvedon Road, Tiptree, Essex. The approximate Ordnance Survey (OS) grid reference for the site is 588663 216996 and the location of the site is shown on Figure 1.

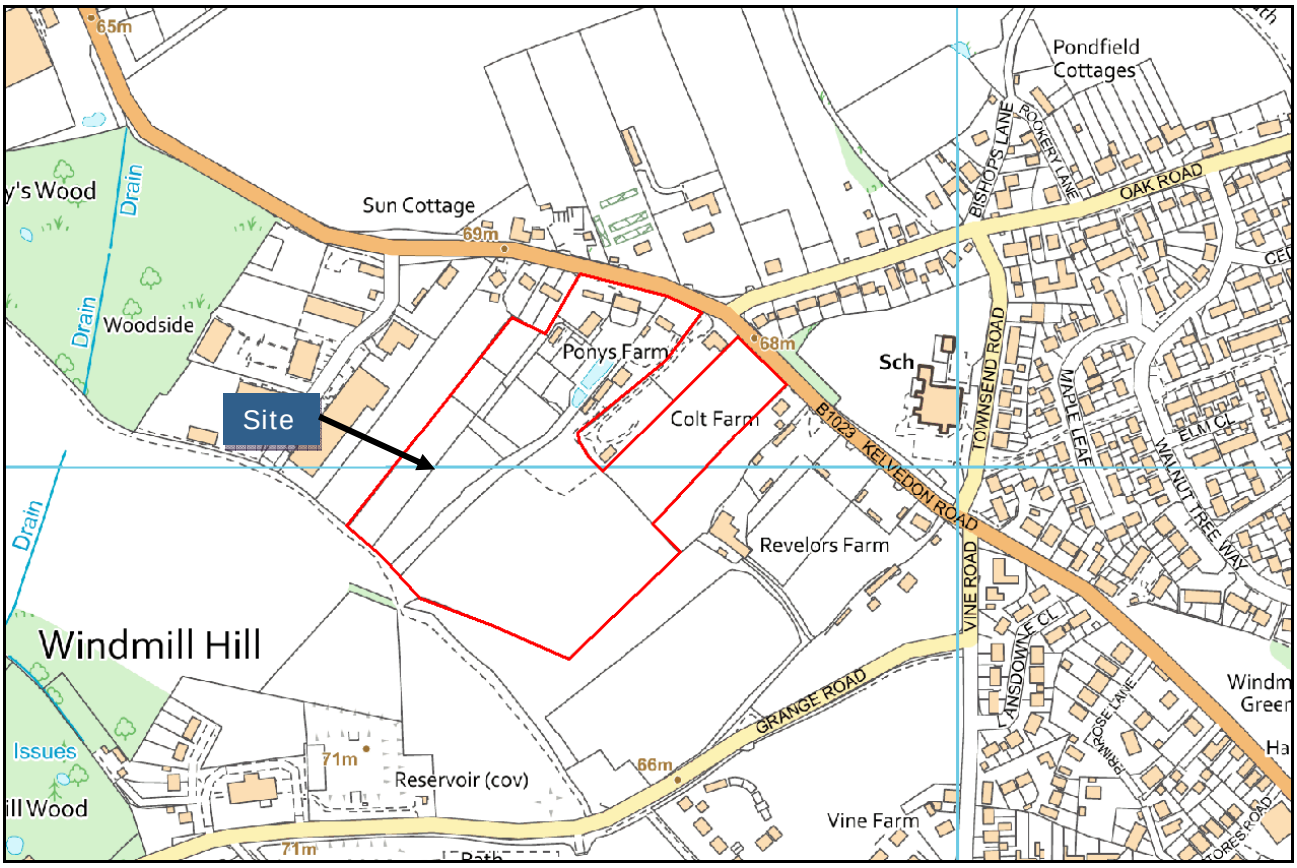

Figure 1: Site location plan (Source: Ordnance Survey)

3.1.2 The site is irregular in shape and covers a total area of approximately 5.11 ha. The site currently comprises Pony's Farm and grassed paddocks. The site is accessed via Kelvedon Road adjacent to the north eastern frontage of the site.

3.1.3 A topographical survey has been carried out by J Taylor Ltd (shown at the end of this report). Ground levels are in metres above Ordnance Datum (m AOD). It can be seen that ground levels fall in a south easterly direction.

3.2 Site Proposals

3.2.1 It is the Client's intention to develop the site with up to 148 residential dwellings, together with driveways, garages, access roads, open space and gardens.

3.2.2 Access will be provided from Kelvedon Road. The site proposals can be seen on Drawing Number 2018.190.002.

4. SOURCES OF FLOODING

4.1 Fluvial

4.1.1 The Environment Agency Flood Map (Figure 2) and Figure 2H/1 of the 2016 SFRA shows that the site is located within the NPPF Flood Zone 1, 'Low Probability' which comprises land as having less than a 1 in 1000 year annual probability of fluvial or tidal flooding (i.e. an event more severe than the extreme 1 in 1000 year event). NPPF states that all uses of land are appropriate in this zone.

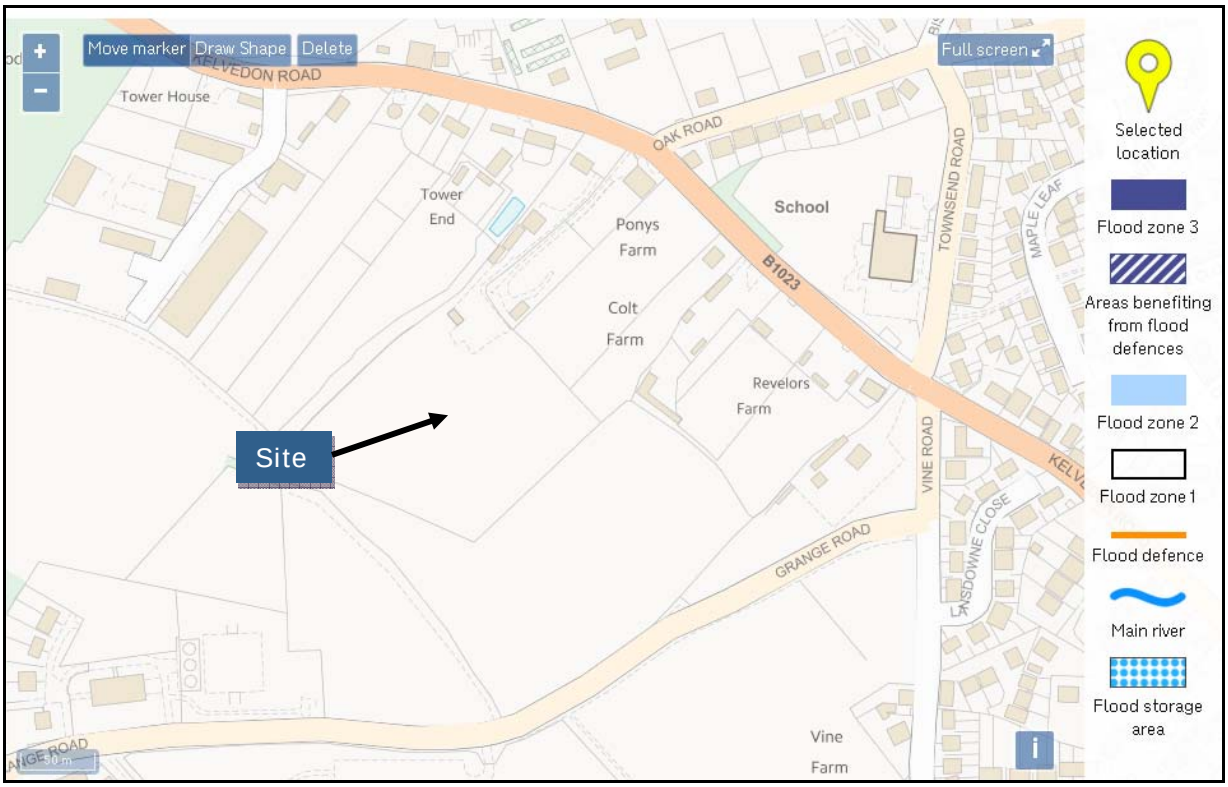

Figure 2: Environment Agency Flood Map (Source: Environment Agency, 2019)

4.2 Groundwater Flooding

4.2.1 In order to assess the potential for groundwater flooding during higher return period rainfall events, the Jacobs/DEFRA report entitled *Strategy for Flood and Coastal Erosion Risk Management: Groundwater Flooding Scoping Study*, published in May 2004, was consulted, together with the guidance offered within the document entitled *Groundwater flooding records collation, monitoring and risk assessment (ref HA5)*, commissioned by DEFRA and carried out by Jacobs in 2006.

Soil and Geology at the Site

4.2.2 The British Geological Survey's *Online Geology of Britain Viewer* indicates that the soils beneath the site comprise sand and gravel.

Groundwater Flooding Potential at the Site

4.2.3 There have been no recorded groundwater flood events across the area between 2000 and 2003, as indicated by the Jacobs study. The BGS Groundwater Flooding

Susceptibility Map indicates that there is "Limited Potential for Groundwater Flooding to Occur".

4.2.4 The *BGS SuDS detailed data* indicates that the water table is 3-5m bgl and that soil permeability is free draining.

4.2.5 It is considered that the evidence suggests a low risk of groundwater flooding to the site.

4.3 Surface Water Flooding and Sewer Flooding

4.3.1 Surface water and sewer flooding across urban areas is often a result of high intensity storm events which exceed the capacity of the sewer thus causing it to surcharge and flood. Poorly maintained sewer networks and blockages can also exacerbate the potential for sewer flooding. Surface water flooding can also occur as a result of overland flow across poorly drained rural areas.

4.3.2 Figure 2H/1 of the 2016 SFRA shows that there have been no recorded Essex County Council flood incidents within the vicinity of the site.

4.3.3 The Environment Agency's Surface Water Flooding Map (Figure 3) indicates that across the site and access there is a very low surface water flooding risk (i.e. chance of flooding less than 1 in 1000 years). Therefore, safe refuge and access/egress is available at all times.

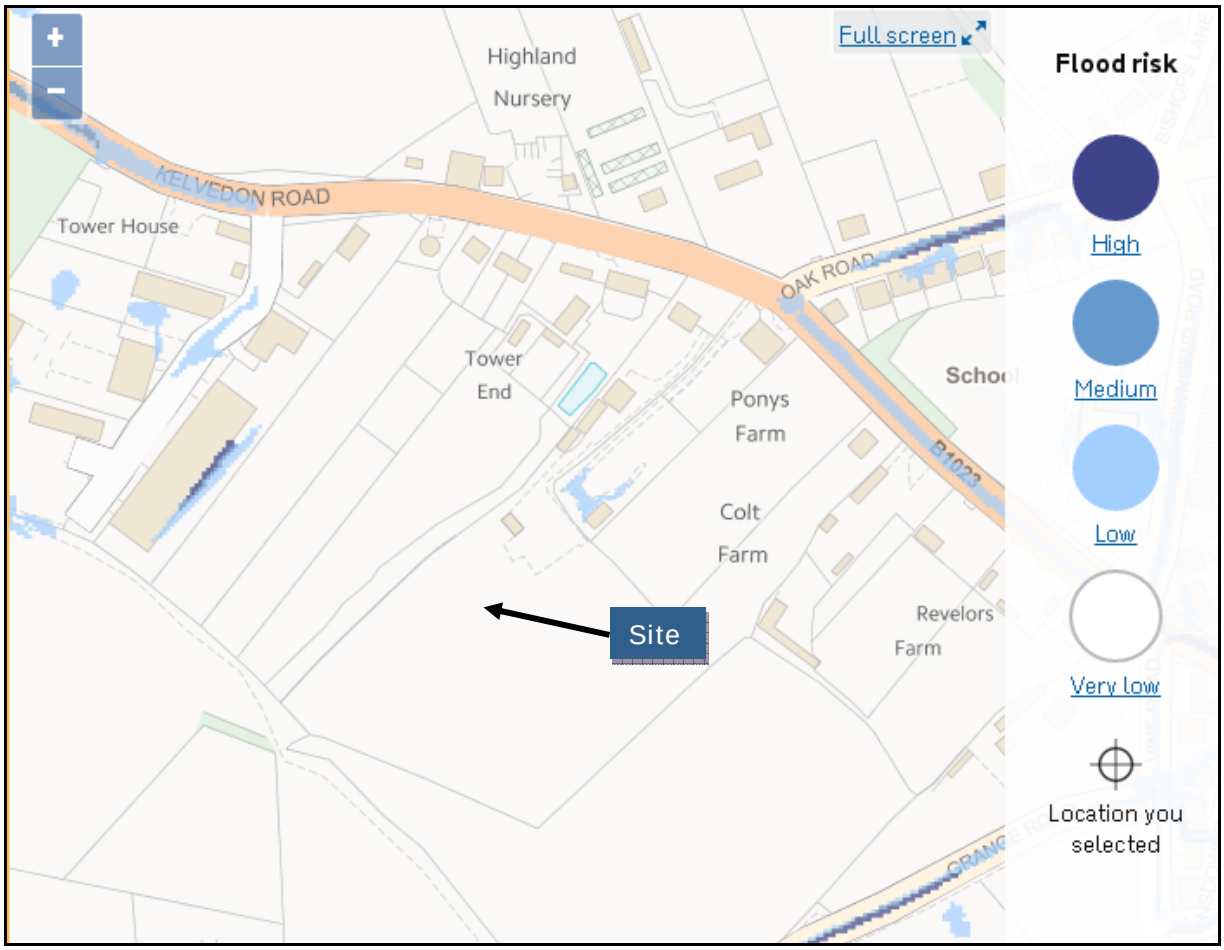

Figure 3: Environment Agency Surface Water Flooding Map (Source: Environment Agency, 2019)

4.4 Reservoirs, Canals And Other Artificial Sources

4.4.1 The failure of man-made infrastructure such as flood defences and other structures can result in unexpected flooding. Flooding from artificial sources such as reservoirs, canals and lakes can also occur suddenly and without warning, leading to high depths and velocities of flood water which pose a safety risk to people and property.

4.4.2 The Environment Agency's "Risk of flooding from reservoirs" map indicates that the site is not at risk from such features.

5. SURFACE WATER DRAINAGE AND SUDS

5.1 Introduction

5.1.1 Planning policy recommends the maximum practical use of Sustainable Drainage Systems (SUDS) within proposals for new sites. There is a requirement that sustainable drainage systems (SUDS) be installed where appropriate, in order to limit the amount of surface water runoff entering drainage systems and to return surface water into the ground to follow its natural drainage path.

5.1.2 The National Planning Policy Framework (NPPF) and the Environment Agency require that the effects of climate change to be considered in any assessment of flood risk for developments. When considering the impacts of climate change on rainfall intensity, Table 2 of the UK Government's climate change allowances guidance dated February 2016, advises that when designing surface water drainage systems, an increase in peak rainfall intensity of up to 40% should be considered.

