Land west of Heath House Lane and north of Uttoxeter Road, Lower Tean, Staffordshire, ST10 4LP

Sustainable Drainage Assessment

For Staffordshire Rural Development Ltd

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www.krsenvironmental.com

CONTACT DETAILS

Registered Office:
KRS Environmental Ltd
3 Princes Square
Princes Street
Montgomery
Powys
SY15 6PZ

Tel: 01686 668957
Mob: 07857 264 376

Email: keelan@krsenvironmental.com
Web: www.krsenvironmental.com
LinkedIn: uk.linkedin.com/in/keelanserjeant/

Office also at:
KRS Environmental Ltd
The Media Centre
7 Northumberland Street
Huddersfield
West Yorkshire
HD1 1RL

Tel: 01484 437420
Mob: 07857 264 376

Land west of Heath House Lane and north of Uttoxeter Road, Lower Tean, Staffordshire, ST10 4LP

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Prepared by	Keelan Serjeant BSc (Hons), MSc, MCIWEM
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1.0 INTRODUCTION

1.1 Background

This Sustainable Drainage Assessment has been prepared by KRS Environmental Limited at the request of Staffordshire Rural Development Ltd to support a planning application for the proposed development at Land west of Heath House Lane and north of Uttoxeter Road, Lower Tean, Staffordshire, ST10 4LP.

It is recognised that developments that are designed without regards to the surface water runoff are likely to result in increased impact on existing off site service provision and may leads to an increase in flood risk.

1.2 Purpose

This Sustainable Drainage Assessment complies with the principles of SUDS presented in the new Defra non-statutory technical standards for SUDS[1], and the National Planning Policy Framework (NPPF)[2]. A surface water drainage assessment is presented with reference to the hydrological and hydrogeological context of the development.

The report findings are based upon professional judgement and are summarised below with detailed recommendations provided at the end of the report.

The report includes baseline data on: flood risk from the Environment Agency, rainfall data from the Flood Estimation Handbook (FEH) and hydrogeological information from the British Geological Survey (BGS). The assessment will summarise and refer to these datasets in the text.

1.3 What are SUDS?

A sustainable drainage system (SUDS) is designed to replicate, as closely as possible, the natural drainage from the site (before development) to ensure that the flood risk downstream of the Site does not increase as a result of the land being developed. SUDS can also significantly improve the quality of water leaving the Site and can enhance the amenity and biodiversity that a site has to offer.

There are a range of SUDS options available to provide effective surface water management that intercept and store excess run-off. The standards set out appropriate design criteria based on four main parameters:

1. Runoff Destination (in order of preference)

    a. To ground;
    b. To surface water body;
    c. To road drain or surface water sewer;
    d. To combined sewer

2. Peak flow rate and volume (pre and post development)

3. Water Quality (based on potential hazards arising from development and sensitivity of the runoff destination)

[1] Department for Environment, Food and Rural Affairs (2015) Non-statutory technical standards for SUDS (March 2015).
[2] Department for Communities and Local Government (2012). National Planning Policy Framework (NPPF).

4. Function (design; flood risk; operation and maintenance)

These parameters are then used to develop a drainage strategy based on the following six principles;

1. Manage surface runoff at source
2. Manage on the surface
3. Utilise public space and integrate into the drainage design
4. Effective operation and maintenance
5. Account for climate change and changes in impermeable area
6. Affordability

This report aims identify the most practicable runoff destination and drainage parameters for each site. A surface water drainage assessment is presented with reference to the hydrological and hydrogeological context of the development.

1.4 Report Structure

This Sustainable Drainage Assessment has the following report structure:

- Section 2 details the location & development description;
- Sections 3 details the existing sewer network within the vicinity of the site;
- Section 4 outlines the proposed surface water drainage for the site; and
- Section 5 presents a summary and conclusions.

2.0 LOCATION & DEVELOPMENT DESCRIPTION

2.1 Site Location

The site is located on Land west of Heath House Lane and north of Uttoxeter Road, Lower Tean, Staffordshire, ST10 4LP (see Figure 1). The National Grid Reference (NGR) of the site is 401649, 338629. The site covers a parcel of land of approximately 1.08 hectares (ha) or 10,800m^2.

The site is a grassed field on the northern side of Uttoxeter Road, the main spine road through Lower Tean, which is the smaller of the two parts making up the settlement of Tean in Checkley Parish. It is on the other side of Heath House Lane from a housing estate centred on Goldhurst Drive. The frontage to Uttoxeter Road is approximately 1.00m above pavement level and is separated from it by a low stone wall with a mature hedge above.

The site rises gently from the Uttoxeter Road frontage to the northernmost fence. Another mature hedge on this boundary separates the site from the field to the north which contains a Bowl Barrow. The western boundary is a well-trimmed hedge interspersed with the gable of an outbuilding to Yewtree, a Grade 2 listed building. To the north the elevations of The Firs are clearly visible. The boundary with Heath House Lane is also a hedge but there is an existing vehicular and pedestrian access here onto the site.



Figure 1 - Site Location

2.2 Existing Development

The current site consists of a grassed field and is in a greenfield state.

2.3 Proposed Development

It is understood that the proposals are for up to twenty dwellings are proposed of which seven will have one or two bedrooms and will be 'affordable' with restricted occupancy. Further details with regard to the proposed development can be found in the accompanying information submitted with the planning application.

2.4 Ground Levels

A topographical survey of the site has recently been undertaken (see Appendix 1). The site falls from north east to south east by 8.00m. The maximum ground level is 134.93 metres Above Ordnance Datum (mAOD) and minimum ground level is 127.06mAOD. The areas surrounding the site also fall from north east to south east down towards Uttoxeter Road.

2.5 Catchment Hydrology

The site lies within the catchment of the River Tean which is located approximately 200m to the south of the site on the southern side of Uttoxeter Road (see Figure 1). There are no other watercourses evident either on, or within the vicinity of the site.

The surface runoff from the field drains into the soil substrate via infiltration or when the infiltration capacity is exceeded may runoff from the site as overland flow following the local topography and discharge into any local ditches linked to the River Tean. Flow paths represent overland sheet flow draining towards the south.

The key catchment descriptors for the site have been extracted from the Flood Estimation Handbook (FEH) CD-ROM (v3)[3] and are summarised in Table 1. The site is located within an area of moderate rainfall. The 1961-1990 Standard Average Annual Rainfall (SAAR) for the site as recorded in the FEH CD-ROM is 838 mm per annum. The UK national average is 832mm per annum.

The SPRHOST value (Standard Percentage Runoff) is low at 23.70 and indicates a permeable catchment and/or evapotranspiration is low. Approximately 23.70% of the rainfall will contribute to direct runoff rather than be stored. The BFIHOST value (Baseflow Index) is 0.742 indicating a responsive catchment to rainfall with the majority of baseflow being rainfall derived. The catchment is essentially rural with an URBEXT1990 value of 0.02.

Table 1 - Key Catchment Descriptors

Catchment Descriptor	Value
BFIHOST (Baseflow Index)	0.742
SAAR (Standard Average Annual Rainfall)	838
SPRHOST (Standard Percentage Runoff)	23.70
URBEXT1990	0.02
C	-0.030
D1	0.395
D2	0.282
D3	0.348
E	0.312
F	2.352

[3] NERC (2009) WINFAP-FEH CD-ROM version 3.0.

The site is located within Flood Zone 1 and therefore, has a 'low probability' of fluvial flooding with a chance of less than 1 in 1000 (0.1%) years. The site has a very low risk of surface water flooding with a chance of less than 1 in 1000 (0.1%) years. The site is not at risk of flooding from reservoirs.

2.6 Geology

The British Geological Survey (BGS) Map4 indicates that the bedrock underlying the site consists of the Tarporley Siltstone Formation - Siltstone, Mudstone and Sandstone. Sedimentary Bedrock formed approximately 237 to 250 million years ago in the Triassic Period. Local environment previously dominated by lakes.