5.1.3 In addition to the consideration of the design event for the SUDS techniques adopted in this report, the possibility of exceedance has been considered further in Section 5.9, and as outlined in CIRIA 635 entitled *Designing for exceedance in urban drainage – good practice,* and the CIRIA/HR Wallingford document entitled *Drainage of development sites – a guide* dated 2004. Although the guidance does not specify a return period event, the exceedance event is usually considered as the event which would exceed the design requirements of the drainage system in question. For example, SUDS attenuation/infiltration devices are usually designed to consider the climate change 1 in 100 year event and therefore the exceedance event in this instance could be considered as the 1 in 1000 year storm event.

5.2 Existing Surface Water Drainage

5.2.1 A detailed drainage survey is not available (and therefore the hydraulic characteristics and condition of the system cannot be determined), therefore in accordance with 2b of Section 24.5 of CIRIA 753, runoff from the site can be estimated using the urbanisation methods in the ReFH2 software.

5.2.2 In order to quantify the existing runoff rate from the site, the methodology outlined within the document entitled *The Revitalised Flood Hydrograph Model ReFH2 Technical Guidance* has been adopted. The document states that Table 24.1 of CIRIA 753 prefers FEH Methods over the IoH 124 Method, as they are more accurate when calculating peak flows within small catchments and plot scale Greenfield runoff calculations.

5.2.3 The method also uses the more up-to-date FEH13 Point rainfall data (which replaces the FEH99 data) which have been imported into the ReFH2.2 software from the FEH Web Service as well as the catchment descriptors.

5.2.4 The total site area is 5.11 ha and as the site has existing roofs/hardstanding, the impact of these areas (3155 sq m) on existing runoff rates have been taken into account by using the Urbanisation tab within the ReFH2.2 software, as recommended in Section 9.3 of the technical guidance (for example the existing hardstanding area of 0.3155 ha was entered as well as an Imperviousness factor of 1 and Impervious Runoff Factor of 1).

5.2.5 When choosing either a winter or summer storm profile, the advice in Section 8.1 of the technical guide and Hydrosolutions support team suggests that winter profiles are used in all but the most heavily urbanised catchments (i.e. URBEXT greater than 0.3) in which a summer storm should be specified. The URBEXT value for the existing site has been

calculated using the QMED Urbanisation tab in the WINFAP Version 4 software and equates to 0.03940 (based on an URBAN value of 0.06174). Therefore, the URBEXT value for the site is less than the URBEXT threshold of 0.3 and hence a winter storm should be used.

5.2.6 As the site area is less than 50 ha, Section 9.1.1 of the technical guidance has been followed in order for the results to be rescaled in accordance with the SUDS guidance (i.e. Tp updated to 3.251 and B_L updated to 38.885).

5.2.7 The results for the existing (urbanised) site have been extracted from the ReFH2.2 software and can be seen in Table 1. The (direct) runoff volume can also be calculated by specifying a storm duration of 6 hours and timestep of 8 minutes.

Table 1: Runoff rates and volumes for the existing site using ReFH2.2

Return Period	Runoff rate (l/s)	Runoff volume for 6 hour event (cu m)
1	18	354
2	20.4	408
30	41.1	869
100	52.4	1120

5.3 Soil Types and SUDS Suitability

5.3.1 Part H of the Building Regulations and Section 3.2.3 of CIRIA 753 prioritises discharges to the ground and then a watercourse, with discharge to a sewer only to be considered when both infiltration and discharge to a watercourse is not reasonably practicable.

5.3.2 Anglian Water plans in Appendix A indicate that there are no surface water sewers across the site or within the immediate vicinity.

5.3.3 By consulting the information outlined in Section 5.1 the soils at the site comprises sand and gravel. The *BGS SuDS detailed data* indicates that the water table is 3-5m bgl and that soil permeability is free draining. The data states that a site investigation should be undertaken to determine whether there are constraints in terms of infiltration.

5.3.4 Therefore, the soil types and expected infiltration rates across the site are considered sufficient for the infiltration of surface water. Based on the information provided in Table 25.1 of CIRIA 753, an infiltration rate of 3×10^{-5} m/s has been assumed for the purposes of this report.

5.3.5 In order to drain the roof area of the proposed dwellings, it is recommended that a Geocellular or modular system is used to construct a soakaway which could be positioned across the rear garden of each dwelling. It is proposed that permeable paving or grass reinforcement/plastic grids with gravel could be used for driveways, minor access roads and parking areas.

5.3.6 The main access road is likely to be constructed using conventional materials, therefore, surface water from this area would be directed to a Geocellular or modular soakaway system beneath the proposed central open space area in front of plots 90-104. It is not viable to create an infiltration basin instead of a soakaway due to the likely depth of the feature and safety/functionality constraints.

5.4 Pervious Surfaces

5.4.1 It is proposed that the driveways, minor access roads and car parking areas are constructed using pervious surfaces such as permeable block paving or grass reinforcement/plastic grids with gravel as discussed further in Section 20.1.3 of CIRIA 753, which will be used for infiltration (Type A).

5.4.2 The Building Regulations state that "infiltration devices should not be built within 5m of a building or road or in areas of unstable land". However, the CIRIA Susdrain factsheet entitled "Using SUDS Close to Buildings", suggests that the 5m rule was originally devised for soakaways, as these devices concentrate runoff into a quite small area of ground (i.e. point infiltration), whereas permeable paving acts as a blanket and promotes diffuse infiltration.

5.4.3 The aforementioned CIRIA Susdrain document continues to state that permeable paving that collects and drains rainwater falling directly on it can be used against any building providing there is no point source of water from any other impermeable surfaces connected to it. Despite this, the document also states that allowing water to soak into the ground close to foundations should always be done in consultation with a geotechnical advisor or registered ground engineering professional (also acknowledged in Section 25.2.3 of CIRIA 753).

5.4.4 The Interpave document entitled *Understanding permeable paving: Guidance for designers, planners and local authorities* dated 2013, states that on many sites even when the flow from roofs is considered, the ratio of area drained to the area of infiltration for paving is much less than a traditional soakaway. An impermeable membrane can be introduced to protect the foundations if foundation design alterations are not possible (Figure 4). Therefore, it is considered that this approach remains viable providing that an appropriate technical professional is consulted throughout the foundation design.

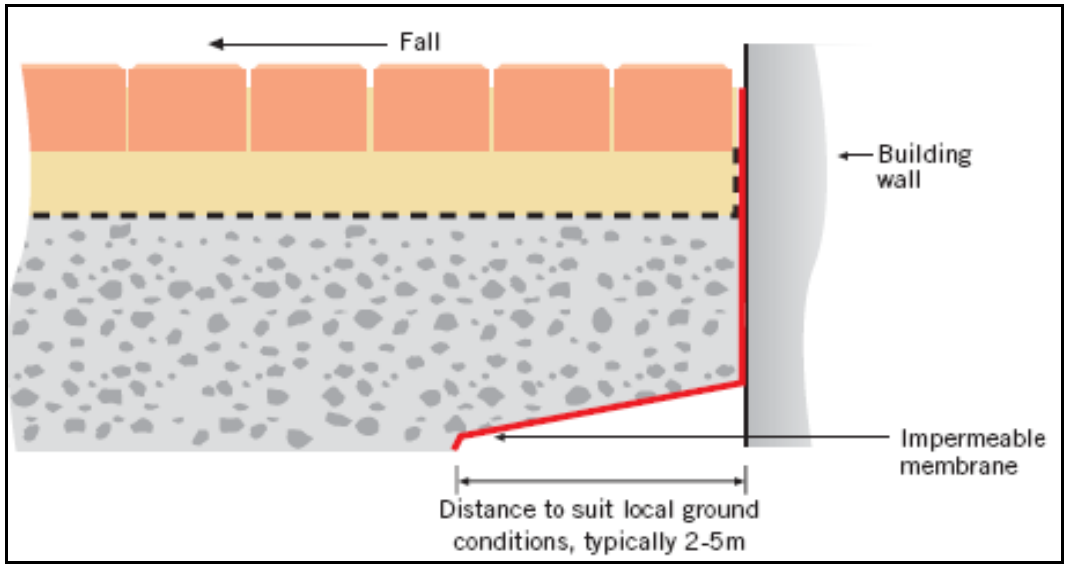

Figure 4: Section through a permeable surface close to building (Source: Interpave *Permeable pavements – guide to the design construction and maintenance of concrete block permeable pavements* dated 2013)

5.4.5 The Interpave document entitled *Understanding permeable paving: Guidance for designers, planners and local authorities* dated 2013, suggests that permeable paving

can permit a flow rate of up to 4000mm/hr. Figure 5 shows the permeable surface in more detail.

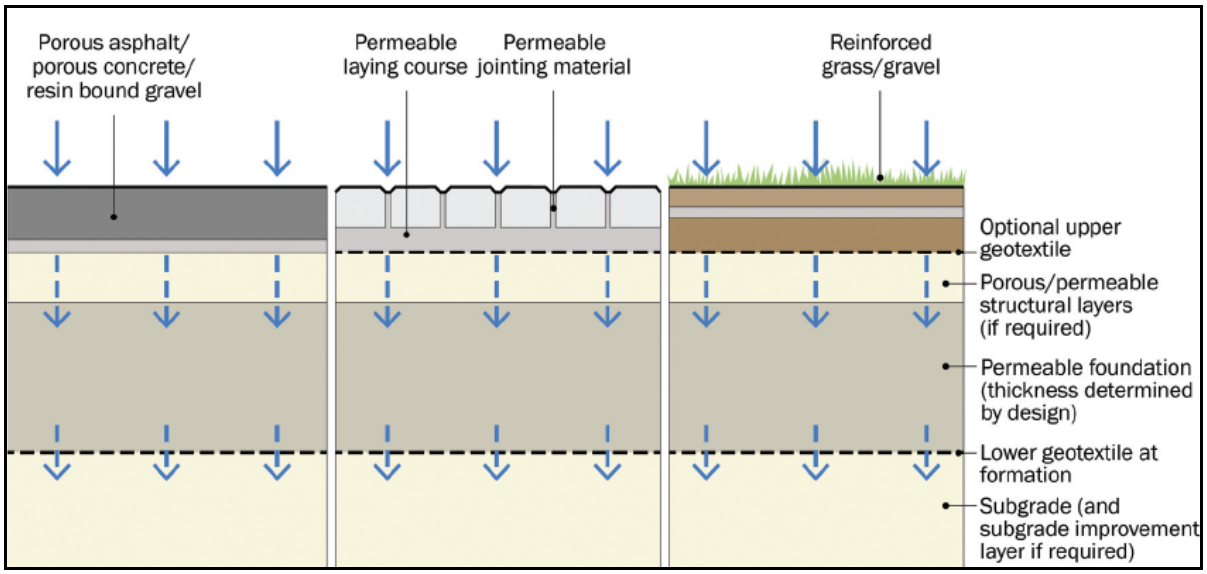

Figure 5: Pervious pavement systems for infiltration (Source: Figure 20.12 of CIRIA 753)

5.4.6 To provide an example of the performance of the pervious surface, using the design criteria outlined within CIRIA 697 *The SUDS Manual* and CIRIA 582 *Source control using pervious surfaces*, the proposed car parking areas and minor access roads (i.e. covering 6528 sq m) has been modelled collectively as a pervious surface within the Microdrainage – *Source Control* function.

5.4.7 Additionally, a 10% increase in impermeable area has been included in the paved area calculations in order to consider urban creep as specified by BS8582:2013 and Section 24.7.2 of CIRIA 753 (i.e. total area increases to 7181 sq m).

5.4.8 In accordance with Table 25.2 of CIRIA 753 (Table 2 below) and Section 20.5 CIRIA 753, a safety factor of 5 has been applied to the surface infiltration rate/membrane percolation and infiltration rate of 3 x 10^{-5} m/s in the software to represent the gradual silting up effects of the concrete block paving joints over its design life (i.e. assuming that there will be a gradual fall across the paving surface away from the buildings).

Table 2: Recommended safety factors applied to infiltration rate (CIRIA, 753)

TABLE 25.2 Suggested factors of safety, F, for use in hydraulic design of infiltration systems (designed using Bettess (1996). Note: not relevant for BRE method)			
Size of area to be drained	Consequences of failure		
	No damage or inconvenience	Minor damage to external areas or inconvenience (eg surface water on car parking)	Damage to buildings or structures, or major inconvenience (eg flooding of roads)
< 100 m²	1.5	2	10
100–1000 m²	1.5	3	10
> 1000 m²	1.5	5	10

5.4.9 Section 25.6 of CIRIA 753 states that infiltration devices are commonly designed for return periods up to the 1 in 100 year event plus an allowance for climate change. Therefore, the model was run to consider events up to and including the 1 in 100 year plus 40% climate change rainfall event and the Microdrainage software, Version 2018.1, has been used together with the Point rainfall data extracted from the FEH Web Service.

5.4.10 It should be noted that the MicroDrainage support team has confirmed that the software does not allow the 1 in 1 year event to be modelled when using FEH13 data and hence the 1 in 2 year event has been modelled instead. The results can be seen in Appendix B and Table 3.

5.4.11 BRE Digest 365 and Section 13.4 of CIRIA 753 require that the time taken for infiltration devices to empty to 50% should be within 24 hours and the results indicate that this will be achieved.

Table 3: Permeable Paving calculations

Return Period	Max water depth (m)	Storage Volume (cu m)
1 in 2 year	0.211	54.1
1 in 30 year	0.335	136.7
1 in 100 year event plus (40%) climate change event	0.480	280

5.5 Roof Drainage

5.5.1 In order to drain the roof area of the proposed dwellings it is recommended that a Geocellular or modular system is used to construct a soakaway for each dwelling which could be positioned across the rear garden. These systems provide a higher porosity (i.e. up to 95%) which will promote more efficient infiltration of surface water (see Chapters 13 and 21 of CIRIA 753).

5.5.2 The soakaway design has been based on the guidance provided by Polypipe and considers a Polystorm-Lite design which is appropriate for untrafficked areas. The typical dimension of each geocellular unit is 1m x 0.5m x 0.4m. The design guidance suggests a minimum depth between the top of the device and ground surface of 0.5m and a maximum effective depth of 2m.

5.5.3 The largest proposed (single) dwelling roof area of 110 sq m has been used in order to provide an example of the performance of the soakaway. Additionally, a 10% increase in impermeable area has been included in the roof area calculations in order to consider urban creep as specified by BS8582:2013 and Section 24.7.2 of CIRIA 753 (i.e. area increases to 121 sq m).

5.5.4 In accordance with Table 25.2 of CIRIA 753 (Table 2 above) and Section 20.5 CIRIA 753, a safety factor of 1.5 has been applied to the infiltration rate in the software to represent the gradual silting up effects of the soakaway over its design life, as the soakaways will be positioned sufficiently away from the dwellings and in the rear gardens.

5.5.5 In order to determine the size of the soakaway and its performance up to the design 1 in 100 year plus climate change (40%) event, the *Source Control – Cellular Storage* function within the Microdrainage software, has been used together with the Point rainfall data extracted from the FEH Web Service.

5.5.6 The optimum dimensions of the soakaway are 3m wide x 3m long and 1.2m effective depth. The results in Table 4 and Appendix C show that the soakaway is sufficiently sized to accommodate surface water without surface flooding.