The superficial deposits consist of River Terrace Deposits, 2 - Sand and Gravel. Superficial Deposits formed up to 3 million years ago in the Quaternary Period. Local environment previously dominated by rivers. No Made Ground (undivided) - artificial deposits is shown to underlay the site.

No ground investigation has been undertaken at the site. However, boreholes SK03NW88 and SK03NW87 area located are located 200m to the north east of the site. The recorded strata is shown in Table 2.

Table 2 - Strata

Borehole	Description	Depth (m)	Thickness (m)
SK03NW88	Topsoil	0.00 – 0.30	0.30
	Brown clayey sand	0.30 – 0.60	0.30
	Very stiff dark brown marly clay	0.60 – 1.80	1.20
SK03NW87	Brown silty topsoil with plant roots	0.00 – 0.30	0.30
	Reddish brown clay with layers of soft sandstone	0.30 – 1.50	1.20
	Reddish brown, soft calcareous sandstone	1.50 – 6.70	5.20

2.7 Aquifers

The Environment Agency[5] has designated the bedrock deposits as a 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. These are generally the water-bearing parts of the former non-aquifers.

The superficial deposits are designated as a Secondary Undifferentiated Aquifer - has been assigned in cases 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.

2.8 Groundwater Levels

No ground investigation has been undertaken at the site. However, boreholes SK03NW88 and SK03NW87 area located are located 200m to the north east of the site. No groundwater was encountered in either borehole to e maximum depth of 6.70 metres below ground level (mbgl).

2.9 Source Protection Zone

The site is located within an Environment Agency Groundwater Source Protection Zone (SPZ). The site is located within the total catchment (Zone 3) - Defined as the area around a source within

[4] British Geological Survey (BGS), 2015. Geology of Britain Viewer. Based on British Geological Survey materials © NERC 2015. (http://mapapps.bgs.ac.uk/geologyofbritain/home.html). Last accessed 01/03/2016.

[5] Environment Agency (2015) What's in my backyard? (http://apps.environmentagency.gov.uk/wiyby/default.aspx). Last Accessed 01/03/2016.

which all groundwater recharge is presumed to be discharged at the source. In confined aquifers, the source catchment may be displaced some distance from the source. For heavily exploited aquifers, the final Source Catchment Protection Zone can be defined as the whole aquifer recharge area where the ratio of groundwater abstraction to aquifer recharge (average recharge multiplied by outcrop area) is >0.75. There is still the need to define individual source protection areas to assist operators in catchment management.

SPZ's have been defined by the Environment Agency around major public water supplies with the intent to show the risk of contamination from any activities that might cause pollution in the area. Three zones are defined: SPZ 1 is the Inner Zone (highest risk); SPZ 2 is the Outer Zone (average risk); SPZ 3 is the Total Catchment (least risk).

2.10 Soil

Information from the National Soil Resource Institute6 details the site area as being situated on freely draining slightly acid loamy soils with drainage to local groundwater and rivers.

The Flood Studies Report WRAP soil map classification is Type 3: i) Relatively impermeable soils in boulder and sedimentary clays, and in alluvium, especially in eastern England; ii) Permeable soils with shallow ground water in low-lying areas; and iii) Mixed areas of permeable and impermeable soils, in approximately equal proportions.

For each of these categories there is a value of SPR which is used in the IOH124 equation. For Type 3 the value of SPR is 0.40. The FEH CD-ROM percentage runoff (SPRHOST) value is 23.70%.

2.11 Contaminated Land

The site is in a greenfield state and we are not aware of any historical industrial land use. The potential for contamination is low. Further investigation would be required to confirm this. The client has not provided information to suggest the potential for contamination within the site boundary from past land uses.

2.12 Ground stability

Dissolution, sand liquefaction and landslides could be enhanced by SUDS infiltration and lead to unstable ground. Dissolution risk is low since the site does not appear to be directly underlain by chalk or other soluble rocks. Sand liquefaction risk is low since the site is not located on unconsolidated superficial sand deposits. Landslide risk is low since there are no records of landslides close to the site according to the BGS.

2.13 Permeability/Infiltration Rate

In determining the future surface runoff from the site, the potential of using infiltration devices has been considered. As no site geotechnical information on the permeability and infiltration rate at the site has been acquired at this stage it is not possible to comment definitively upon the suitability of infiltration based systems. However, an overview of the general ground conditions (see Sections 2.4 to 2.12) may be used to gauge if there is potential for their application.

The general ground conditions suggest that the permeability and infiltration rate of the site will be moderate. Whilst the permeability and infiltration rate of the site should ideally be confirmed by a site investigation into the hydrogeology of the site, the ground conditions suggest infiltration techniques such as soakaways may work and may t provide a suitable option at the site.

[6] https://www.landis.org.uk/soilscapes/

If an infiltration system is proposed, it is recommended that a series of infiltration/soakaway tests are carried out on site to BRE Digest 365 Guidelines to confirm the assumptions made in the calculations. Such work is beyond the scope of this FRA, but should be undertaken to inform the detailed drainage strategy for the site.

3.0 SEWER NETWORKS

3.1 Introduction

This section details the existing water network infrastructure within and adjacent to the site. The existing water network has been identified and assessed using a number of techniques including correspondence with Severn Trent Water (see Appendix 2).

It is recognised that developments that are designed without regards to the foul and surface water sewers are likely to result in increased impact on existing off site service provision. In addition, it is possible that substantial services cross the site, which may have associated easements.

Understanding the impact of existing services and potential reinforcement can be helpful in determining development areas of the scheme and also associated costs. In addition, any foul and/or surface water strategy may also require an understanding of the existing capacity.

3.2 Existing Foul Sewers

There are two 150mm diameter Severn Trent Water public foul sewers in Uttoxeter Road one heading north west and the other heading south east.

Severn Trent Water has no duty to keep records of private sewers, and there are no comprehensive records kept elsewhere. It is highly recommended that site investigation of any proposed working area is undertaken to establish whether any unmapped public or private sewers and lateral drains are in existence.

3.3 Foul Sewer Capacity Check

Severn Trent Water has confirmed that the average foul flows from 20 properties estimated to be 0.30l/s at 2DWF should not have an adverse hydraulic impact on their network. A connection of connections is therefore acceptable to Severn Trent Water at manhole reference 6501 and 6507 or any convenient location subject to formal S106 approval,

3.4 Existing Surface Water Sewers

There is a 150mm diameter Severn Trent Water public surface water sewer adjacent to the site in Heath House Lane (MH7602) and a 300mm diameter surface water sewer at the junction of Uttoxeter Road and Leigh Lane.

Severn Trent Water has no duty to keep records of private sewers, and there are no comprehensive records kept elsewhere. It is highly recommended that site investigation of any proposed working area is undertaken to establish whether any unmapped public or private sewers and lateral drains are in existence.

3.5 Surface Water Sewer Capacity Check

Severn Trent Water has confirmed in the event that following comprehensive testing it is demonstrated that soakaways are not feasible for surface water disposal on the site, a connection to the surface water sewer system would be appropriate within flows rates restricted in accordance with our guidance note 3, or stipulated by Staffordshire County Council as the Lead Local Flood Authority.

4.0 SURFACE WATER DRAINAGE

4.1 Surface Water Overview

It is recognised that consideration of flood issues should not be confined to the floodplain. The alteration of natural surface water flow patterns through developments can lead to problems elsewhere in the catchment, particularly flooding downstream. For example, replacing vegetated areas with roofs, roads and other paved areas can increase both the total and the peak flow of surface water runoff from the development site. Changes of land use on previously developed land can also have significant downstream impacts where the existing drainage system may not have sufficient capacity for the additional drainage.