5.5.7 BRE Digest 365 and Section 13.4 of CIRIA 753 require that the time taken for infiltration devices to empty to 50% should be within 24 hours and the results indicate that this will be achieved.

Table 4: Roof Soakaway calculations

Return Period	Max water depth (m)	Storage Volume (cu m)
1 in 2 year	0.119	1.0
1 in 30 year	0.295	2.5
1 in 100 year event plus (40%) climate change event	0.596	5.1

5.6 Road Drainage

5.6.1 Surface water from the main access road which will be constructed using conventional materials will be directed to a Geocellular or modular soakaway system beneath the central open space in front of dwellings 90-104. The soakaway will be accessed from the adjacent proposed access road.

5.6.3 In accordance with Table 25.2 of CIRIA 753 (Table 2 above) and Section 20.5 CIRIA 753, a safety factor of 1.5 has been applied to the infiltration rate in the software to represent the gradual silting up effects of the soakaway over its design life, as the soakaway will be positioned sufficiently away from the dwellings.

5.6.4 By consulting the proposed layout the contributing area has been calculated as 6272 sq m. Additionally, a 10% increase in impermeable area has been included in the area calculations in order to consider urban creep as specified by BS8582:2013 and Section 24.7.2 of CIRIA 753 (i.e. area increases to 6899 sq m).

5.6.5 The optimum dimensions of the soakaway are 22m wide x 22m long and 1.2m effective depth. The results in Table 5 and Appendix D show that the soakaway is sufficiently sized to accommodate surface water without surface flooding.

Table 5: Road Soakaway calculations

Return Period	Max water depth (m)	Storage Volume (cu m)
1 in 2 year	0.137	63.1
1 in 30 year	0.345	158.8
1 in 100 year event plus (40%) climate change event	0.726	333.7

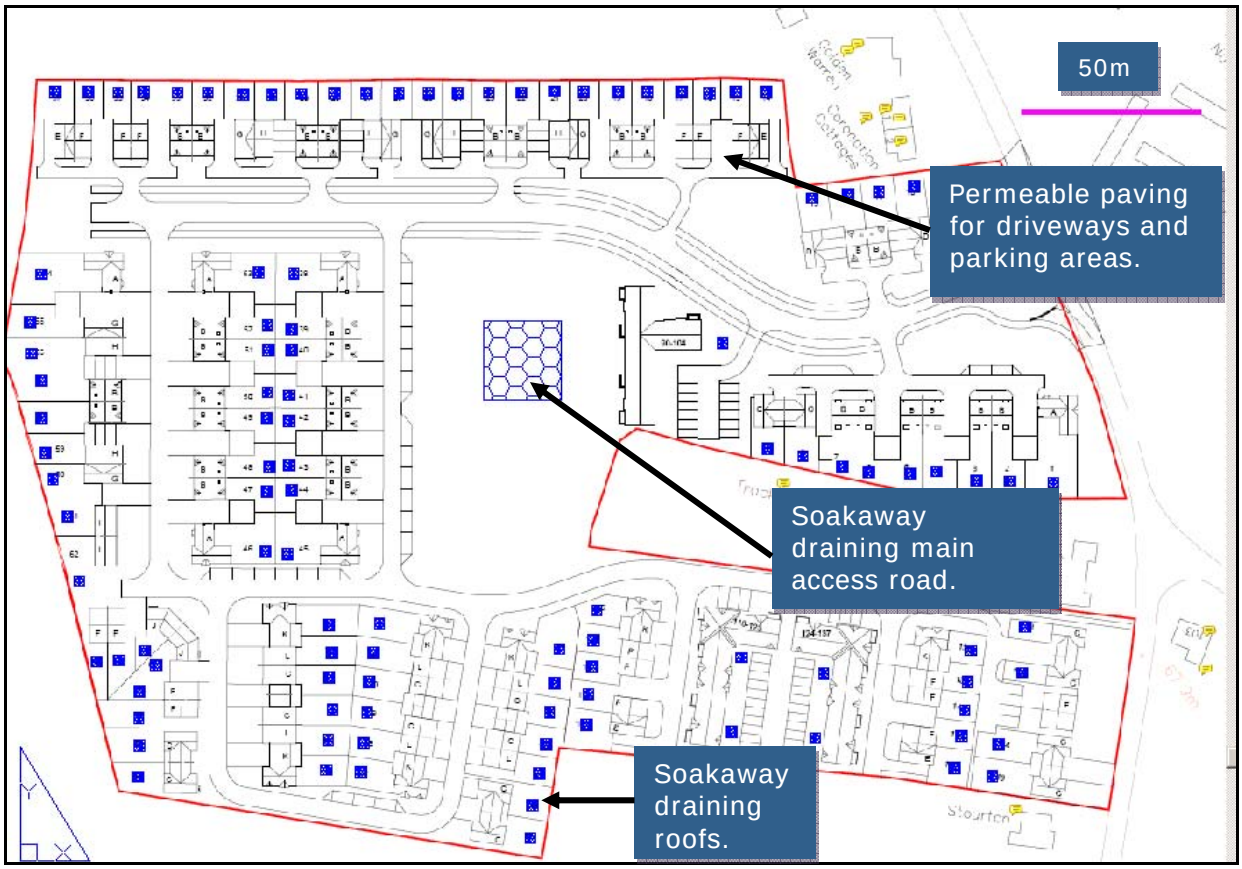

Figure 6: SUDS Strategy

5.7 Pollution Prevention

5.7.1 Table 26.2 of CIRIA 753 shows that roof water has a very low pollution hazard level. Table 26.2 of CIRIA 753 shows that driveways and low traffic roads have a low pollution hazard level.

5.7.2 Permeable paving will sufficiently cleanse surface water from hardstanding areas such as driveways. Chapter 20 of CIRIA 753 confirms that permeable paving can improve water quality by sedimentation, filtration, adsorption and biodegradation.

5.7.3 Chapter 13 of CIRIA 697 states that geocellular systems have a low potential to remove suspended solids and heavy metals and no potential to remove nutrients. CIRIA 753 states in Section 21.6 that geocellular systems do not provide any form of treatment of surface water runoff and should therefore be combined in a Management Train.

5.7.4 In accordance with the Simple Index Approach outlined in Section 26.7.1 of CIRIA 753 and more specifically Table 26.4 of CIRIA 753, proprietary treatment systems will be used to cleanse the roof water before it enters the soakaway. Section 13.2 of CIRIA 753 states that effective upstream pre-treatment is required to remove sediment and silt loads to prevent long-term clogging. Chapter 16 of CIRIA 697 and Chapter 14 of CIRIA 753 suggests that pre-treatment measures could comprise, for example, proprietary filtration systems which trap particulates and soluble pollutants from the runoff prior to discharge into the soakaway. Section 21.9.9 of CIRIA 753 indicates that a sediment sump could be included or sediment traps.

5.7.5 It is therefore considered that (collectively) the SUDS measures included within this report will sufficiently improve water quality across the proposed site and comply with Box 4.3 of CIRIA 753.

5.7.6 When considering water quality treatment, the Simple Index Approach set out in 26.7.1 of CIRIA 753 needs to be considered. Using Tables 26.2 and 26.4 in CIRIA 753, it can be seen on Table 6 below, that the SUDS measures will meet the pollution mitigation requirements (i.e. values in Table 6 for SUDS components should be equal to, or greater than the values for Land Use).

Table 6: Simple Index Approach

Land Use	Total Suspended Solids index	Metals index	Hydrocarbons index
Driveways	0.5	0.4	0.4
Roofs	0.2	0.2	0.05
Low traffic roads	0.5	0.4	0.4
SUDS Component for treatment	**Total Suspended Solids index**	**Metals index**	**Hydrocarbons index**
Permeable Paving	0.7	0.6	0.7
Proprietary treatment systems	Designed and specified to cleanse surface water from roof and to meet indices above.		

5.8 Adoption and Maintenance

5.8.1 The *Interim Code of Practice for Sustainable Drainage Systems*, compiled by the National SUDS Working Group in July 2004, states that Local Authorities have powers to adopt SUDS features providing they form part of the provision of open space.

5.8.2 The SUDS measures comprising the permeable paving and soakaways will be privately adopted and maintained by the homeowner.

5.8.3 The soakaway draining the road could also be privately adopted and maintained (perhaps by a management company) as it will remain private but to adoptable standards.

5.8.4 The permeable paving, soakaways and proprietary treatment system should be maintained in accordance with Table 20.15, Table 13.1 and Table 14.2 respectively of CIRIA 753, shown as Tables 7, 8 and 9 hereafter.

Table 7: Maintenance regime for permeable paving (Source: taken from Table 20.15 of CIRIA 753)

TABLE 20.15	Operation and maintenance requirements for pervious pavements		
	Maintenance schedule	**Required action**	**Typical frequency**
	Regular maintenance	Brushing and vacuuming (standard cosmetic sweep over whole surface)	Once a year, after autumn leaf fall, or reduced frequency as required, based on site-specific observations of clogging or manufacturer's recommendations – pay particular attention to areas where water runs onto pervious surface from adjacent impermeable areas as this area is most likely to collect the most sediment
	Occasional maintenance	Stabilise and mow contributing and adjacent areas	As required
		Removal of weeds or management using glyphospate applied directly into the weeds by an applicator rather than spraying	As required – once per year on less frequently used pavements
	Remedial Actions	Remediate any landscaping which, through vegetation maintenance or soil slip, has been raised to within 50 mm of the level of the paving	As required
		Remedial work to any depressions, rutting and cracked or broken blocks considered detrimental to the structural performance or a hazard to users, and replace lost jointing material	As required
		Rehabilitation of surface and upper substructure by remedial sweeping	Every 10 to 15 years or as required (if infiltration performance is reduced due to significant clogging)
	Monitoring	Initial inspection	Monthly for three months after installation
		Inspect for evidence of poor operation and/or weed growth – if required, take remedial action	Three-monthly, 48 h after large storms in first six months
		Inspect silt accumulation rates and establish appropriate brushing frequencies	Annually
		Monitor inspection chambers	Annually

Table 8: Maintenance regime for soakaway (Source: taken from Table 13.1 of CIRIA 753)

TABLE 13.1 Operation and maintenance requirements for soakaways		
Maintenance schedule	**Required action**	**Typical frequency**
Regular maintenance	Inspect for sediment and debris in pre-treatment components and floor of inspection tube or chamber and inside of concrete manhole rings	Annually
	Cleaning of gutters and any filters on downpipes	Annually (or as required based on inspections)
	Trimming any roots that may be causing blockages	Annually (or as required)
Occasional maintenance	Remove sediment and debris from pre-treatment components and floor of inspection tube or chamber and inside of concrete manhole rings	As required, based on inspections
Remedial actions	Reconstruct soakaway and/or replace or clean void fill, if performance deteriorates or failure occurs	As required
	Replacement of clogged geotextile (will require reconstruction of soakaway)	As required
Monitoring	Inspect silt traps and note rate of sediment accumulation	Monthly in the first year and then annually
	Check soakaway to ensure emptying is occurring	Annually

Table 9: Maintenance regime for proprietary treatment system (Source: taken from Table 14.2 of CIRIA 753)

TABLE 14.2 An example of operation and maintenance requirements for a proprietary treatment system		
Maintenance schedule	**Required action**	**Typical frequency**
Routine maintenance	Remove litter and debris and inspect for sediment, oil and grease accumulation	Six monthly
	Change the filter media	As recommended by manufacturer
	Remove sediment, oil, grease and floatables	As necessary – indicated by system inspections or immediately following significant spill
Remedial actions	Replace malfunctioning parts or structures	As required
Monitoring	Inspect for evidence of poor operation	Six monthly
	Inspect filter media and establish appropriate replacement frequencies	Six monthly
	Inspect sediment accumulation rates and establish appropriate removal frequencies	Monthly during first half year of operation, then every six months

5.9 Designing For Exceedance

5.9.1 Section 3.2.6 of CIRIA 753 states that the designated drainage system may include areas that are only designed to flood on an infrequent basis such as car parks, roads and recreational areas. For larger events, the site layout should be designed so that exceedance flows are managed in safe conveyance and storage zones so that the risk of flooding is acceptable for all people and property. Section 13.4.5 of CIRIA 753 states that an exceedance flow route or temporary storage area will be required for rainfall events that exceed the design capacity of the system.

5.9.2 The permeable paving and soakaway calculations in this FRA consider the climate change (40%) 1 in 100 year event and therefore are designed to accommodate flows during the design event. The exceedance return period event has been assumed to be the 1 in 1000 year event as this yields a storage depth and volume higher than the design event.

5.9.3 The results in Appendix E, F and G indicate that the permeable paving and soakaways are able to accommodate all of the surface water during the exceedance return period event without surface flooding.

5.9.4 It is recommended that the proposed dwellings have a finished floor level of 150mm higher than ground levels to ensure no internal flooding caused by wave action from vehicles.

5.9.5 Permeable paving areas should be graded so that runoff onto neighbouring areas is prevented.

5.9.6 Ground levels at the proposed site entrance are shown to fall away from Kelvedon Road and this will ensure no off-site flooding via this direction.

5.9.7 It is considered that flood routing can be investigated further at the detailed design stage and that the measures outlined in this FRA provide sufficient reassurance that there is scope when designing for exceedance at this site. This element could be conditioned as part of any planning approval.

5.10 Runoff from Permeable Areas

5.10.1 Permeable areas will not be permitted to drain into the drainage system and therefore long term storage including climate change allowances from these areas has been considered separately. The Essex County Council's SUDS Design Guide dated 2014 discusses the requirement to consider permeable areas and long term storage, as these will be subject to climate change which may result in measurable runoff.

5.10.2 In section 4.2.2 and 4.5.5 of CIRIA 697 *The SUDS Manual,* guidance is provided on how to determine runoff volume. The *REFH2 Greenfield Runoff Volume* calculator provided in the MicroDrainage software also allows a Greenfield runoff volume to be calculated based on the FEH13 data and user defined permeable area.

5.10.3 Figure 7 shows that the runoff volume for a typical garden area of 84 sq m is 1.648 cu m during the 1 in 100 year event. Applying 40% climate change to this figure increases it to 2.31 cu m.

5.10.4 When applying the volume of runoff of 2.31 cu m across its area would result in a depth of 0.03m.

5.10.5 It is recommended that in order to contain the water across these areas, each garden area should be profiled/lowered by a maximum of 0.1m. This will prevent runoff onto other areas. It is considered that this water would evaporate and infiltrate over time (which would mimic a more natural scenario).

5.10.6 It is not considered viable to include permeable areas within the SUDS calculations due to the risk of high sediment loads and the risk of overdesign.

Evans Rivers & Costal Ltd		Page 1
19 St Andrews Avenue Thorpe St Andrew Norwich NR7 0RG	Runoff volume	
Date 15/01/2019 13:01 File 1000yr road.srcx	Designed by rupertercl Checked by	
Micro Drainage	Source Control 2018.1	

ReFH2 Greenfield Runoff Volume

Input

Return Period (Years)	100
Storm Duration (min)	360
FEH Rainfall Version	2013
Site Location	GB 588788 217031
Data Type	Point
Season	Winter
Country	England/Wales/Northern Ireland
Area (ha)	0.008
SAAR (mm)	569
BFIHOST	0.382
FARL	0.000
SPRHOST	0.000
URBEXT (2000)	0.0000

Results

Percentage Runoff (%)	51.10
Greenfield Runoff Volume (m^3)	1.648

Figure 7: Greenfield runoff volume from rear garden areas during 1 in 100 year event

6. CONCLUSIONS

- A review of the relevant guidance documents and various types of data collected at the site has enabled a full assessment of the flood risks to be quantified.

- The site is located within the Flood Zone 1 therefore all uses of land are appropriate in this zone.

- This assessment has investigated the possibility of groundwater flooding and flooding from other sources at the site. It is considered that there will be a low risk of groundwater flooding across the site and very low risk of flooding from other sources such as surface water.

- An assessment of the practical use of sustainable drainage techniques has been carried out. As the soil types will support the effective use of infiltration devices, it is proposed that surface water from driveways, parking areas and minor access roads will be drained using permeable paving, and surface water from roofs drained to soakaways. A soakaway located beneath the central open space will drain the proposed main access road.

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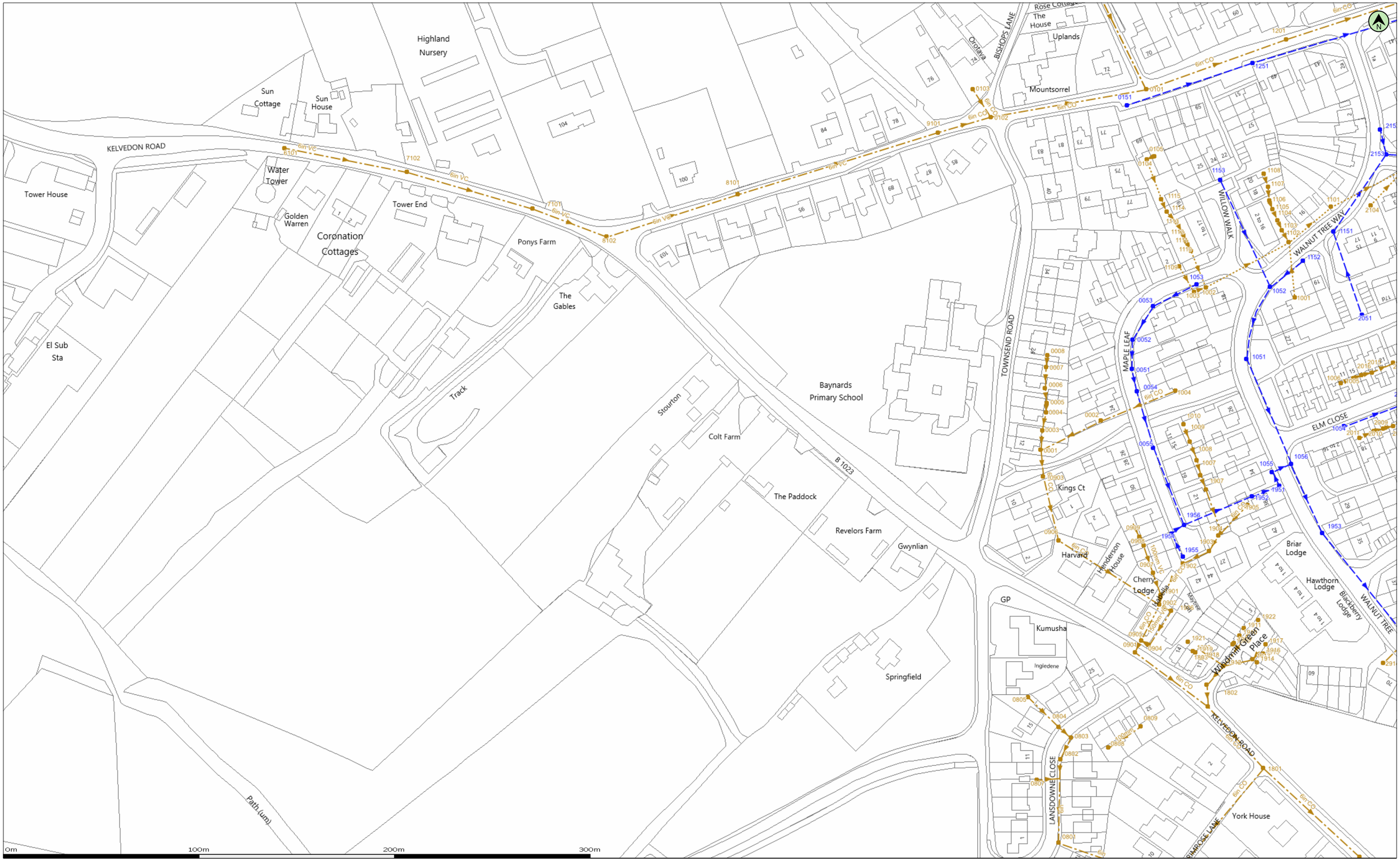
APPENDIX A – ANGLIAN WATER PLANS



Date: 13/01/19

Scale: 1:1250

Map Centre: 588865,217025

Data updated: 01/11/18

Our Ref: 294182 - 1

Wastewater Plan A2

- Foul Sewer
- Surface Sewer
- Combined Sewer
- Final Effluent
- Rising Main*
- Private Sewer*
- Decommissioned Sewer*
- Outfall*
- Inlet*
- Manhole*
- Sewage Treatment Works
- Public Pumping Station
- Decommissioned Pumping Station

*(Colour denotes effluent type)

rupert.evans@evansriversandcoastal.co.uk

Tiptree

love every drop anglianwater

Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert
0001	F	-	-	2.6
0002	F	-	-	1.77
0003	F	-	-	-
0004	F	-	1.91	-
0005	F	-	1.86	-
0006	F	-	1.87	-
0007	F	-	1.74	-
0008	F	-	1.1	-
0101	F	67.63	64.68	2.95
0102	F	-	-	2.37
0103	F	-	-	1.2
0104	F	-	-	1.47
0105	F	-	-	1.28
0801	F	-	-	1.61
0802	F	-	-	0.54
0803	F	-	-	0.56
0804	F	-	-	1.08
0805	F	-	-	0.59
0807	F	-	-	0.62
0808	F	-	-	-
0809	F	-	-	-
0901	F	-	-	2.24
0902	F	-	-	1.9
0903	F	-	-	2.52
0904	F	63.5	61.46	2.04
0905	F	63.57	61.4	2.17
0906	F	-	-	-
0907	F	-	-	-
0908	F	-	-	-
0909	F	-	-	-
1001	F	-	-	0.75
1002	F	-	-	1.32
1003	F	-	-	1.3
1004	F	-	-	1.2
1005	F	-	-	0.92
1006	F	-	-	0.95
1007	F	-	-	-
1008	F	-	-	-
1009	F	-	-	-
1010	F	-	-	-
1101	F	-	-	1.4
1102	F	-	-	1.36
1103	F	-	-	1.4
1104	F	-	-	1.05
1105	F	-	-	1
1106	F	-	-	0.95
1107	F	0.85	-	0.85
1108	F	-	-	0.9
1109	F	-	-	1.31
1110	F	-	-	1.4
1111	F	-	-	1.3
1112	F	-	-	1.2
1113	F	-	-	1.24
1114	F	-	-	1.24
1115	F	-	-	1.3
1201	F	66.49	64.1	2.39
1801	F	62.155	60.402	1.753
1802	F	62.904	61.103	1.801
1803	F	62.555	61.205	1.35
1901	F	-	-	1.75
1902	F	-	-	7.75
1903	F	-	-	1.51
1904	F	-	-	1.45
1905	F	-	-	1.14
1906	F	63.6	61.7	1.9
1907	F	-	-	-
1908	F	-	-	-
1909	F	-	-	-
1910	F	-	-	-
1911	F	-	-	-
1912	F	-	-	-

Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert
1913	F	-	-	-
1914	F	-	-	-
1915	F	-	-	-
1916	F	-	-	-
1917	F	-	-	-
1918	F	-	-	-
1919	F	-	-	-
1920	F	-	-	-
1921	F	-	-	-
1922	F	-	-	-
2008	F	-	-	1.11
2009	F	-	-	1.1
2010	F	-	-	1
2011	F	-	-	0.88
2013	F	-	-	1.49
2015	F	-	-	1.12
2016	F	-	-	1.06
2104	F	-	-	1.44
2801	F	61.08	59.38	1.7
2914	F	-	-	-
6101	F	70.01	68.34	1.67
7101	F	69.43	67.62	1.81
7102	F	69.754	67.94	1.814
8101	F	68.53	66.83	1.7
8102	F	69.06	67.26	1.8
9101	F	67.925	65.45	2.475
0051	S	-	-	-
0052	S	-	-	-
0053	S	-	-	-
0054	S	-	-	-
0055	S	-	-	-
0151	S	-	-	-
1051	S	-	-	-
1052	S	-	-	-
1053	S	-	-	-
1054	S	-	-	-
1055	S	-	-	-
1056	S	-	-	-
1151	S	-	-	-
1152	S	-	-	-
1153	S	-	-	-
1251	S	-	-	-
1951	S	-	-	-
1952	S	-	-	-
1953	S	-	-	-
1954	S	-	-	-
1955	S	-	-	-
1956	S	-	-	-
2051	S	-	-	-
2152	S	-	-	-
2153	S	-	-	-

Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert

Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert

APPENDIX B – PERMEABLE PAVING

2 YEAR EVENT

Summary of Results for 2 year Return Period

Half Drain Time : 56 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	0.087	0.087	4.2	9.3	O K
30 min Summer	0.122	0.122	5.9	18.2	O K
60 min Summer	0.142	0.142	6.9	24.4	O K
120 min Summer	0.182	0.182	8.8	40.1	O K
180 min Summer	0.195	0.195	9.5	46.3	O K
240 min Summer	0.200	0.200	9.7	48.6	O K
360 min Summer	0.199	0.199	9.7	47.9	O K
480 min Summer	0.192	0.192	9.3	44.7	O K
600 min Summer	0.184	0.184	8.9	41.0	O K
720 min Summer	0.175	0.175	8.5	37.4	O K
960 min Summer	0.160	0.160	7.8	31.0	O K
1440 min Summer	0.134	0.134	6.5	21.9	O K
2160 min Summer	0.108	0.108	5.3	14.3	O K
2880 min Summer	0.091	0.091	4.4	10.1	O K
4320 min Summer	0.071	0.071	3.5	6.2	O K
5760 min Summer	0.059	0.059	2.9	4.3	O K
7200 min Summer	0.052	0.052	2.5	3.2	O K
8640 min Summer	0.048	0.048	2.3	2.8	O K
10080 min Summer	0.046	0.046	2.1	2.6	O K
15 min Winter	0.108	0.108	5.2	14.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	32.617	0.0	18
30 min Summer	20.831	0.0	32
60 min Summer	12.872	0.0	56
120 min Summer	9.257	0.0	86
180 min Summer	7.282	0.0	120
240 min Summer	6.033	0.0	154
360 min Summer	4.518	0.0	222
480 min Summer	3.628	0.0	286
600 min Summer	3.045	0.0	350
720 min Summer	2.632	0.0	412
960 min Summer	2.085	0.0	530
1440 min Summer	1.500	0.0	768
2160 min Summer	1.085	0.0	1128
2880 min Summer	0.869	0.0	1476
4320 min Summer	0.649	0.0	2204
5760 min Summer	0.535	0.0	2936
7200 min Summer	0.467	0.0	3656
8640 min Summer	0.420	0.0	4360
10080 min Summer	0.387	0.0	5128
15 min Winter	32.617	0.0	18

Summary of Results for 2 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
30 min Winter	0.142	0.142	6.9	24.3	O K
60 min Winter	0.161	0.161	7.8	31.7	O K
120 min Winter	0.199	0.199	9.7	48.0	O K
180 min Winter	0.209	0.209	10.2	53.3	O K
240 min Winter	0.211	0.211	10.2	54.1	O K
360 min Winter	0.204	0.204	9.9	50.4	O K
480 min Winter	0.192	0.192	9.3	44.7	O K
600 min Winter	0.179	0.179	8.7	39.1	O K
720 min Winter	0.168	0.168	8.2	34.1	O K
960 min Winter	0.147	0.147	7.1	26.1	O K
1440 min Winter	0.115	0.115	5.6	16.1	O K
2160 min Winter	0.087	0.087	4.2	9.1	O K
2880 min Winter	0.070	0.070	3.4	5.9	O K
4320 min Winter	0.052	0.052	2.5	3.2	O K
5760 min Winter	0.046	0.046	2.0	2.6	O K
7200 min Winter	0.043	0.043	1.8	2.2	O K
8640 min Winter	0.040	0.040	1.6	1.9	O K
10080 min Winter	0.038	0.038	1.4	1.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
30 min Winter	20.831	0.0	31
60 min Winter	12.872	0.0	58
120 min Winter	9.257	0.0	92
180 min Winter	7.282	0.0	130
240 min Winter	6.033	0.0	166
360 min Winter	4.518	0.0	236
480 min Winter	3.628	0.0	302
600 min Winter	3.045	0.0	368
720 min Winter	2.632	0.0	428
960 min Winter	2.085	0.0	550
1440 min Winter	1.500	0.0	782
2160 min Winter	1.085	0.0	1144
2880 min Winter	0.869	0.0	1496
4320 min Winter	0.649	0.0	2204
5760 min Winter	0.535	0.0	2936
7200 min Winter	0.467	0.0	3664
8640 min Winter	0.420	0.0	4296
10080 min Winter	0.387	0.0	4976

Rainfall Details

Rainfall Model	FEH	Winter Storms	Yes
Return Period (years)	2	Cv (Summer)	0.750
FEH Rainfall Version	2013	Cv (Winter)	0.840
Site Location	GB 588788 217031	Shortest Storm (mins)	15
Data Type	Point	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 0.718

Time (mins) From:	To:	Area (ha)
0	4	0.718

Model Details

Storage is Online Cover Level (m) 1.000

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.10800	Width (m)	81.0
Membrane Percolation (mm/hr)	400	Length (m)	81.0
Max Percolation (l/s)	729.0	Slope (1:X)	100.0
Safety Factor	5.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	0.000	Membrane Depth (m)	0