A surface water management strategy for the site proposals has been developed to manage and reduce the flood risk posed by the surface water runoff from the site. An assessment of the surface water runoff rates has been undertaken, in order to determine the surface water options and attenuation requirements for the site. The assessment considers the impact of the development compared to current conditions. Therefore, the surface water attenuation requirement for the developed site can be determined and reviewed against existing arrangements.

The requirement for managing surface water runoff from developments depends on the pre-developed nature of the site. If it is an undeveloped greenfield site, then the impact of the development will need to be mitigated so that the runoff from the site replicates the natural drainage characteristics of the pre-developed site. In the case of brownfield sites, drainage proposals will be measured against the existing performance of the site, although it is preferable for solutions to provide runoff characteristics that are similar to greenfield behaviour.

The surface water drainage arrangements for any development site should be such that the volumes and peak flow rates of surface water leaving a developed site are no greater than the rates prior to the proposed development, unless specific off-site arrangements are made and result in the same net effect.

It should be acknowledged that the satisfactory collection, control and discharge of surface water runoff are now a principle planning and design consideration. This is reflected in recently implemented guidance as well as the new Defra non-statutory technical standards for SUDS.

At this stage a detailed surface water drainage design has not been undertaken, however it is necessary to demonstrate that the surface water from the proposed development can be discharged safety and sustainably.

4.2 Site Areas

The current site consists of a grassed field and is in a greenfield state and covers an of 1.08ha or 10,800m^2. It is understood that the existing drainage infrastructure at the site efficiently and effectively manages surface water runoff generated at the site. As there is no history of surface water flooding at the site it is likely that the current drainage system is sufficient for the current and proposed site use. It is understood that the proposals are for up to twenty dwellings.

Table 3 shows that the pre-development site is constructed from 1.08ha (100%) of permeable surfaces with 0.00ha (0%) impermeable surfaces. At this stage a proposed site layout has not been finalised therefore, a conservative estimate of the post-development site permeable and impermeable surfaces has been used in the calculations.

The post-development will be constructed from 0.54ha (50%) of impermeable surfaces with 0.54ha (50%) of permeable surfaces. The proposed development will increase the impermeable area and therefore, the developed site will generate higher surface water runoff rates and volumes post-development if the surface water runoff is not restricted and attenuated on site.

Table 3 - Site Areas (ha)

Element	Pre-development	Post-development	Difference
Permeable Surfaces	1.08 (10,800m^2)	0.54 (5,400m^2)	- 0.54 (5,400m^2)
Impermeable Surfaces	0.00 (00m^2)	0.54 (5,400m^2)	+ 0.54 (5,400m^2)
Total	**1.08 (10,800m^2)**	**1.08 (10,800m^2)**	----

4.3 Climate change

Projections of future climate change, in the UK, indicate more frequent, short-duration, high intensity rainfall and more frequent periods of long duration rainfall. Guidance included within the NPPF recommends that the effects of climate change are incorporated into Flood Risk Assessments. Recommended precautionary sensitivity ranges for peak rainfall intensities and peak river flows are outlined in the associated Planning Practice Guidance to the NPPF[7].

The recommended national precautionary sensitivity range for peak rainfall intensity are summarised in (see Table 4).

Table 4 - National precautionary sensitivity ranges relevant to site

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

4.4 Surface Water Runoff Rates

An estimation of run-off is required to permit effective site water management and prevent any increase in flood risk to off-site receptors. The SUDS Manual recommends the use of Institute of Hydrology Report No. 124 (IoH124)[8] for site runoff calculations for sites less than 50ha but a recent Environment Agency Research & Development report[9] recommends that this method should no longer be used.

Using rainfall data from the Flood Estimation Handbook (FEH) CD-ROM[10], the potential surface water run-off generated from the site during 1 in 1, 1 in 2, 1 in 30 and 1 in 100 year return period rainfall events have been calculated for a storm duration of 6 hours. The method used for calculating the runoff complies with the NPPF, as well as the new Defra non-statutory technical standards for SUDS, and assumes that the excess runoff associated with the proposed development (plus an allowance for future climate change) will need to be managed by the proposed SUDS scheme.

For the impermeable surfaces, it has been assumed that 100% runoff will occur from these areas in the proposed development. The assumed minimum lifespan of the proposed residential development is 100 years, therefore 20% and 30% future climate change has been accounted for in the proposed development calculations with an influence of +30% for both impermeable and permeable surfaces, in accordance with the Planning Practice Guidance to the NPPF.

[7] Communities and Local Government (2014) Planning Practice Guidance - Flood Risk and Coastal Change.
[8] Institute of Hydrology Report No. 124, Flood Estimation for Small Catchments.
[9] Estimating flood peaks and hydrographs for small catchments: Phase 1, SC090031, June 2012.
[10] NERC (2009) WINFAP-FEH CD-ROM version 3.0.

In accordance with The SUDS Manual, the Greenfield run-off from the site has been calculated using the IoH124 method. This is used as a reference representative of the run-off generated on the permeable surfaces within the site. QBAR (rural) has been calculated to be 4.05l/s.

Table 5 below shows a comparison of surface water runoff rates pre- and post-development.

Table 5 - Pre-development Peak Flows

Rainfall Event (6 hours)	Rainfall (mm)	Rainfall + CC (mm)	Existing Site Run-off Rate (l/s)	Existing Site Run-off Rate + CC (l/s)
1	15.70	20.41	2.00	2.40
2	23.40	30.42	2.00	2.40
30	51.10	66.43	5.90	7.08
100	69.90	90.87	8.00	9.16

In accordance with The SUDS Manual, the Greenfield run-off from the site has been calculated using the IoH124 method. This is used as a reference representative of the run-off generated on the permeable surfaces within the site. QBAR (rural) has been calculated to be 0.082l/s.

4.5 Opportunities for Discharge of Surface Water

There are four possible options to discharge the surface water runoff in accordance with the requirements the Defra non-statutory technical standards for SUDS. The Runoff Destination is (in order of preference):

a) To ground;

b) To surface water body;

c) To road drain or surface water sewer;

d) To combined sewer

It is necessary to identify the most appropriate method of controlling and discharging surface water. The design should seek to improve the local runoff profile by using systems that can either attenuate runoff and reduce peak flow rates or positively impact on the existing surface water runoff.

4.5.1 Discharge to Ground

Whilst the permeability and infiltration rate of the site should ideally be confirmed by a site investigation into the hydrogeology of the site, the ground conditions suggest infiltration techniques such as soakaways may work and may provide a suitable option at the site (see Section 2.13).

If an infiltration system is proposed, it is recommended that a series of infiltration/soakaway tests are carried out on site to BRE Digest 365 Guidelines to confirm the assumptions made in the calculations. Such work is beyond the scope of this FRA, but should be undertaken to inform the detailed drainage strategy for the site. This option should be explored further.

4.5.2 Discharge to Surface Water Body

Should infiltration be found to be unsuitable, the next option is discharge to a watercourse. The River Tean is located approximately 100m to the south of the site. There are no other watercourses evident either on, or within the vicinity of the site.

It has been determined that surface water runoff from the site cannot practicably be discharged to a surface water body, for the following reasons:

1. The distance from the point of discharge from the site to the surface water body is significantly greater than to the proposed alternative receiving public sewer, and this constraint outweighs any negative impacts resulting from discharging to the alternative location.

2. Access over 3rd party land between the site and the receiving surface water body cannot be secured.

Therefore, discharge to water body will not be possible.

4.5.3 Discharge to Road Drain or Surface Water Sewer

In the event that discharge of surface water via infiltration or discharge to a watercourse is deemed unsuitable, then discharge to the public surface water sewer will be possible. All surface water runoff that cannot be discharged via infiltration or to a watercourse will be managed on site and then discharged to a surface water sewer. This has been confirmed by Severn Trent Water. (see Appendix 2). In the event of surface water draining to the public surface water sewer, the pass forward flow rate to the public sewer must be restricted to 5l/s/ha.

Discharge to the surface water sewers would be restricted to 5l/s. It would be prudent to undertake further detailed surveys to verify the inverts, depth and arrangement of the existing public sewer. A connection to the sewers may be made at a location/s adjacent to the site. It will may be possible to discharge to the public surface water sewers, at a point adjacent to the site. This option should be explored further.

4.5.4 Discharge to a Combined Sewer

This option will not be required.

4.6 SUDS and Water Quality

Current guidance promotes sustainable water management through the use of SUDS. SUDS measures should be used to control the surface water runoff from the proposed development site therefore, managing the flood risk to the site and surrounding areas from surface water runoff.

One of the aims of the NPPF is to provide not only flood risk mitigation but also to maximise additional gains such as improvements in runoff quality and provision of amenity and bio-diversity. Systems incorporating these features are often termed SUDS and it is the requirement of NPPF that these are considered as the primary means of collection, control and disposal for storm water as close to source as possible.

A hierarchy of techniques is identified[11]:

1. **Prevention** – the use of good site design and housekeeping measures on individual sites to prevent runoff and pollution (e.g. minimise areas of hard standing).

2. **Source Control** – control of runoff at or very near its source (such as the use of rainwater harvesting, permeable paving, soakaways and/or green roofs).

[11] CIRIA (2004) Report C609, Sustainable Drainage Systems – Hydraulic, Structural and Water Quality advice.

3. **Site Control** – management of water from several sub-catchments (including routing water from roofs and car parks to one/several large soakaways for the whole site, swales and/or infiltration trenches).

4. **Regional Control** – management of runoff from several sites, typically in a detention pond, basins, tanks and/or wetland.

It is generally accepted that the implementation of SUDS as opposed to conventional drainage systems, provides several benefits by:

- reducing peak flows to watercourses or sewers and potentially reducing the risk of flooding downstream;
- reducing the volumes and frequency of water flowing directly to watercourses or sewers from developed sites;
- improving water quality over conventional surface water sewers by removing pollutants from diffuse pollutant sources;
- reducing potable water demand through rainwater harvesting;
- improving amenity through the provision of public open spaces and wildlife habitat; and
- replicating natural drainage patterns, including the recharge of groundwater so that base flows are maintained.

The most appropriate attenuation system will need to satisfy three main characteristics, firstly, provide the required volume of storage, secondly, minimise the loss of developable land and thirdly, where possible provide local amenity.

The application of the SUDS Manual[12] requires that the runoff from sites is not only restricted to meet the Greenfield runoff characteristics but also that SUDS systems are utilised to improve the quality of the runoff prior to outfall to watercourses.

The SUDS Manual and Environment Agency guidance applies a sustainability hierarchy to the various types of SUDS systems, this is summarised in Table 6.

[12] CIRIA C697 SUDS Manual, 2007.

Table 6 - Sustainability Hierarchy

Most Sustainable	SUDS Technique	Flood Reduction	Pollution Reduction	Landscape & Wildlife
	Living Roofs	✓	✓	✓
	Basins and ponds - Constructed wetlands - Balancing ponds - Detention basins - Retention ponds	✓	✓	✓
	Filter strips and swales	✓	✓	✓
	Infiltration Devices - Soakaways	✓	✓	✓
	Permeable Surfaces and Filter Drains - Gravelled areas - Solid paving blocks - Permeable paving	✓	✓	
Least Sustainable	**Tanked systems** - Over-sized pipes/tanks - Cellular storage	✓		

Systems at the top of the hierarchy provide a combination of attenuation, treatment and ecology and are deemed the most sustainable options. There are always specific scenarios where systems are more suitable than others and at this stage it is not possible to guide the development towards a particular strategy.

The usual approach is to consider the 'SUDS train' where each of the above options are considered in turn until a suitable solution is found. Thus source control techniques such as soakaways, rainwater harvesting and/or infiltration trenches, if suitable on a site, are considered preferable to permeable conveyance and passive treatment systems such as tanks or ponds. The various options are considered in outline below.

The volume of attenuation storage required could be provided by a variety of means these methods are discussed below.

4.6.1 Source Control

(i) Soakaways

Soakaways are buried rings or tanks filled with rubble or stone and allow gradual infiltration of collected runoff from impermeable areas into the surrounding soil. They require relatively permeable strata below a site to allow percolation and the reduction in runoff is achieved by the volume of percolation and the available storage volume. An assessment of their suitability requires the characteristics of the sub-soils or the geology to confirm the infiltration rate or vertical permeability.

The availability of suitable locations on the site is very limited due to the site being impermeable. Whilst the permeability and infiltration rate of the site should ideally be confirmed by a site investigation into the hydrogeology of the site, the ground conditions suggest infiltration techniques such as soakaways may work and may provide a suitable option at the site.

If an infiltration system is proposed, it is recommended that a series of infiltration/soakaway tests are carried out on site to BRE Digest 365 Guidelines to confirm the assumptions made in the

calculations. Such work is beyond the scope of this FRA, but should be undertaken to inform the detailed drainage strategy for the site.

(ii) Permeable Paving

The use of permeable paving can often be considered for pedestrian or car parking areas but not for heavy traffic areas such as roadways where the heavy loading could damage the paving infrastructure. Permeable paving also depends on having permeable underlying strata. The permeable paving can either discharge via infiltration or discharge to cellular storage.

Permeable paving will provide storage for the first 5mm (interception storage) as a minimum. It is should be noted that any permeable paving system to be installed by a developer must have an infiltration rate of at least 30mm/hr (0.03m/hr) to avoid ponding on the surface before it reaches the natural soil (permeable paving systems generally would have an infiltration rate in excess of 30mm/hr).

These systems also encourage biological treatment of flow and extraction of oils and heavy metals from the run-off. Treatment processes that occur within the surface structure and the geotextile layers include:

- Filtration
- Absorption
- Biodegradation
- Sedimentation

Land take is reduced as storage is located under car parks and access roads. However, maintenance is potentially a long term issue and the possibility of the paving being damaged, dug up and not properly reinstated or not regularly swept could lead to compromising the future capacity of the system.

This system will negate the need for a separate collection system such as kerbs and gullies. It will also assist in reducing the flood profile of the site by significantly attenuating the run-off from the development within the sub base material.

There is no specific amenity provided by the system other than enabling other areas to be utilised for development rather than potentially sterilizing areas with an easement for a sewer or stand-off for a basin.

Permeable paving could be utilised within the car parking area of the site. Permeable paving could also discharge to cellular storage (see Section 3.6.3).

(iii) Rainwater Harvesting

The reuse of water from roofed areas to provide grey (non-potable) water for flushing WCs within buildings can reduce storm runoff without the need for treatment or oil separators since the risk of spillage or contamination is low. Such a facility could be practical depending on the available water volumes. Over the course of a year a grey water system will reduce the volume of water entering the storm water disposal system and could be considered.

Such a system would require one or more tanks at roof level and under optimum conditions these would be kept as near as full as possible to ensure a reliable water supply. For the purposes of a worst case design scenario it is assumed that the tanks would be full at the start of an extreme rainfall event and hence all storm rainfall would enter the surface water drainage system rather than

grey water storage. Whilst there may be merit in including such a scheme in the overall designs these are not considered appropriate in the SUDS assessment.

(iv) Green Roofs

A green roof is a multi-layered system that covers the top of a building with soil and vegetation and which can provide a degree of rain storm attenuation and a reduction in site runoff. These can either be extensive roofs which are low maintenance with a 25-125mm soil layer in which a variety of hardy drought tolerant low plants are grown, or intensive roofs with trees and planters which impose a greater load on the roof structure but are more suitable in certain circumstances. Green roofs can be used to reduce the volume and rate of runoff so that other SUDS techniques in the scheme can be significantly reduced in size. As the building will not have a flat roof this is not a practical option and is therefore not considered further.