30 YEAR EVENT

Summary of Results for 30 year Return Period

Half Drain Time : 86 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	0.220	0.220	10.7	59.0	O K
30 min Summer	0.259	0.259	12.6	81.6	O K
60 min Summer	0.285	0.285	13.8	98.7	O K
120 min Summer	0.308	0.308	15.0	115.5	O K
180 min Summer	0.315	0.315	15.3	120.6	O K
240 min Summer	0.315	0.315	15.3	120.6	O K
360 min Summer	0.307	0.307	14.9	114.3	O K
480 min Summer	0.294	0.294	14.3	105.3	O K
600 min Summer	0.281	0.281	13.7	96.2	O K
720 min Summer	0.269	0.269	13.1	87.7	O K
960 min Summer	0.245	0.245	11.9	73.2	O K
1440 min Summer	0.209	0.209	10.1	52.9	O K
2160 min Summer	0.171	0.171	8.3	35.5	O K
2880 min Summer	0.145	0.145	7.1	25.6	O K
4320 min Summer	0.113	0.113	5.5	15.4	O K
5760 min Summer	0.093	0.093	4.5	10.6	O K
7200 min Summer	0.081	0.081	3.9	7.9	O K
8640 min Summer	0.072	0.072	3.5	6.2	O K
10080 min Summer	0.065	0.065	3.1	5.1	O K
15 min Winter	0.240	0.240	11.7	70.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	72.378	0.0	18
30 min Summer	47.098	0.0	32
60 min Summer	29.401	0.0	60
120 min Summer	18.743	0.0	92
180 min Summer	14.072	0.0	124
240 min Summer	11.360	0.0	160
360 min Summer	8.266	0.0	228
480 min Summer	6.536	0.0	294
600 min Summer	5.427	0.0	358
720 min Summer	4.653	0.0	422
960 min Summer	3.638	0.0	548
1440 min Summer	2.570	0.0	792
2160 min Summer	1.824	0.0	1148
2880 min Summer	1.439	0.0	1500
4320 min Summer	1.043	0.0	2208
5760 min Summer	0.840	0.0	2936
7200 min Summer	0.717	0.0	3672
8640 min Summer	0.635	0.0	4400
10080 min Summer	0.576	0.0	5136
15 min Winter	72.378	0.0	18

Summary of Results for 30 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
30 min Winter	0.281	0.281	13.6	95.9	O K
60 min Winter	0.308	0.308	15.0	115.6	O K
120 min Winter	0.331	0.331	16.1	133.1	O K
180 min Winter	0.335	0.335	16.3	136.7	O K
240 min Winter	0.332	0.332	16.1	134.3	O K
360 min Winter	0.318	0.318	15.4	122.7	O K
480 min Winter	0.300	0.300	14.6	109.2	O K
600 min Winter	0.282	0.282	13.7	96.4	O K
720 min Winter	0.265	0.265	12.9	85.1	O K
960 min Winter	0.234	0.234	11.4	66.7	O K
1440 min Winter	0.188	0.188	9.1	43.0	O K
2160 min Winter	0.144	0.144	7.0	25.2	O K
2880 min Winter	0.117	0.117	5.7	16.5	O K
4320 min Winter	0.085	0.085	4.1	8.8	O K
5760 min Winter	0.068	0.068	3.3	5.7	O K
7200 min Winter	0.058	0.058	2.8	4.0	O K
8640 min Winter	0.051	0.051	2.5	3.1	O K
10080 min Winter	0.048	0.048	2.2	2.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
30 min Winter	47.098	0.0	31
60 min Winter	29.401	0.0	60
120 min Winter	18.743	0.0	96
180 min Winter	14.072	0.0	134
240 min Winter	11.360	0.0	172
360 min Winter	8.266	0.0	244
480 min Winter	6.536	0.0	314
600 min Winter	5.427	0.0	380
720 min Winter	4.653	0.0	446
960 min Winter	3.638	0.0	570
1440 min Winter	2.570	0.0	810
2160 min Winter	1.824	0.0	1168
2880 min Winter	1.439	0.0	1524
4320 min Winter	1.043	0.0	2208
5760 min Winter	0.840	0.0	2936
7200 min Winter	0.717	0.0	3672
8640 min Winter	0.635	0.0	4328
10080 min Winter	0.576	0.0	5088

Rainfall Details

Rainfall Model	FEH	Winter Storms	Yes
Return Period (years)	30	Cv (Summer)	0.750
FEH Rainfall Version	2013	Cv (Winter)	0.840
Site Location	GB 588788 217031	Shortest Storm (mins)	15
Data Type	Point	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 0.718

Time (mins) From:	To:	Area (ha)
0	4	0.718

Model Details

Storage is Online Cover Level (m) 1.000

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.10800	Width (m)	81.0
Membrane Percolation (mm/hr)	400	Length (m)	81.0
Max Percolation (l/s)	729.0	Slope (1:X)	100.0
Safety Factor	5.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	0.000	Membrane Depth (m)	0

100 YEAR PLUS (40%) CLIMATE CHANGE

Summary of Results for 100 year Return Period (+40%)

Half Drain Time : 118 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	0.328	0.328	16.0	130.8	O K
30 min Summer	0.380	0.380	18.5	175.4	O K
60 min Summer	0.416	0.416	20.2	210.3	O K
120 min Summer	0.442	0.442	21.5	237.6	O K
180 min Summer	0.450	0.450	21.9	246.1	O K
240 min Summer	0.451	0.451	21.9	246.9	O K
360 min Summer	0.442	0.442	21.5	237.3	O K
480 min Summer	0.428	0.428	20.8	222.7	O K
600 min Summer	0.413	0.413	20.1	207.3	O K
720 min Summer	0.398	0.398	19.3	192.5	O K
960 min Summer	0.369	0.369	17.9	165.9	O K
1440 min Summer	0.322	0.322	15.7	126.2	O K
2160 min Summer	0.271	0.271	13.2	89.3	O K
2880 min Summer	0.235	0.235	11.4	66.8	O K
4320 min Summer	0.185	0.185	9.0	41.8	O K
5760 min Summer	0.154	0.154	7.5	28.9	O K
7200 min Summer	0.134	0.134	6.5	21.8	O K
8640 min Summer	0.119	0.119	5.8	17.2	O K
10080 min Summer	0.108	0.108	5.2	14.1	O K
15 min Winter	0.352	0.352	17.1	150.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	128.332	0.0	18
30 min Summer	84.560	0.0	32
60 min Summer	52.943	0.0	60
120 min Summer	33.210	0.0	100
180 min Summer	24.857	0.0	132
240 min Summer	20.057	0.0	166
360 min Summer	14.608	0.0	234
480 min Summer	11.563	0.0	302
600 min Summer	9.605	0.0	368
720 min Summer	8.236	0.0	434
960 min Summer	6.438	0.0	562
1440 min Summer	4.528	0.0	810
2160 min Summer	3.194	0.0	1172
2880 min Summer	2.503	0.0	1528
4320 min Summer	1.784	0.0	2248
5760 min Summer	1.415	0.0	2944
7200 min Summer	1.195	0.0	3672
8640 min Summer	1.048	0.0	4408
10080 min Summer	0.942	0.0	5136
15 min Winter	128.332	0.0	18

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
30 min Winter	0.407	0.407	19.8	201.5	O K
60 min Winter	0.446	0.446	21.7	242.1	O K
120 min Winter	0.474	0.474	23.0	272.8	O K
180 min Winter	0.480	0.480	23.3	280.0	O K
240 min Winter	0.479	0.479	23.3	278.2	O K
360 min Winter	0.464	0.464	22.5	261.5	O K
480 min Winter	0.444	0.444	21.6	239.5	O K
600 min Winter	0.423	0.423	20.6	217.6	O K
720 min Winter	0.403	0.403	19.6	197.1	O K
960 min Winter	0.365	0.365	17.8	161.9	O K
1440 min Winter	0.304	0.304	14.8	112.2	O K
2160 min Winter	0.241	0.241	11.7	70.4	O K
2880 min Winter	0.199	0.199	9.7	47.9	O K
4320 min Winter	0.147	0.147	7.1	26.2	O K
5760 min Winter	0.117	0.117	5.7	16.7	O K
7200 min Winter	0.099	0.099	4.8	11.9	O K
8640 min Winter	0.086	0.086	4.2	9.1	O K
10080 min Winter	0.077	0.077	3.8	7.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
30 min Winter	84.560	0.0	32
60 min Winter	52.943	0.0	60
120 min Winter	33.210	0.0	112
180 min Winter	24.857	0.0	140
240 min Winter	20.057	0.0	178
360 min Winter	14.608	0.0	254
480 min Winter	11.563	0.0	326
600 min Winter	9.605	0.0	394
720 min Winter	8.236	0.0	462
960 min Winter	6.438	0.0	596
1440 min Winter	4.528	0.0	840
2160 min Winter	3.194	0.0	1208
2880 min Winter	2.503	0.0	1556
4320 min Winter	1.784	0.0	2248
5760 min Winter	1.415	0.0	2944
7200 min Winter	1.195	0.0	3672
8640 min Winter	1.048	0.0	4408
10080 min Winter	0.942	0.0	5144

Rainfall Details

Rainfall Model	FEH	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
FEH Rainfall Version	2013	Cv (Winter)	0.840
Site Location	GB 588788 217031	Shortest Storm (mins)	15
Data Type	Point	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.718

Time (mins) From:	To:	Area (ha)
0	4	0.718

Model Details

Storage is Online Cover Level (m) 1.000

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.10800	Width (m)	81.0
Membrane Percolation (mm/hr)	400	Length (m)	81.0
Max Percolation (l/s)	729.0	Slope (1:X)	100.0
Safety Factor	5.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	0.000	Membrane Depth (m)	0

APPENDIX C – ROOF SOAKAWAY

2 YEAR EVENT

Summary of Results for 2 year Return Period

Half Drain Time : 44 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	0.072	0.072	0.2	0.6	O K
30 min Summer	0.083	0.083	0.2	0.7	O K
60 min Summer	0.089	0.089	0.2	0.8	O K
120 min Summer	0.107	0.107	0.2	0.9	O K
180 min Summer	0.109	0.109	0.2	0.9	O K
240 min Summer	0.104	0.104	0.2	0.9	O K
360 min Summer	0.090	0.090	0.2	0.8	O K
480 min Summer	0.076	0.076	0.2	0.6	O K
600 min Summer	0.064	0.064	0.2	0.5	O K
720 min Summer	0.055	0.055	0.2	0.5	O K
960 min Summer	0.045	0.045	0.2	0.4	O K
1440 min Summer	0.034	0.034	0.1	0.3	O K
2160 min Summer	0.026	0.026	0.1	0.2	O K
2880 min Summer	0.021	0.021	0.1	0.2	O K
4320 min Summer	0.016	0.016	0.1	0.1	O K
5760 min Summer	0.014	0.014	0.1	0.1	O K
7200 min Summer	0.012	0.012	0.0	0.1	O K
8640 min Summer	0.011	0.011	0.0	0.1	O K
10080 min Summer	0.010	0.010	0.0	0.1	O K
15 min Winter	0.082	0.082	0.2	0.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	32.617	0.0	16
30 min Summer	20.831	0.0	29
60 min Summer	12.872	0.0	44
120 min Summer	9.257	0.0	82
180 min Summer	7.282	0.0	116
240 min Summer	6.033	0.0	150
360 min Summer	4.518	0.0	214
480 min Summer	3.628	0.0	276
600 min Summer	3.045	0.0	332
720 min Summer	2.632	0.0	390
960 min Summer	2.085	0.0	504
1440 min Summer	1.500	0.0	750
2160 min Summer	1.085	0.0	1104
2880 min Summer	0.869	0.0	1472
4320 min Summer	0.649	0.0	2204
5760 min Summer	0.535	0.0	2904
7200 min Summer	0.467	0.0	3672
8640 min Summer	0.420	0.0	4304
10080 min Summer	0.387	0.0	5120
15 min Winter	32.617	0.0	17

Summary of Results for 2 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
30 min Winter	0.095	0.095	0.2	0.8	O K
60 min Winter	0.100	0.100	0.2	0.9	O K
120 min Winter	0.119	0.119	0.2	1.0	O K
180 min Winter	0.117	0.117	0.2	1.0	O K
240 min Winter	0.108	0.108	0.2	0.9	O K
360 min Winter	0.086	0.086	0.2	0.7	O K
480 min Winter	0.065	0.065	0.2	0.6	O K
600 min Winter	0.051	0.051	0.2	0.4	O K
720 min Winter	0.045	0.045	0.2	0.4	O K
960 min Winter	0.037	0.037	0.1	0.3	O K
1440 min Winter	0.027	0.027	0.1	0.2	O K
2160 min Winter	0.020	0.020	0.1	0.2	O K
2880 min Winter	0.016	0.016	0.1	0.1	O K
4320 min Winter	0.012	0.012	0.0	0.1	O K
5760 min Winter	0.010	0.010	0.0	0.1	O K
7200 min Winter	0.009	0.009	0.0	0.1	O K
8640 min Winter	0.008	0.008	0.0	0.1	O K
10080 min Winter	0.007	0.007	0.0	0.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
30 min Winter	20.831	0.0	30
60 min Winter	12.872	0.0	48
120 min Winter	9.257	0.0	88
180 min Winter	7.282	0.0	126
240 min Winter	6.033	0.0	162
360 min Winter	4.518	0.0	226
480 min Winter	3.628	0.0	286
600 min Winter	3.045	0.0	334
720 min Winter	2.632	0.0	392
960 min Winter	2.085	0.0	510
1440 min Winter	1.500	0.0	762
2160 min Winter	1.085	0.0	1108
2880 min Winter	0.869	0.0	1496
4320 min Winter	0.649	0.0	2216
5760 min Winter	0.535	0.0	2952
7200 min Winter	0.467	0.0	3632
8640 min Winter	0.420	0.0	4424
10080 min Winter	0.387	0.0	5104

Rainfall Details

Rainfall Model	FEH	Winter Storms	Yes
Return Period (years)	2	Cv (Summer)	0.750
FEH Rainfall Version	2013	Cv (Winter)	0.840
Site Location	GB 588788 217031	Shortest Storm (mins)	15
Data Type	Point	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 0.012

Time (mins) From:	To:	Area (ha)
0	4	0.012

Model Details

Storage is Online Cover Level (m) 1.200

Cellular Storage Structure

Invert Level (m) 0.000 Safety Factor 1.5
Infiltration Coefficient Base (m/hr) 0.10800 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.10800

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	9.0	9.0	1.300	0.0	23.4
1.200	9.0	23.4			

30 YEAR EVENT

Summary of Results for 30 year Return Period

Half Drain Time : 96 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	0.172	0.172	0.2	1.5	O K
30 min Summer	0.212	0.212	0.2	1.8	O K
60 min Summer	0.238	0.238	0.2	2.0	O K
120 min Summer	0.258	0.258	0.2	2.2	O K
180 min Summer	0.257	0.257	0.2	2.2	O K
240 min Summer	0.248	0.248	0.2	2.1	O K
360 min Summer	0.224	0.224	0.2	1.9	O K
480 min Summer	0.198	0.198	0.2	1.7	O K
600 min Summer	0.174	0.174	0.2	1.5	O K
720 min Summer	0.152	0.152	0.2	1.3	O K
960 min Summer	0.115	0.115	0.2	1.0	O K
1440 min Summer	0.067	0.067	0.2	0.6	O K
2160 min Summer	0.044	0.044	0.2	0.4	O K
2880 min Summer	0.035	0.035	0.1	0.3	O K
4320 min Summer	0.026	0.026	0.1	0.2	O K
5760 min Summer	0.021	0.021	0.1	0.2	O K
7200 min Summer	0.018	0.018	0.1	0.2	O K
8640 min Summer	0.016	0.016	0.1	0.1	O K
10080 min Summer	0.015	0.015	0.1	0.1	O K
15 min Winter	0.194	0.194	0.2	1.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	72.378	0.0	18
30 min Summer	47.098	0.0	32
60 min Summer	29.401	0.0	60
120 min Summer	18.743	0.0	94
180 min Summer	14.072	0.0	126
240 min Summer	11.360	0.0	162
360 min Summer	8.266	0.0	230
480 min Summer	6.536	0.0	296
600 min Summer	5.427	0.0	362
720 min Summer	4.653	0.0	424
960 min Summer	3.638	0.0	542
1440 min Summer	2.570	0.0	766
2160 min Summer	1.824	0.0	1104
2880 min Summer	1.439	0.0	1472
4320 min Summer	1.043	0.0	2204
5760 min Summer	0.840	0.0	2936
7200 min Summer	0.717	0.0	3672
8640 min Summer	0.635	0.0	4312
10080 min Summer	0.576	0.0	5056
15 min Winter	72.378	0.0	18