(v) Water Butts

Water butts are the most common means of harvesting rainwater for garden use. They are small, off-line storage devices that are designed to capture and store roof runoff. They are a simple water conservation technique that can contribute to sustainable water management for developed areas. In general water butts do not provide water quality treatment.

A water butt collects rainwater from roofs via an inlet that is connected to the roof down-pipe. Water butts are manufactured in a wide variety of sizes and can consist of inter-connectable units.

During wet periods, water butts are often full, resulting in little or no attenuation or reduction in outflow rates or volumes. However, water butts can be designed to attenuate runoff by using a throttled overflow system with excess water discharge to the drainage system or soakaway. They can be used to provide betterment but not as the primary system.

4.6.2 Site Control - Permeable Conveyance Systems

Permeable conveyance systems can take the form of infiltration trenches, swales or filter strips at road margins where surface runoff from roads, car parking areas and also roof drainage can be directed. Used to collect water directly from linear systems, percolate the flow, attenuate and then discharge the flow to either a traditional system or a secondary SUDS device.

The use of these systems is more suited to linear applications such as roads as the typical cross section is relatively small and longer runs are required to provide attenuation volume. Land take can be relatively small in comparison to other systems and both types perform well in improving water quality. They are also ideally suited for disposal of water via secondary infiltration.

(i) Infiltration Trench

Infiltration trenches are essentially linear soakaways which allows water to infiltrate into the soils as it is transported to a disposal point. There is space available on this site for infiltration trenches.

(ii) Swales

Swales are open wide trapezoidal channels across a site which allows water to infiltrate into the soils as it is transported to a disposal point. There is space available on this site for swales.

(iii) Filter Strips

Filter strips will be smaller in plan area than a swale although the swale can be landscaped to be incorporated in to the verge of the carriageway, combining two functions. There is space available on this site for filter strips.

4.6.3 Passive Treatment Systems

Where ground conditions prevent the use of infiltration, such as on ground that may be impermeable or contaminated, SUDS methods that are designed not to infiltrate can be considered. Passive treatment systems can include a pond, wetland, tank or a basin on the lower parts of a site. These will reduce peak flows, but not the volume of runoff, and slow down flows before disposal to a surface water drainage system. These may provide a suitable SUDS solution for this site and options are therefore considered in outline below.

(i) Ponds and Basins

The nature of these systems is such that the runoff from the development can be treated by biological action and stilling to significantly improve the quality of water discharged from the system.

Basins also provide large areas of open space that can be developed for recreational uses or as new habitats for wildlife. Both systems do, however, take up significant amounts of developable land and have residual maintenance and liability issues attached to their implementation.

(ii) Storage Tanks

Hard engineered tank storage systems have traditionally been used for attenuation structures for the past decade and are often specified where large volumes of storage are required (>200m^3) and available space is an issue. These could be located underneath the roads and paved areas.

These systems have no inherent water treatment properties bar potential sedimentation of the attenuated flow and offer no additional amenity benefits. In some cases, the easement to the tank or culvert is such that a significant portion of land area is sterilized from development and certain planting.

There are also significant costs associated with these systems in production, transportation and installation. However, once installed the long term maintenance of the system is relatively low. With a proven record of successful installation, tanks and culverts are regularly adopted by water authorities across the country, albeit with a large associated easement that will sterilise that portion of the site.

It has been concluded that storage tanks will work at the site and can be used to attenuate the surface water runoff.

(iii) Oversized Drainage Network

A further option on storage and attenuation would be the use of an oversized drainage network designed to act as inline storage, rather than a tank or pond, to provide the required storage volume underground. These could be located underneath the roads and paved areas.

As the diameter of larger pipes readily available is limited the applicability of these types of systems is more suited to <200m^3 of attenuation. Above this volume the length of pipe required is excessive and difficult to suitably fit into a normal site layout.

There is no intrinsic amenity provided by the use of this system neither is there any specific level of run-off treatment over and above that of a standard pipe and gully system.

However, due to their traditional nature, the adoption of these types of systems by water authorities is straightforward and does not require any specialist input. The pipes are generally available direct from suppliers with little or no lead in time and the satisfactory long term performance of these systems is well documented.

This option could be used in combination with other SUDS elements to provide the required storage volume. It has been concluded that oversized drainage networks will work at the site and can be used to attenuate the surface water runoff.

(iv) Cellular Storage

Large volumes of storage can be provided under grassed and lightly trafficked areas by using proprietary plastic cellular systems. This will maximise the developable area of the site. These could be located underneath the roads and paved areas.

There is no specific mechanism within the system designed to treat flow but extended detention times will allow sedimentation reducing the suspended solids within the discharge.

There is no creation of amenity by the installation of these types of systems, indeed by maintaining access to the system small areas may need to be reserved.

If the developable footprint is tight then these systems may be advantageous however to ensure adoptability it is recommended that the use of these systems is discussed with the adopting authority as they are not always preferred.

There would be room to install cellular storage under the drive way areas to provide the storage volume required. This will require the new drainage network to divert flow from the impermeable buildings and parking areas to this cellular storage facility. This could also be drained via permeable pavement surfaces.

It has been concluded that cellular storage will work at the site and can be used to attenuate the surface water runoff.

(v) Surface Storage

The use of roads, public areas and even landscaped areas as additional storage is becoming a widely accepted form of attenuation.

Water spilling from drainage systems can be collected via roads and kerbs and channelled to lower lying areas where it would be stored until the capacity in the existing system returns.

These systems have the advantage of requiring little additional infrastructure merely detailing of the proposed roads and grassed areas.

As these systems will only be used in extreme events when the adopted drainage system is exceeded (>1 in 30 years), they provide a very efficient way of catering for these events rather than providing permanent capacity.

There is no inherent water treatment capability in this system or any particular increase in amenity; however, the costs associated with this provision are relatively small. It is recommended that these systems are only used in emergency circumstances (e.g. for events greater than the 1 in 30 year event).

4.7 Site Storage Volumes

The provision of suitable storage on site to mitigate the flood risk resulting from the development of the site will be a key factor in the evolution of the site development layout. The provision of large volumes of attenuation can be achieved by a number of methods; however, not all systems can be assessed in direct comparison.

One of the aims of the NPPF is to provide not only flood risk mitigation but also to maximise additional gains such as improvements in runoff quality and provision of amenity and bio-diversity. Systems incorporating these features are often termed SUDS and it is the requirement of the NPPF that these are considered as the primary means of collection, control and disposal for storm water as close to source as possible.

4.7.1 Assuming Infiltration

At this stage it is proposed that the impermeable areas of the site could be discharged to soakaways. The soakaways would be sized according to on the site infiltration rates obtained during infiltration/soakaway tests. Table 7 shows the soakaway characteristics required such that the 1 in 100 year (plus climate change) event can be fully discharged. This is based on an infiltration rate of 0.00003m/s.

Table 7 shows the BRE365 calculation procedure for a trench soakaway with a void ratio of 30% was used to demonstrate that the proposed surface water runoff volumes can be viably accommodated on site and drained by infiltration during the 1 in 100 year storms with a 30% allowance for climate change (increase the size of the soakaway by 30%) assuming an impermeable area of 5,600m^2 of impermeable areas for the site (see Appendix 3). The required half emptying time of 24 hours for each of the design storms is met and therefore this method of storm water disposal is appropriate for use on this site.

Table 7 - BRE365 Concrete Trench Soakaway Calculations

Return Period (years)	Length (m)	Width (m)	Depth (m)	Half Emptying Time (hr:min)
100 + 30%	100	7.00	1.90	18:44

If an infiltration system is proposed, it is recommended that a series of infiltration/soakaway tests are carried out on site to BRE Digest 365 Guidelines to confirm the assumptions made in the calculations.

4.7.2 Assuming No Infiltration

If after further investigation the infiltration rate is found to be low and therefore unsuitable for soakaways and/or other infiltration methods it would be proposed that the impermeable areas of the site could be discharged to passive treatment systems/attenuation storage (e.g. pond/basin, oversized drainage network, cellular storage or underground tanks) before discharge to the public surfaces water sewers.

The principle applied in the design of storage is to limit the discharge rate of surface water runoff from the developed site for events of similar frequency of occurrence to the same peak rate of runoff as that which takes place from a greenfield site prior to development. QBAR (rural) has been calculated to be 4.96l/s. Using a complex control device and practical minimum pipe sizes it is not

practical to control the discharge rate to below 5.00l/s. Therefore, a value of 5.00l/s has been used as the limiting discharge rate.

Table 8 shows the volume of storage required for the proposed development estimated using the Masterdrain Drainage Software for the 100 year events during the 6 hour event[13], with a 30% allowance for climate change (increase in peak rainfall) assuming the proposed 5,600m^2 of impermeable area with 5.00l/s used as the limiting discharge rate (see Appendix 4).

Table 8 - Storage Volumes

Return Period (years)	Limiting Discharge Rate (l/s)	Volume (m^3)
100 + 30%	5.00l/s	414

4.8 Proposed SUDS Strategy

The objective of this SUDS Strategy is to ensure that a sustainable drainage solution can be achieved which reduces the peak discharge rate to manage and reduce the flood risk posed by the surface water runoff from the site. At this stage a detailed surface water drainage design has not been undertaken, however it is necessary to demonstrate that the surface water from the proposed development can be discharged safety and sustainably. The SUDS Strategy takes into account the following principles:

- No increase in the volume or runoff rate of surface water runoff from the site.
- No increase in flooding to people or property off-site as a result of the development.
- No surface water flooding of the site.
- The proposals take into account a 30% increase in rainfall intensity due to climate change during the next 100 years which is the lifetime of the development

For all development, a hierarchical approach to surface water management. This approach has been adopted within this SUDS Strategy with infiltration being utilised wherever possible. If discharge via infiltration is not possible the surface water will be discharge to the public surface water sewers located within the vicinity of the site.

In line with adopting a 'management train' it is recommended that water is managed as close to source as possible. This will reduce the size and cost of infrastructure further downstream and also shares the maintenance burden more equitably. It is therefore recommended that each plot provides its own attenuation, and one stage of treatment. This may be in the form of:

- Water Butts for each dwelling.
- Permeable paving of all driveways and car parking areas.
- House soakaways for each dwelling.
- Filter strips, infiltration trenches, swales adjacent to the highways.
- Cellular storage below the permeable paving, if required.
- For larger events in other areas such as car-parking and landscaping, provided that it will not cause damage or prevent access.

[13] 6 hour events are important flood events for small catchments.

The precise nature and form of the SUDS system will be influenced by the type of the dwellings on the site, so some flexibility should be offered, providing proposals are robust and adequate plans for their maintenance made. Each plot may discharge into the drainage system.

If ground permeability is poor then surface features such as filter strips, canals and rills, swales etc. would be required for conveying surface water runoff. Some pipework would invariably be required for road crossings and flow control purposes.

The remainder of the site that is not formally drained, i.e. gardens and areas of open space, will be permeable (grass). The majority of rainwater falling on these areas will soak into the ground. Surface water runoff would be directed to the drainage system through drainage gullies located around the perimeter of the buildings and through contouring of the hardstanding areas.

These methods will reduce peak flows, the volume of runoff, and slow down flows and will provide a suitable SUDS solution for this site. These preliminary considerations are based on the outline development scheme provided and hence the design purposes. The adoption of a surface water management strategy for the site represents an enhancement from the current conditions as the current surface water runoff from the site is uncontrolled, untreated, unmanaged and unmitigated.

Where SUDS are to be used it must be established that these options are feasible, can be adopted and properly maintained and would not lead to any other environmental problems with a maintenance schedule or the lifetime of the facility and these issues should be considered at the detailed design stage.

At this stage of the planning process it is proposed that a planning condition can be adopted to cover the detailed design of the surface water runoff from the site. It is proposed that the detailed drainage design of the final scheme would be secured by a planning condition attached to any planning permission granted and agreed with the LPA, the LLFA, Severn Trent Water and the Environment Agency.

In adopting these principles, it has been demonstrated that a scheme can be developed that does not increase the risk of flooding to adjacent properties and development further downstream.

Quantity

As a consequence of limiting the rate of discharge from the site, at times of heavy rainfall the volume of water leaving the site will be significantly less than that draining from it. In order to prevent this water backing up in the system and causing flooding, the surface water will be discharged by infiltration methods (e.g. soakaways, permeable paving etc.) however; if this is not possible 414m^3 of attenuation storage will be incorporated into the site layout.

This volume may be reduced when moderate infiltration is taken into account. The volume is dependent on the values assumed for infiltration. Local site specific investigations and testing will improve this estimate and refine the volumes for infiltration.

The size of this attenuation storage has been calculated such that the proposed development has the capacity to accommodate the 1 in 100 year rainfall event including a 30% increase in rainfall intensity that is predicted to occur as a result of climate change. Consequently, all areas drained have been designed to accommodate a 100 year (+30% climate change) storm event.

This restriction will provide significant flood mitigation benefits to existing third party property and land downstream of the site that may be potentially at risk from flooding.

Quality

Two stages of treatment are required for run-off from roads and hard standings, whilst one stage of treatment is required for run-off from roofs. Based on a site area of 1.08ha with an impermeable area of 50%, the treatment volume Vt will amount to 109m^3.

Amenity Benefits

SUDS features may be integrated into the landscape forming a harmonious whole, which will have a visually pleasing affect. Paths may be constructed to enable access for both maintenance and recreation, with surface finishes that are durable, and in keeping with the surroundings. Street furniture may be used to enhance enjoyment of the space. Visual clutter such as signposts and fences which prevent access to the space and make it less inviting may be avoided. Careful barrier planting and use of aquatic benches and shallow slopes will reduce health and safety risks.

Biodiversity Benefits

Planting should use a variety of native species of local provenance to ensure opportunities for biodiversity and sustain habitat within the development. A range of habitats may be created using SUDS features such as ponds, with aquatic benches for marginal planting, areas for natural wetland and meadow planting. Features should aim to mimic equivalent natural features, following natural drainage paths and fitting in with site contours, with natural elongated sinuous forms where possible. SUDS features may also be managed for wildlife for example by encouraging flowering plants, changing mowing regimes to allow plants to set seeds, and leaving them over winter as a food source. Carrying out grass cuts, and removing from site may also improve biodiversity of landscaped areas. However, such management regimes are likely to differ from normal regimes and may need additional equipment, training and agreement from the maintaining authority to implement.

'Traditional' Drainage'

More traditional or conventional drainage structures are likely to be required as part of the proposed development: collecting runoff where source control is not practical, conveying water within the site, or providing additional attenuation storage underground.

In certain areas within the proposed development, gullies or linear drains may be the most practical option, when whole-life issues are considered: such as operation, maintenance, and change of use.

If the SUDS described above cannot provide the total attenuation volume required in order to mimic pre-development conditions, other storage systems may need to be provided, such as oversized pipes, cellular storage or underground tanks. These are unlikely to meet water quality or amenity objectives and should be used in conjunction with other SUDS where possible, particularly source control.

All drainage elements should be designed appropriately and considered as part of the overall site strategy.

4.9 Designing for Local Drainage System Failure/Design Exceedance

When considering residual risk, it is necessary to make predictions as to the impacts of a storm event that exceeds the design event, or the impact of a failure of the local drainage system. The SWMS applies a safe and sustainable approach to discharging rainfall runoff from the site and this reduces the risk of flooding however, it Is not possible to completely remove the risk. This section of the FRA is therefore associated with the way the residual risk is managed.