Summary of Results for 30 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
30 min Winter	0.241	0.241	0.2	2.1	O K
60 min Winter	0.273	0.273	0.2	2.3	O K
120 min Winter	0.295	0.295	0.3	2.5	O K
180 min Winter	0.292	0.292	0.3	2.5	O K
240 min Winter	0.279	0.279	0.2	2.4	O K
360 min Winter	0.243	0.243	0.2	2.1	O K
480 min Winter	0.205	0.205	0.2	1.8	O K
600 min Winter	0.170	0.170	0.2	1.5	O K
720 min Winter	0.139	0.139	0.2	1.2	O K
960 min Winter	0.090	0.090	0.2	0.8	O K
1440 min Winter	0.046	0.046	0.2	0.4	O K
2160 min Winter	0.033	0.033	0.1	0.3	O K
2880 min Winter	0.026	0.026	0.1	0.2	O K
4320 min Winter	0.019	0.019	0.1	0.2	O K
5760 min Winter	0.016	0.016	0.1	0.1	O K
7200 min Winter	0.013	0.013	0.1	0.1	O K
8640 min Winter	0.012	0.012	0.0	0.1	O K
10080 min Winter	0.011	0.011	0.0	0.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
30 min Winter	47.098	0.0	31
60 min Winter	29.401	0.0	60
120 min Winter	18.743	0.0	98
180 min Winter	14.072	0.0	136
240 min Winter	11.360	0.0	176
360 min Winter	8.266	0.0	248
480 min Winter	6.536	0.0	318
600 min Winter	5.427	0.0	386
720 min Winter	4.653	0.0	448
960 min Winter	3.638	0.0	562
1440 min Winter	2.570	0.0	752
2160 min Winter	1.824	0.0	1108
2880 min Winter	1.439	0.0	1472
4320 min Winter	1.043	0.0	2164
5760 min Winter	0.840	0.0	2984
7200 min Winter	0.717	0.0	3576
8640 min Winter	0.635	0.0	4264
10080 min Winter	0.576	0.0	4960

Rainfall Details

Rainfall Model	FEH	Winter Storms	Yes
Return Period (years)	30	Cv (Summer)	0.750
FEH Rainfall Version	2013	Cv (Winter)	0.840
Site Location	GB 588788 217031	Shortest Storm (mins)	15
Data Type	Point	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 0.012

Time (mins) From:	To:	Area (ha)
0	4	0.012

Model Details

Storage is Online Cover Level (m) 1.200

Cellular Storage Structure

Invert Level (m) 0.000 Safety Factor 1.5
Infiltration Coefficient Base (m/hr) 0.10800 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.10800

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	9.0	9.0	1.300	0.0	23.4
1.200	9.0	23.4			

100 YEAR PLUS (40%) CLIMATE CHANGE

Summary of Results for 100 year Return Period (+40%)

Half Drain Time : 149 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	0.315	0.315	0.3	2.7	O K
30 min Summer	0.400	0.400	0.3	3.4	O K
60 min Summer	0.466	0.466	0.3	4.0	O K
120 min Summer	0.512	0.512	0.3	4.4	O K
180 min Summer	0.519	0.519	0.3	4.4	O K
240 min Summer	0.512	0.512	0.3	4.4	O K
360 min Summer	0.484	0.484	0.3	4.1	O K
480 min Summer	0.450	0.450	0.3	3.8	O K
600 min Summer	0.416	0.416	0.3	3.6	O K
720 min Summer	0.385	0.385	0.3	3.3	O K
960 min Summer	0.327	0.327	0.3	2.8	O K
1440 min Summer	0.233	0.233	0.2	2.0	O K
2160 min Summer	0.139	0.139	0.2	1.2	O K
2880 min Summer	0.082	0.082	0.2	0.7	O K
4320 min Summer	0.045	0.045	0.2	0.4	O K
5760 min Summer	0.036	0.036	0.1	0.3	O K
7200 min Summer	0.031	0.031	0.1	0.3	O K
8640 min Summer	0.027	0.027	0.1	0.2	O K
10080 min Summer	0.024	0.024	0.1	0.2	O K
15 min Winter	0.355	0.355	0.3	3.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	128.332	0.0	18
30 min Summer	84.560	0.0	32
60 min Summer	52.943	0.0	62
120 min Summer	33.210	0.0	112
180 min Summer	24.857	0.0	142
240 min Summer	20.057	0.0	174
360 min Summer	14.608	0.0	244
480 min Summer	11.563	0.0	312
600 min Summer	9.605	0.0	380
720 min Summer	8.236	0.0	448
960 min Summer	6.438	0.0	578
1440 min Summer	4.528	0.0	826
2160 min Summer	3.194	0.0	1188
2880 min Summer	2.503	0.0	1528
4320 min Summer	1.784	0.0	2204
5760 min Summer	1.415	0.0	2936
7200 min Summer	1.195	0.0	3664
8640 min Summer	1.048	0.0	4376
10080 min Summer	0.942	0.0	5120
15 min Winter	128.332	0.0	18

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
30 min Winter	0.453	0.453	0.3	3.9	O K
60 min Winter	0.531	0.531	0.3	4.5	O K
120 min Winter	0.592	0.592	0.3	5.1	O K
180 min Winter	0.596	0.596	0.3	5.1	O K
240 min Winter	0.588	0.588	0.3	5.0	O K
360 min Winter	0.548	0.548	0.3	4.7	O K
480 min Winter	0.500	0.500	0.3	4.3	O K
600 min Winter	0.453	0.453	0.3	3.9	O K
720 min Winter	0.407	0.407	0.3	3.5	O K
960 min Winter	0.327	0.327	0.3	2.8	O K
1440 min Winter	0.200	0.200	0.2	1.7	O K
2160 min Winter	0.083	0.083	0.2	0.7	O K
2880 min Winter	0.046	0.046	0.2	0.4	O K
4320 min Winter	0.033	0.033	0.1	0.3	O K
5760 min Winter	0.026	0.026	0.1	0.2	O K
7200 min Winter	0.022	0.022	0.1	0.2	O K
8640 min Winter	0.019	0.019	0.1	0.2	O K
10080 min Winter	0.018	0.018	0.1	0.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
30 min Winter	84.560	0.0	32
60 min Winter	52.943	0.0	60
120 min Winter	33.210	0.0	116
180 min Winter	24.857	0.0	148
240 min Winter	20.057	0.0	186
360 min Winter	14.608	0.0	262
480 min Winter	11.563	0.0	338
600 min Winter	9.605	0.0	410
720 min Winter	8.236	0.0	480
960 min Winter	6.438	0.0	616
1440 min Winter	4.528	0.0	868
2160 min Winter	3.194	0.0	1208
2880 min Winter	2.503	0.0	1472
4320 min Winter	1.784	0.0	2204
5760 min Winter	1.415	0.0	2920
7200 min Winter	1.195	0.0	3624
8640 min Winter	1.048	0.0	4408
10080 min Winter	0.942	0.0	5120

Rainfall Details

Rainfall Model	FEH	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
FEH Rainfall Version	2013	Cv (Winter)	0.840
Site Location	GB 588788 217031	Shortest Storm (mins)	15
Data Type	Point	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.012

Time (mins) From:	To:	Area (ha)
0	4	0.012

Model Details

Storage is Online Cover Level (m) 1.200

Cellular Storage Structure

Invert Level (m) 0.000 Safety Factor 1.5
Infiltration Coefficient Base (m/hr) 0.10800 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.10800

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	9.0	9.0	1.300	0.0	23.4
1.200	9.0	23.4			

APPENDIX D – ROAD SOAKAWAY

2 YEAR EVENT

Summary of Results for 2 year Return Period

Half Drain Time : 56 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	0.078	0.078	9.8	36.0	O K
30 min Summer	0.092	0.092	9.8	42.3	O K
60 min Summer	0.098	0.098	9.9	45.2	O K
120 min Summer	0.121	0.121	9.9	55.6	O K
180 min Summer	0.124	0.124	9.9	57.2	O K
240 min Summer	0.121	0.121	9.9	55.6	O K
360 min Summer	0.107	0.107	9.9	49.3	O K
480 min Summer	0.091	0.091	9.8	42.0	O K
600 min Summer	0.077	0.077	9.8	35.6	O K
720 min Summer	0.066	0.066	9.8	30.2	O K
960 min Summer	0.050	0.050	9.8	23.1	O K
1440 min Summer	0.039	0.039	7.6	17.8	O K
2160 min Summer	0.029	0.029	5.7	13.5	O K
2880 min Summer	0.024	0.024	4.7	11.1	O K
4320 min Summer	0.018	0.018	3.6	8.5	O K
5760 min Summer	0.015	0.015	3.0	7.0	O K
7200 min Summer	0.013	0.013	2.6	6.2	O K
8640 min Summer	0.012	0.012	2.4	5.5	O K
10080 min Summer	0.011	0.011	2.2	5.1	O K
15 min Winter	0.089	0.089	9.8	40.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	32.617	0.0	17
30 min Summer	20.831	0.0	30
60 min Summer	12.872	0.0	48
120 min Summer	9.257	0.0	84
180 min Summer	7.282	0.0	120
240 min Summer	6.033	0.0	154
360 min Summer	4.518	0.0	220
480 min Summer	3.628	0.0	282
600 min Summer	3.045	0.0	342
720 min Summer	2.632	0.0	398
960 min Summer	2.085	0.0	508
1440 min Summer	1.500	0.0	750
2160 min Summer	1.085	0.0	1104
2880 min Summer	0.869	0.0	1468
4320 min Summer	0.649	0.0	2204
5760 min Summer	0.535	0.0	2936
7200 min Summer	0.467	0.0	3672
8640 min Summer	0.420	0.0	4392
10080 min Summer	0.387	0.0	5088
15 min Winter	32.617	0.0	17

Summary of Results for 2 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
30 min Winter	0.105	0.105	9.9	48.3	O K
60 min Winter	0.112	0.112	9.9	51.3	O K
120 min Winter	0.136	0.136	9.9	62.5	O K
180 min Winter	0.137	0.137	9.9	63.1	O K
240 min Winter	0.130	0.130	9.9	59.7	O K
360 min Winter	0.107	0.107	9.9	49.1	O K
480 min Winter	0.083	0.083	9.8	38.1	O K
600 min Winter	0.063	0.063	9.8	29.1	O K
720 min Winter	0.051	0.051	9.8	23.2	O K
960 min Winter	0.041	0.041	8.1	18.9	O K
1440 min Winter	0.030	0.030	5.9	13.9	O K
2160 min Winter	0.022	0.022	4.3	10.2	O K
2880 min Winter	0.018	0.018	3.6	8.3	O K
4320 min Winter	0.014	0.014	2.7	6.2	O K
5760 min Winter	0.011	0.011	2.2	5.1	O K
7200 min Winter	0.010	0.010	1.9	4.4	O K
8640 min Winter	0.009	0.009	1.7	3.9	O K
10080 min Winter	0.008	0.008	1.6	3.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
30 min Winter	20.831	0.0	30
60 min Winter	12.872	0.0	50
120 min Winter	9.257	0.0	92
180 min Winter	7.282	0.0	130
240 min Winter	6.033	0.0	166
360 min Winter	4.518	0.0	236
480 min Winter	3.628	0.0	298
600 min Winter	3.045	0.0	350
720 min Winter	2.632	0.0	396
960 min Winter	2.085	0.0	512
1440 min Winter	1.500	0.0	754
2160 min Winter	1.085	0.0	1120
2880 min Winter	0.869	0.0	1484
4320 min Winter	0.649	0.0	2232
5760 min Winter	0.535	0.0	2880
7200 min Winter	0.467	0.0	3600
8640 min Winter	0.420	0.0	4432
10080 min Winter	0.387	0.0	4984

Rainfall Details

Rainfall Model	FEH	Winter Storms	Yes
Return Period (years)	2	Cv (Summer)	0.750
FEH Rainfall Version	2013	Cv (Winter)	0.840
Site Location	GB 588788 217031	Shortest Storm (mins)	15
Data Type	Point	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 0.689

Time (mins) From:	To:	Area (ha)
0	4	0.689

Model Details

Storage is Online Cover Level (m) 1.200

Cellular Storage Structure

Invert Level (m) 0.000 Safety Factor 1.5
Infiltration Coefficient Base (m/hr) 0.10800 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.10800

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	484.0	484.0	1.300	0.0	589.6
1.200	484.0	589.6			

30 YEAR EVENT

Summary of Results for 30 year Return Period

Half Drain Time : 133 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	0.187	0.187	10.0	85.9	O K
30 min Summer	0.233	0.233	10.1	107.2	O K
60 min Summer	0.268	0.268	10.2	123.1	O K
120 min Summer	0.297	0.297	10.2	136.4	O K
180 min Summer	0.299	0.299	10.2	137.3	O K
240 min Summer	0.292	0.292	10.2	134.2	O K
360 min Summer	0.269	0.269	10.2	123.6	O K
480 min Summer	0.243	0.243	10.1	111.6	O K
600 min Summer	0.217	0.217	10.1	99.9	O K
720 min Summer	0.193	0.193	10.0	88.8	O K
960 min Summer	0.150	0.150	9.9	69.2	O K
1440 min Summer	0.089	0.089	9.8	41.0	O K
2160 min Summer	0.049	0.049	9.6	22.6	O K
2880 min Summer	0.040	0.040	7.8	18.3	O K
4320 min Summer	0.030	0.030	5.8	13.6	O K
5760 min Summer	0.024	0.024	4.7	11.1	O K
7200 min Summer	0.021	0.021	4.1	9.4	O K
8640 min Summer	0.018	0.018	3.6	8.4	O K
10080 min Summer	0.017	0.017	3.3	7.6	O K
15 min Winter	0.211	0.211	10.1	97.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	72.378	0.0	18
30 min Summer	47.098	0.0	32
60 min Summer	29.401	0.0	62
120 min Summer	18.743	0.0	108
180 min Summer	14.072	0.0	140
240 min Summer	11.360	0.0	172
360 min Summer	8.266	0.0	240
480 min Summer	6.536	0.0	308
600 min Summer	5.427	0.0	374
720 min Summer	4.653	0.0	440
960 min Summer	3.638	0.0	560
1440 min Summer	2.570	0.0	794
2160 min Summer	1.824	0.0	1104
2880 min Summer	1.439	0.0	1472
4320 min Summer	1.043	0.0	2204
5760 min Summer	0.840	0.0	2928
7200 min Summer	0.717	0.0	3664
8640 min Summer	0.635	0.0	4400
10080 min Summer	0.576	0.0	5072
15 min Winter	72.378	0.0	18

Summary of Results for 30 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
30 min Winter	0.264	0.264	10.1	121.6	O K
60 min Winter	0.307	0.307	10.2	141.1	O K
120 min Winter	0.345	0.345	10.3	158.8	O K
180 min Winter	0.345	0.345	10.3	158.6	O K
240 min Winter	0.336	0.336	10.3	154.5	O K
360 min Winter	0.303	0.303	10.2	139.3	O K
480 min Winter	0.264	0.264	10.1	121.6	O K
600 min Winter	0.226	0.226	10.1	104.1	O K
720 min Winter	0.191	0.191	10.0	87.8	O K
960 min Winter	0.129	0.129	9.9	59.4	O K
1440 min Winter	0.054	0.054	9.8	24.8	O K
2160 min Winter	0.037	0.037	7.3	17.2	O K
2880 min Winter	0.030	0.030	5.8	13.6	O K
4320 min Winter	0.022	0.022	4.2	9.9	O K
5760 min Winter	0.018	0.018	3.5	8.1	O K
7200 min Winter	0.015	0.015	3.0	6.9	O K
8640 min Winter	0.013	0.013	2.6	6.0	O K
10080 min Winter	0.012	0.012	2.4	5.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
30 min Winter	47.098	0.0	32
60 min Winter	29.401	0.0	60
120 min Winter	18.743	0.0	116
180 min Winter	14.072	0.0	150
240 min Winter	11.360	0.0	186
360 min Winter	8.266	0.0	262
480 min Winter	6.536	0.0	334
600 min Winter	5.427	0.0	404
720 min Winter	4.653	0.0	470
960 min Winter	3.638	0.0	590
1440 min Winter	2.570	0.0	778
2160 min Winter	1.824	0.0	1124
2880 min Winter	1.439	0.0	1472
4320 min Winter	1.043	0.0	2156
5760 min Winter	0.840	0.0	2920
7200 min Winter	0.717	0.0	3680
8640 min Winter	0.635	0.0	4264
10080 min Winter	0.576	0.0	5184

Rainfall Details

Rainfall Model	FEH	Winter Storms	Yes
Return Period (years)	30	Cv (Summer)	0.750
FEH Rainfall Version	2013	Cv (Winter)	0.840
Site Location	GB 588788 217031	Shortest Storm (mins)	15
Data Type	Point	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 0.689

Time (mins) From:	To:	Area (ha)
0	4	0.689

Model Details

Storage is Online Cover Level (m) 1.200

Cellular Storage Structure

Invert Level (m) 0.000 Safety Factor 1.5
Infiltration Coefficient Base (m/hr) 0.10800 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.10800

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	484.0	484.0	1.300	0.0	589.6
1.200	484.0	589.6			

100 YEAR PLUS (40%) CLIMATE CHANGE

Summary of Results for 100 year Return Period (+40%)

Half Drain Time : 274 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	0.342	0.342	10.3	157.2	O K
30 min Summer	0.439	0.439	10.5	202.0	O K
60 min Summer	0.524	0.524	10.6	240.8	O K
120 min Summer	0.603	0.603	10.7	277.1	O K
180 min Summer	0.623	0.623	10.8	286.3	O K
240 min Summer	0.618	0.618	10.8	284.3	O K
360 min Summer	0.592	0.592	10.7	272.2	O K
480 min Summer	0.559	0.559	10.7	257.3	O K
600 min Summer	0.527	0.527	10.6	242.2	O K
720 min Summer	0.495	0.495	10.6	227.4	O K
960 min Summer	0.433	0.433	10.4	199.3	O K
1440 min Summer	0.326	0.326	10.3	150.1	O K
2160 min Summer	0.206	0.206	10.0	94.5	O K
2880 min Summer	0.124	0.124	9.9	57.0	O K
4320 min Summer	0.051	0.051	9.8	23.4	O K
5760 min Summer	0.041	0.041	8.0	18.6	O K
7200 min Summer	0.034	0.034	6.7	15.8	O K
8640 min Summer	0.030	0.030	5.9	13.8	O K
10080 min Summer	0.027	0.027	5.3	12.4	O K
15 min Winter	0.385	0.385	10.4	177.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	128.332	0.0	18
30 min Summer	84.560	0.0	33
60 min Summer	52.943	0.0	62
120 min Summer	33.210	0.0	122
180 min Summer	24.857	0.0	180
240 min Summer	20.057	0.0	216
360 min Summer	14.608	0.0	276
480 min Summer	11.563	0.0	340
600 min Summer	9.605	0.0	408
720 min Summer	8.236	0.0	476
960 min Summer	6.438	0.0	608
1440 min Summer	4.528	0.0	866
2160 min Summer	3.194	0.0	1232
2880 min Summer	2.503	0.0	1560
4320 min Summer	1.784	0.0	2204
5760 min Summer	1.415	0.0	2936
7200 min Summer	1.195	0.0	3672
8640 min Summer	1.048	0.0	4392
10080 min Summer	0.942	0.0	5136
15 min Winter	128.332	0.0	18

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
30 min Winter	0.496	0.496	10.6	228.1	O K
60 min Winter	0.595	0.595	10.7	273.6	O K
120 min Winter	0.693	0.693	10.9	318.6	O K
180 min Winter	0.724	0.724	11.0	333.0	O K
240 min Winter	0.726	0.726	11.0	333.7	O K
360 min Winter	0.691	0.691	10.9	317.5	O K
480 min Winter	0.649	0.649	10.8	298.6	O K
600 min Winter	0.604	0.604	10.7	277.9	O K
720 min Winter	0.559	0.559	10.7	256.9	O K
960 min Winter	0.470	0.470	10.5	216.0	O K
1440 min Winter	0.314	0.314	10.2	144.4	O K
2160 min Winter	0.145	0.145	9.9	66.6	O K
2880 min Winter	0.055	0.055	9.8	25.1	O K
4320 min Winter	0.037	0.037	7.3	17.0	O K
5760 min Winter	0.030	0.030	5.8	13.6	O K
7200 min Winter	0.025	0.025	4.8	11.5	O K
8640 min Winter	0.022	0.022	4.2	10.0	O K
10080 min Winter	0.020	0.020	3.9	9.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
30 min Winter	84.560	0.0	32
60 min Winter	52.943	0.0	62
120 min Winter	33.210	0.0	118
180 min Winter	24.857	0.0	176
240 min Winter	20.057	0.0	230
360 min Winter	14.608	0.0	294
480 min Winter	11.563	0.0	368
600 min Winter	9.605	0.0	444
720 min Winter	8.236	0.0	518
960 min Winter	6.438	0.0	664
1440 min Winter	4.528	0.0	924
2160 min Winter	3.194	0.0	1276
2880 min Winter	2.503	0.0	1528
4320 min Winter	1.784	0.0	2188
5760 min Winter	1.415	0.0	2928
7200 min Winter	1.195	0.0	3672
8640 min Winter	1.048	0.0	4408
10080 min Winter	0.942	0.0	4984

Rainfall Details

Rainfall Model	FEH	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
FEH Rainfall Version	2013	Cv (Winter)	0.840
Site Location	GB 588788 217031	Shortest Storm (mins)	15
Data Type	Point	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.689

Time (mins) From:	To:	Area (ha)
0	4	0.689

Model Details

Storage is Online Cover Level (m) 1.200

Cellular Storage Structure

Invert Level (m) 0.000 Safety Factor 1.5
Infiltration Coefficient Base (m/hr) 0.10800 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.10800

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	484.0	484.0	1.300	0.0	589.6
1.200	484.0	589.6			

APPENDIX E – PERVIOUS PAVING EXCEEDANCE (1000YR EVENT)

Summary of Results for 1000 year Return Period

Half Drain Time : 146 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	0.364	0.364	17.7	160.8	O K
30 min Summer	0.424	0.424	20.6	218.0	O K
60 min Summer	0.467	0.467	22.7	265.3	O K
120 min Summer	0.510	0.510	24.8	316.2	O K
180 min Summer	0.526	0.526	25.6	336.7	O K
240 min Summer	0.532	0.532	25.9	344.2	O K
360 min Summer	0.528	0.528	25.7	339.2	O K
480 min Summer	0.516	0.516	25.1	324.0	O K
600 min Summer	0.501	0.501	24.4	305.4	O K
720 min Summer	0.485	0.485	23.6	286.3	O K
960 min Summer	0.454	0.454	22.1	250.4	O K
1440 min Summer	0.399	0.399	19.4	193.3	O K
2160 min Summer	0.336	0.336	16.3	137.1	O K
2880 min Summer	0.289	0.289	14.1	101.8	O K
4320 min Summer	0.226	0.226	11.0	62.2	O K
5760 min Summer	0.185	0.185	9.0	41.6	O K
7200 min Summer	0.158	0.158	7.7	30.2	O K
8640 min Summer	0.138	0.138	6.7	23.0	O K
10080 min Summer	0.122	0.122	5.9	18.0	O K
15 min Winter	0.390	0.390	18.9	184.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	151.466	0.0	18
30 min Summer	101.386	0.0	32
60 min Summer	64.293	0.0	62
120 min Summer	42.153	0.0	106
180 min Summer	32.298	0.0	136
240 min Summer	26.425	0.0	170
360 min Summer	19.518	0.0	238
480 min Summer	15.553	0.0	308
600 min Summer	12.957	0.0	374
720 min Summer	11.120	0.0	442
960 min Summer	8.679	0.0	570
1440 min Summer	6.054	0.0	824
2160 min Summer	4.190	0.0	1188
2880 min Summer	3.224	0.0	1556
4320 min Summer	2.233	0.0	2252
5760 min Summer	1.726	0.0	2992
7200 min Summer	1.420	0.0	3680
8640 min Summer	1.214	0.0	4408
10080 min Summer	1.066	0.0	5136
15 min Winter	151.466	0.0	18

Summary of Results for 1000 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
30 min Winter	0.453	0.453	22.0	249.4	O K
60 min Winter	0.500	0.500	24.3	304.2	O K
120 min Winter	0.547	0.547	26.6	363.7	O K
180 min Winter	0.562	0.562	27.3	383.6	O K
240 min Winter	0.566	0.566	27.5	389.6	O K
360 min Winter	0.557	0.557	27.1	377.5	O K
480 min Winter	0.539	0.539	26.2	353.6	O K
600 min Winter	0.518	0.518	25.2	326.6	O K
720 min Winter	0.497	0.497	24.1	300.0	O K
960 min Winter	0.455	0.455	22.1	251.7	O K
1440 min Winter	0.384	0.384	18.7	179.0	O K
2160 min Winter	0.305	0.305	14.8	113.3	O K
2880 min Winter	0.251	0.251	12.2	76.6	O K
4320 min Winter	0.183	0.183	8.9	40.6	O K
5760 min Winter	0.143	0.143	7.0	24.9	O K
7200 min Winter	0.118	0.118	5.7	16.9	O K
8640 min Winter	0.101	0.101	4.9	12.3	O K
10080 min Winter	0.088	0.088	4.3	9.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
30 min Winter	101.386	0.0	32
60 min Winter	64.293	0.0	60
120 min Winter	42.153	0.0	114
180 min Winter	32.298	0.0	144
240 min Winter	26.425	0.0	182
360 min Winter	19.518	0.0	258
480 min Winter	15.553	0.0	332
600 min Winter	12.957	0.0	404
720 min Winter	11.120	0.0	472
960 min Winter	8.679	0.0	606
1440 min Winter	6.054	0.0	864
2160 min Winter	4.190	0.0	1232
2880 min Winter	3.224	0.0	1584
4320 min Winter	2.233	0.0	2288
5760 min Winter	1.726	0.0	2992
7200 min Winter	1.420	0.0	3672
8640 min Winter	1.214	0.0	4408
10080 min Winter	1.066	0.0	5096

Rainfall Details

Rainfall Model	FEH	Winter Storms	Yes
Return Period (years)	1000	Cv (Summer)	0.750
FEH Rainfall Version	2013	Cv (Winter)	0.840
Site Location	GB 588788 217031	Shortest Storm (mins)	15
Data Type	Point	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 0.718

Time (mins) From:	To:	Area (ha)
0	4	0.718

Model Details

Storage is Online Cover Level (m) 1.000

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.10800	Width (m)	81.0
Membrane Percolation (mm/hr)	400	Length (m)	81.0
Max Percolation (l/s)	729.0	Slope (1:X)	100.0
Safety Factor	5.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	0.000	Membrane Depth (m)	0

APPENDIX F – ROOF SOAKAWAY EXCEEDANCE (1000YR EVENT)

Summary of Results for 1000 year Return Period

Half Drain Time : 181 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	0.375	0.375	0.3	3.2	O K
30 min Summer	0.485	0.485	0.3	4.1	O K
60 min Summer	0.577	0.577	0.3	4.9	O K
120 min Summer	0.678	0.678	0.3	5.8	O K
180 min Summer	0.709	0.709	0.4	6.1	O K
240 min Summer	0.717	0.717	0.4	6.1	O K
360 min Summer	0.699	0.699	0.3	6.0	O K
480 min Summer	0.665	0.665	0.3	5.7	O K
600 min Summer	0.627	0.627	0.3	5.4	O K
720 min Summer	0.589	0.589	0.3	5.0	O K
960 min Summer	0.518	0.518	0.3	4.4	O K
1440 min Summer	0.396	0.396	0.3	3.4	O K
2160 min Summer	0.261	0.261	0.2	2.2	O K
2880 min Summer	0.168	0.168	0.2	1.4	O K
4320 min Summer	0.066	0.066	0.2	0.6	O K
5760 min Summer	0.044	0.044	0.2	0.4	O K
7200 min Summer	0.036	0.036	0.1	0.3	O K
8640 min Summer	0.031	0.031	0.1	0.3	O K
10080 min Summer	0.027	0.027	0.1	0.2	O K
15 min Winter	0.422	0.422	0.3	3.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	151.466	0.0	18
30 min Summer	101.386	0.0	33
60 min Summer	64.293	0.0	62
120 min Summer	42.153	0.0	120
180 min Summer	32.298	0.0	150
240 min Summer	26.425	0.0	182
360 min Summer	19.518	0.0	250
480 min Summer	15.553	0.0	318
600 min Summer	12.957	0.0	386
720 min Summer	11.120	0.0	456
960 min Summer	8.679	0.0	588
1440 min Summer	6.054	0.0	852
2160 min Summer	4.190	0.0	1216
2880 min Summer	3.224	0.0	1584
4320 min Summer	2.233	0.0	2248
5760 min Summer	1.726	0.0	2936
7200 min Summer	1.420	0.0	3640
8640 min Summer	1.214	0.0	4376
10080 min Summer	1.066	0.0	5080
15 min Winter	151.466	0.0	18