As part of the SUDS Strategy it must be demonstrated that the flooding of property would not occur in the event of local drainage system failure and/or design exceedance. It is not economically viable or sustainable to build a drainage system that can accommodate the most extreme events. Consequently, the capacity of the drainage system may be exceeded on rare occasions, with excess water flowing above ground[14].

The attenuation requirements have been designed to accommodate the 1 in 100 year storm event plus climate change (+ 30%). The design of the site layout provides an opportunity to manage this local drainage system failure/exceedance flow and ensure that indiscriminate flooding of property does not occur.

There will not be an extensive sewerage network on the proposed development site and therefore any potential exceedance flooding would be from the sewers and lateral drains connecting the properties to the underground storage areas. It is very unlikely that a catastrophic failure would occur. An exceedance or blockage event of the sewers would not affect the proposed buildings because the finished floor level will be raised above surrounding ground levels, ensuring any exceedance flooding would not affect the buildings. Exceedance flows would be contained within the highways adjacent to the site and within the site and would flow to the lower ground levels where the public open space is located. It is not considered that there is an increased risk to the properties on the site or located adjacent to the site.

In particular, the landscaped areas will include preferential flow paths that convey water away from buildings. Surface water runoff would be directed to the drainage system through drainage gullies located around the perimeter of the buildings and through contouring of the hardstanding areas.

When considering the impacts of a storm event that exceeds the 1 in 100 year (plus climate change) event, there is safety factor for oversized drainage network, cellular storage or underground tanks, even under the design event conditions. Consequently, if this event were to be exceeded there is additional capacity with the system to accommodate this (i.e. within the manholes). If this freeboard was to be exceeded the consequences would be similar, if not less than for the local drainage system failure. Consequently, the impact of an exceedance event is not considered to represent any significant flood hazard.

The above manages and mitigates the flood risk from surface water runoff to the proposed properties from surface water runoff generated by the site development and to offsite locations as well the risk from surface water runoff generated offsite.

4.10 Off-Site Impacts

The proposed SUDS Strategy is designed to attenuate surface water runoff up to and including the 1 in 100 year (plus climate change) event. This restriction will provide significant flood mitigation benefits to existing third party property and land downstream of the site that may be potentially at risk from flooding.

[14] CIRIA (2006) Designing for exceedance in urban drainage – good practice.

5.0 SUMMARY AND CONCLUSIONS

5.1 Introduction

This report presents a Sustainable Drainage Assessment for the proposed development on Land west of Heath House Lane and north of Uttoxeter Road, Lower Tean, Staffordshire, ST10 4LP.

5.2 Surface Water Drainage

The SUDS Strategy ensures that a sustainable drainage solution can be achieved which reduces the peak discharge rate to manage and reduce the flood risk posed by the surface water runoff from the site. At this stage a detailed surface water drainage design has not been undertaken, however it is necessary to demonstrate that the surface water from the proposed development can be discharged safety and sustainably. The SUDS Strategy takes into account the following principles:

- No increase in the volume or runoff rate of surface water runoff from the site.
- No increase in flooding to people or property off-site as a result of the development.
- No surface water flooding of the site.
- The proposals take into account a 30% increase in rainfall intensity due to climate change during the next 100 years which is the lifetime of the development

For all development, a hierarchical approach to surface water management. This approach has been adopted within this SUDS Strategy with infiltration being utilised wherever possible. If discharge via infiltration is not possible the surface water will be discharge to the public surface water sewers located within the vicinity of the site.

In line with adopting a 'management train' it is recommended that water is managed as close to source as possible. This will reduce the size and cost of infrastructure further downstream and also shares the maintenance burden more equitably. It is therefore recommended that each plot provides its own attenuation, and one stage of treatment. This may be in the form of:

- Water Butts for each dwelling.
- Permeable paving of all driveways and car parking areas.
- House soakaways for each dwelling.
- Filter strips, infiltration trenches, swales adjacent to the highways.
- Cellular storage below the permeable paving, if required.
- For larger events in other areas such as car-parking and landscaping, provided that it will not cause damage or prevent access.

The precise nature and form of the SUDS system will be influenced by the type of the dwellings on the site, so some flexibility should be offered, providing proposals are robust and adequate plans for their maintenance made. Each plot may discharge into the drainage system.

If ground permeability is poor then surface features such as filter strips, canals and rills, swales etc. would be required for conveying surface water runoff. Some pipework would invariably be required for road crossings and flow control purposes.

The remainder of the site that is not formally drained, i.e. gardens and areas of open space, will be permeable (grass). The majority of rainwater falling on these areas will soak into the ground. Surface water runoff would be directed to the drainage system through drainage gullies located around the perimeter of the buildings and through contouring of the hardstanding areas.

These methods will reduce peak flows, the volume of runoff, and slow down flows and will provide a suitable SUDS solution for this site. These preliminary considerations are based on the outline development scheme provided and hence the design purposes. The adoption of a surface water management strategy for the site represents an enhancement from the current conditions as the current surface water runoff from the site is uncontrolled, untreated, unmanaged and unmitigated.

Where SUDS are to be used it must be established that these options are feasible, can be adopted and properly maintained and would not lead to any other environmental problems with a maintenance schedule or the lifetime of the facility and these issues should be considered at the detailed design stage.

At this stage of the planning process it is proposed that a planning condition can be adopted to cover the detailed design of the surface water runoff from the site. It is proposed that the detailed drainage design of the final scheme would be secured by a planning condition attached to any planning permission granted and agreed with the LPA, the LLFA, Severn Trent Water and the Environment Agency.

In adopting these principles, it has been demonstrated that a scheme can be developed that does not increase the risk of flooding to adjacent properties and development further downstream.

Quantity

As a consequence of limiting the rate of discharge from the site, at times of heavy rainfall the volume of water leaving the site will be significantly less than that draining from it. In order to prevent this water backing up in the system and causing flooding, the surface water will be discharged by infiltration methods (e.g. soakaways, permeable paving etc.) however; if this is not possible 414m^3 of attenuation storage will be incorporated into the site layout.

This volume may be reduced when moderate infiltration is taken into account. The volume is dependent on the values assumed for infiltration. Local site specific investigations and testing will improve this estimate and refine the volumes for infiltration.

The size of this attenuation storage has been calculated such that the proposed development has the capacity to accommodate the 1 in 100 year rainfall event including a 30% increase in rainfall intensity that is predicted to occur as a result of climate change. Consequently, all areas drained have been designed to accommodate a 100 year (+30% climate change) storm event.

This restriction will provide significant flood mitigation benefits to existing third party property and land downstream of the site that may be potentially at risk from flooding.

Quality

Two stages of treatment are required for run-off from roads and hard standings, whilst one stage of treatment is required for run-off from roofs. Based on a site area of 1.08ha with an impermeable area of 50%, the treatment volume Vt will amount to 109m^3.

Amenity Benefits

SUDS features may be integrated into the landscape forming a harmonious whole, which will have a visually pleasing affect. Paths may be constructed to enable access for both maintenance and

recreation, with surface finishes that are durable, and in keeping with the surroundings. Street furniture may be used to enhance enjoyment of the space. Visual clutter such as signposts and fences which prevent access to the space and make it less inviting may be avoided. Careful barrier planting and use of aquatic benches and shallow slopes will reduce health and safety risks.

Biodiversity Benefits

Planting should use a variety of native species of local provenance to ensure opportunities for biodiversity and sustain habitat within the development. A range of habitats may be created using SUDS features such as ponds, with aquatic benches for marginal planting, areas for natural wetland and meadow planting. Features should aim to mimic equivalent natural features, following natural drainage paths and fitting in with site contours, with natural elongated sinuous forms where possible. SUDS features may also be managed for wildlife for example by encouraging flowering plants, changing mowing regimes to allow plants to set seeds, and leaving them over winter as a food source. Carrying out grass cuts, and removing from site may also improve biodiversity of landscaped areas. However, such management regimes are likely to differ from normal regimes and may need additional equipment, training and agreement from the maintaining authority to implement.