Summary of Results for 1000 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
30 min Winter	0.548	0.548	0.3	4.7	O K
60 min Winter	0.656	0.656	0.3	5.6	O K
120 min Winter	0.779	0.779	0.4	6.7	O K
180 min Winter	0.816	0.816	0.4	7.0	O K
240 min Winter	0.823	0.823	0.4	7.0	O K
360 min Winter	0.798	0.798	0.4	6.8	O K
480 min Winter	0.750	0.750	0.4	6.4	O K
600 min Winter	0.697	0.697	0.3	6.0	O K
720 min Winter	0.644	0.644	0.3	5.5	O K
960 min Winter	0.544	0.544	0.3	4.7	O K
1440 min Winter	0.380	0.380	0.3	3.2	O K
2160 min Winter	0.206	0.206	0.2	1.8	O K
2880 min Winter	0.095	0.095	0.2	0.8	O K
4320 min Winter	0.041	0.041	0.2	0.4	O K
5760 min Winter	0.032	0.032	0.1	0.3	O K
7200 min Winter	0.026	0.026	0.1	0.2	O K
8640 min Winter	0.023	0.023	0.1	0.2	O K
10080 min Winter	0.020	0.020	0.1	0.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
30 min Winter	101.386	0.0	32
60 min Winter	64.293	0.0	60
120 min Winter	42.153	0.0	116
180 min Winter	32.298	0.0	168
240 min Winter	26.425	0.0	190
360 min Winter	19.518	0.0	268
480 min Winter	15.553	0.0	344
600 min Winter	12.957	0.0	418
720 min Winter	11.120	0.0	492
960 min Winter	8.679	0.0	634
1440 min Winter	6.054	0.0	896
2160 min Winter	4.190	0.0	1276
2880 min Winter	3.224	0.0	1588
4320 min Winter	2.233	0.0	2200
5760 min Winter	1.726	0.0	2936
7200 min Winter	1.420	0.0	3664
8640 min Winter	1.214	0.0	4384
10080 min Winter	1.066	0.0	5008

Rainfall Details

Rainfall Model	FEH	Winter Storms	Yes
Return Period (years)	1000	Cv (Summer)	0.750
FEH Rainfall Version	2013	Cv (Winter)	0.840
Site Location	GB 588788 217031	Shortest Storm (mins)	15
Data Type	Point	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 0.012

Time (mins) From:	To:	Area (ha)
0	4	0.012

Model Details

Storage is Online Cover Level (m) 1.200

Cellular Storage Structure

Invert Level (m) 0.000 Safety Factor 1.5
Infiltration Coefficient Base (m/hr) 0.10800 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.10800

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	9.0	9.0	1.300	0.0	23.4
1.200	9.0	23.4			

APPENDIX G – ROAD SOAKAWAY EXCEEDANCE (1000YR EVENT)

Summary of Results for 1000 year Return Period

Half Drain Time : 361 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	0.406	0.406	10.4	186.7	O K
30 min Summer	0.532	0.532	10.6	244.8	O K
60 min Summer	0.648	0.648	10.8	298.1	O K
120 min Summer	0.797	0.797	11.1	366.4	O K
180 min Summer	0.861	0.861	11.2	396.0	O K
240 min Summer	0.884	0.884	11.2	406.6	O K
360 min Summer	0.872	0.872	11.2	401.0	O K
480 min Summer	0.840	0.840	11.2	386.4	O K
600 min Summer	0.804	0.804	11.1	369.7	O K
720 min Summer	0.767	0.767	11.0	352.8	O K
960 min Summer	0.694	0.694	10.9	319.3	O K
1440 min Summer	0.560	0.560	10.7	257.4	O K
2160 min Summer	0.392	0.392	10.4	180.2	O K
2880 min Summer	0.264	0.264	10.1	121.3	O K
4320 min Summer	0.105	0.105	9.9	48.4	O K
5760 min Summer	0.049	0.049	9.6	22.7	O K
7200 min Summer	0.041	0.041	8.0	18.7	O K
8640 min Summer	0.035	0.035	6.8	16.1	O K
10080 min Summer	0.031	0.031	6.0	14.1	O K
15 min Winter	0.457	0.457	10.5	210.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	151.466	0.0	18
30 min Summer	101.386	0.0	33
60 min Summer	64.293	0.0	62
120 min Summer	42.153	0.0	122
180 min Summer	32.298	0.0	182
240 min Summer	26.425	0.0	240
360 min Summer	19.518	0.0	310
480 min Summer	15.553	0.0	372
600 min Summer	12.957	0.0	434
720 min Summer	11.120	0.0	500
960 min Summer	8.679	0.0	636
1440 min Summer	6.054	0.0	906
2160 min Summer	4.190	0.0	1280
2880 min Summer	3.224	0.0	1644
4320 min Summer	2.233	0.0	2292
5760 min Summer	1.726	0.0	2936
7200 min Summer	1.420	0.0	3672
8640 min Summer	1.214	0.0	4400
10080 min Summer	1.066	0.0	5112
15 min Winter	151.466	0.0	18

Summary of Results for 1000 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
30 min Winter	0.601	0.601	10.7	276.3	O K
60 min Winter	0.735	0.735	11.0	338.1	O K
120 min Winter	0.912	0.912	11.3	419.1	Flood Risk
180 min Winter	0.994	0.994	11.4	456.9	Flood Risk
240 min Winter	1.029	1.029	11.5	473.2	Flood Risk
360 min Winter	1.026	1.026	11.5	471.9	Flood Risk
480 min Winter	0.983	0.983	11.4	452.0	Flood Risk
600 min Winter	0.938	0.938	11.3	431.3	Flood Risk
720 min Winter	0.889	0.889	11.2	408.9	O K
960 min Winter	0.789	0.789	11.1	362.6	O K
1440 min Winter	0.596	0.596	10.7	274.1	O K
2160 min Winter	0.357	0.357	10.3	164.3	O K
2880 min Winter	0.183	0.183	10.0	84.1	O K
4320 min Winter	0.046	0.046	9.0	21.3	O K
5760 min Winter	0.036	0.036	7.0	16.5	O K
7200 min Winter	0.030	0.030	5.8	13.6	O K
8640 min Winter	0.025	0.025	4.9	11.5	O K
10080 min Winter	0.022	0.022	4.3	10.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
30 min Winter	101.386	0.0	33
60 min Winter	64.293	0.0	62
120 min Winter	42.153	0.0	120
180 min Winter	32.298	0.0	178
240 min Winter	26.425	0.0	234
360 min Winter	19.518	0.0	342
480 min Winter	15.553	0.0	396
600 min Winter	12.957	0.0	464
720 min Winter	11.120	0.0	542
960 min Winter	8.679	0.0	692
1440 min Winter	6.054	0.0	980
2160 min Winter	4.190	0.0	1364
2880 min Winter	3.224	0.0	1700
4320 min Winter	2.233	0.0	2204
5760 min Winter	1.726	0.0	2936
7200 min Winter	1.420	0.0	3624
8640 min Winter	1.214	0.0	4400
10080 min Winter	1.066	0.0	5120

Rainfall Details

Rainfall Model	FEH	Winter Storms	Yes
Return Period (years)	1000	Cv (Summer)	0.750
FEH Rainfall Version	2013	Cv (Winter)	0.840
Site Location	GB 588788 217031	Shortest Storm (mins)	15
Data Type	Point	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 0.689

Time (mins) From:	To:	Area (ha)
0	4	0.689

Model Details

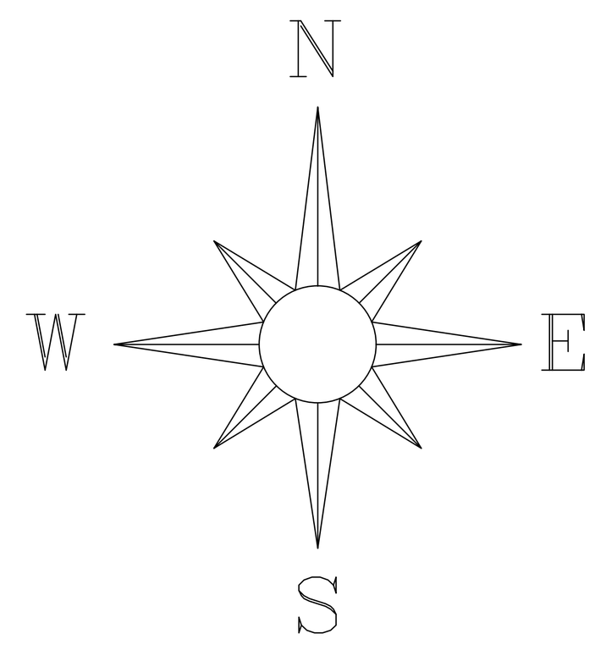
Storage is Online Cover Level (m) 1.200

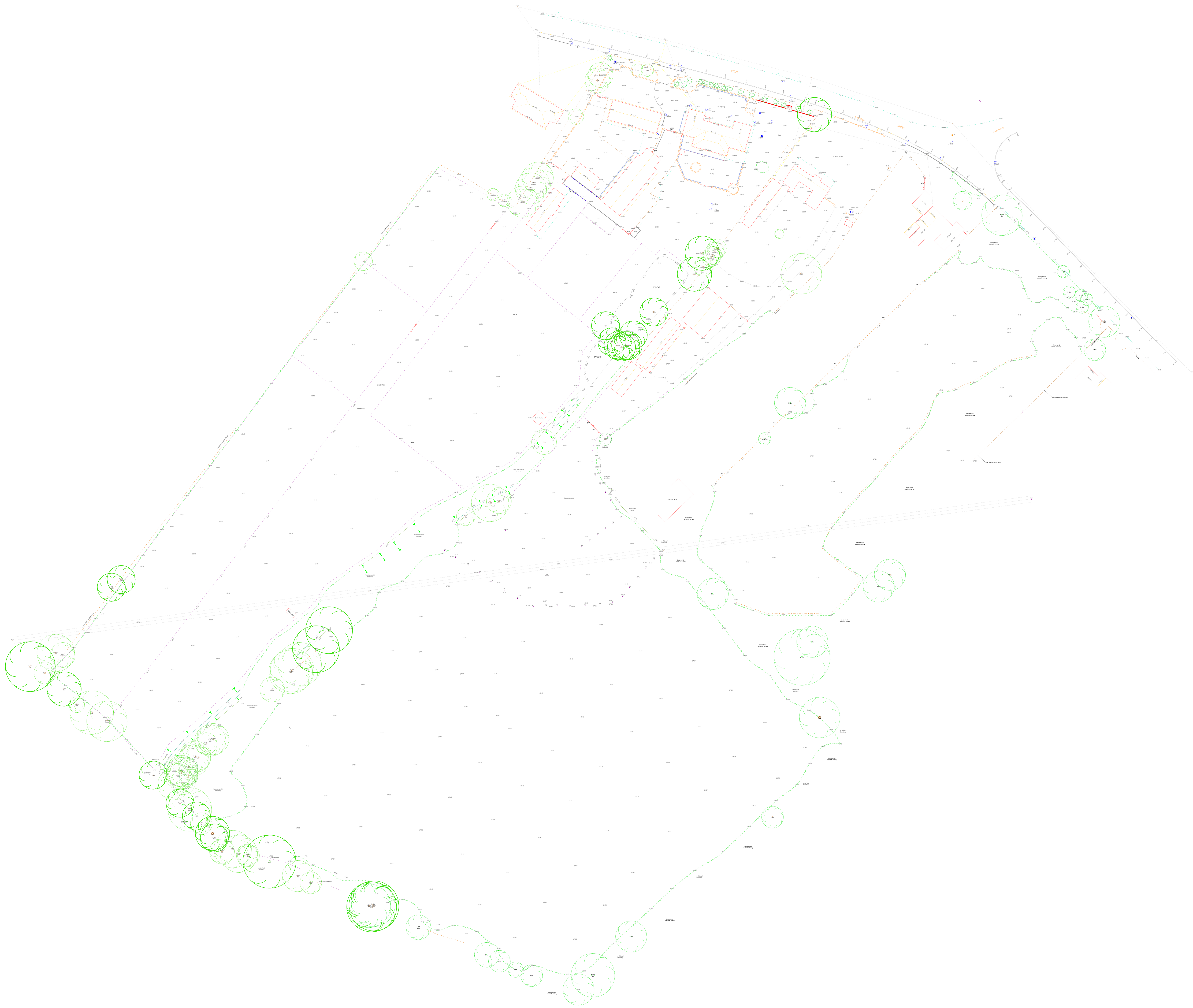
Cellular Storage Structure

Invert Level (m) 0.000 Safety Factor 1.5
Infiltration Coefficient Base (m/hr) 0.10800 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.10800

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	484.0	484.0	1.300	0.0	589.6
1.200	484.0	589.6			

DRAWINGS





CONTROL STATION COORDINATES

Station	Easting	Northing	Level
GPS1	588708.597	217153.763	69.398
GPS2	588727.975	217148.798	69.213
GPS3	588750.012	217143.078	69.106
GPS4	588790.853	217129.436	68.808
GPS5	588832.090	217118.010	68.409

All levels related to Ordnance Survey (Leica Smartnet network)

Revision	Description	Date

L E G E N D

Survey control station — 5

Banking

Gate (double)

Tree Spread and Girth shown to scale

Abbreviations

Bollard	BD	Post	P
Borehole	BH	Pipe	PE
British Telecom Box	BTB	Road Sign	RS
BT Inspection Cover	BT	Rodding Eye	RE
Concrete Paving Slabs	CPS	Service Marker	MK
Cable Television Cover	CTV	Sign Post	SP
Electricity Cable Pit	EC	Sluice Valve	SV
Electricity Pole	EP	Stop Tap	ST
Earth Rod	ER	Stop Cock	SC
Fire Hydrant	FH	Telegraph Pole	TP
Flag Staff	FS	Telephone Call Box	TCB
Gas Valve	GV	Traffic Light	TL
Gate Post	GP	Underside	U\S
Gully	GY	Vent Pipe	VP
Inspection Cover	IC	Water Meter	WM
Kerb Outlet	KO	Eaves Tile Level	ETL
Lamp Post	LP	Ridge Level	RL
Manhole	MH	Roof Level	RFL
Marker Post	MK	Soffit Level	SFL
Parking Meter	PM	Stop Valve	SV
		Threshold Level	THL
Retaining Wall	RTW	Cover Level	CL
Barbed Wire Fence	BWF	Invert Level	IL
Close Boarded Fence	CBF	No Visible Connection	NVC
Chainlink Fence	CLF	Unable to Lift	UTL
Panel Fence	PF		
Post and Chain Fence	PCF		
Post and Rail Fence	PRF		
Post and Wire Fence	PWF		

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Email : jtaylorsiteeng@aol.co.uk

CLIENT:

Marden Homes Ltd

PROJECT:

Towers End,
Kelvedon Rd,
Tipree

TITLE:

Topographical Survey

SURVEYOR: JT/RC

DRAWN BY: JT/RC — SHEET SIZE: A0

DATE: Nov 17 — SCALE: 1:500 @A0

DRAWING No: 0 — JOB No:

0 5 10 15 20 25 30 Scale Bar

Scale : 1:500 @ A1

Date : Nov2018

Status : PLANNING

Dwg No : 2018.190.002

Rev :

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Client : Marden Homes Ltd

Project : Land at Kelvedon Road, Tiptree

Drawing : Site Plan


EVANS
Rivers and Coastal