'Traditional' Drainage'

More traditional or conventional drainage structures are likely to be required as part of the proposed development: collecting runoff where source control is not practical, conveying water within the site, or providing additional attenuation storage underground.

In certain areas within the proposed development, gullies or linear drains may be the most practical option, when whole-life issues are considered: such as operation, maintenance, and change of use.

If the SUDS described above cannot provide the total attenuation volume required in order to mimic pre-development conditions, other storage systems may need to be provided, such as oversized pipes, cellular storage or underground tanks. These are unlikely to meet water quality or amenity objectives and should be used in conjunction with other SUDS where possible, particularly source control.

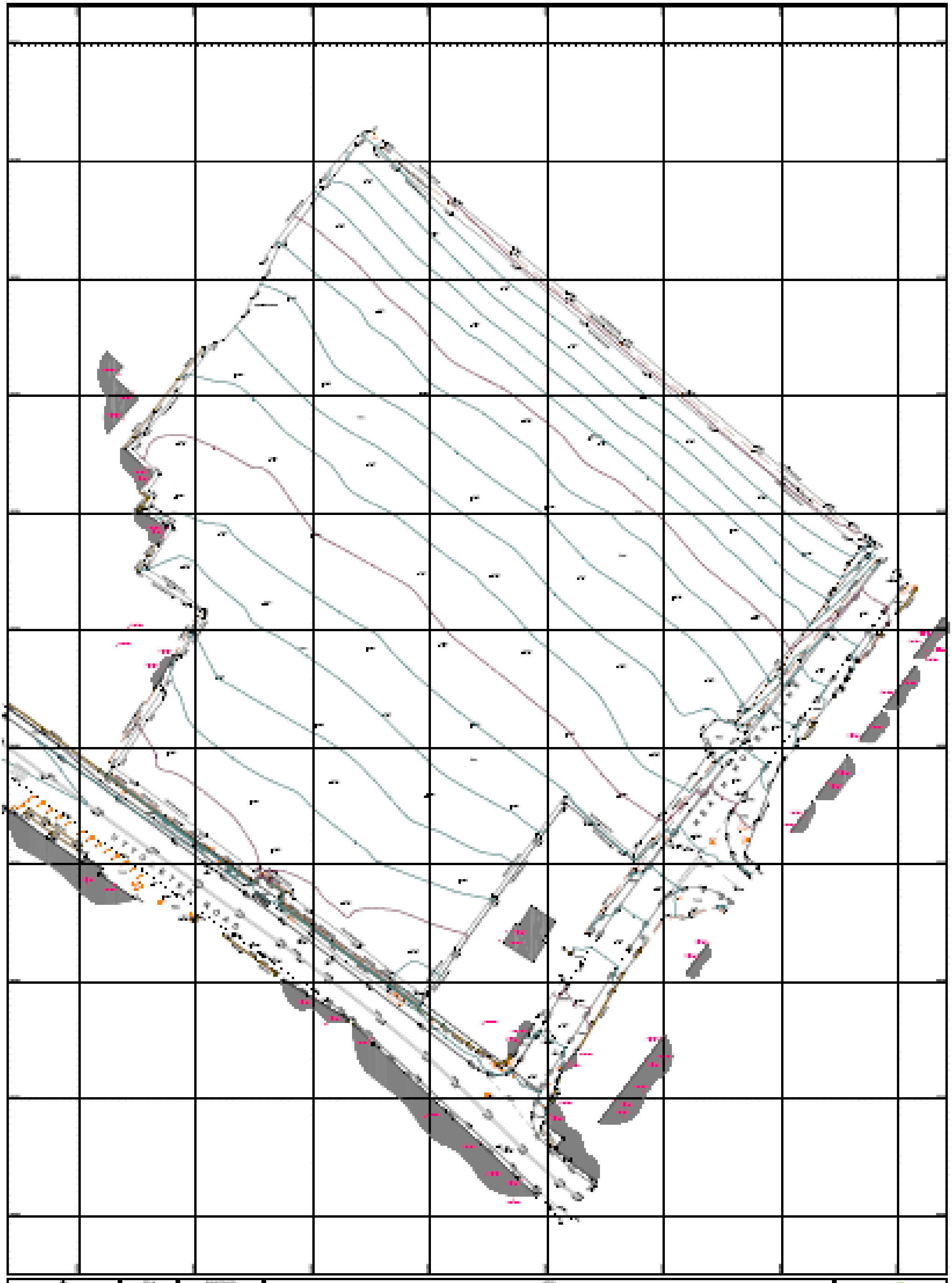
All drainage elements should be designed appropriately and considered as part of the overall site strategy.

5.3 Conclusion

This Surface Water Drainage Assessment demonstrates that the proposed development would be operated with minimal risk from flooding, would not increase flood risk elsewhere and is compliant with the requirements of the NPPF. The proposed development will considerably reduce the flood risk posed to the site and to off-site locations due to the adoption of the SUDS Strategy.

The development should not therefore be precluded on the grounds of flood risk.

APPENDIX 1 – Topographical Survey


HEATH HOUSE LANE
LOWER TEAR

APPENDIX 2 – Severn Trent Water Correspondence

SEVERN TRENT WATER

Severn Trent Water

KRS Environmental Ltd
3 Princes Square
Princes Street
Montgomery
SY15 6PZ
FAO Keelan Serjeant

Severn Trent Water Ltd
Regis Road
Wolverhampton
WV6 8RU

Tel: 01902 793871
Fax: 01902 793971

www.stwater.co.uk
net.dev.west@severntrent.co.uk

Contact: Dave Hadley

Your ref:
Our ref: 8213598

24 February 2016

Dear Mr Serjeant,

Proposed Development at Land West of Heath House Lane and North of Uttoxeter Road, Lower Tean, Staffordshire ST10 4LP

I refer to your 'Development Enquiry Request' in respect of the above site. Please find enclosed the sewer records that are included in the fee together with the Supplementary Guidance Notes which refer to surface water disposal from development sites.

Foul Water Drainage

As you can see on the records there are two 150mm diameter foul water sewers in Uttoxeter Road one heading north west and the other heading south east. I confirm that the average foul flows from 20 properties estimated to be 0.3 l/s at 2DWF should not have an adverse hydraulic impact on our network. A connection or connections are therefore acceptable to the Company at manhole references 6501 and 6507 or any convenient location subject to formal S106 approval (see later).

Surface Water Drainage

The records indicate that there is a 150mm diameter surface water sewer adjacent to the site in Heath House Lane (MH7602) and a 300mm diameter surface water sewer at the junction of Uttoxeter Road and Leigh Lane. In the event that following comprehensive testing it is demonstrated that soakaways are not feasible for surface water disposal on the site, evidence should be submitted. This would satisfy SGN1. A connection to the surface water sewer system would then be appropriate with flow rates restricted in accordance with our guidance note 3. or as stipulated by Staffordshire County Council as the Lead Local Flood Authority and statutory consultee in the planning process for this area.

SEVERN TRENT WATER

Severn Trent Water

New Connections

For any new connections (including the re-use of existing connections) to the public sewerage system, the developer will need to submit Section 106 application forms. Our New Connections department are responsible for handling all such enquiries and applications. To contact them for an application form and associated guidance notes please call 0800 7076600 or download from www.stwater.co.uk.

Please quote 8213598 in any future correspondence (including e-mails) with STW Limited. Please note that 'Development Enquiry' responses are only valid for 6 months from the date of this letter.

Yours sincerely

D. J. Hadley

D J Hadley
Asset Protection (Waste Water) West
Wholesale Network Control and Asset Management

SUPPLEMENTARY GUIDANCE NOTES

In 2006 the Government issued national advice in the form of "Planning Policy Statement 25: Development and Flood Risk" and in 2012 the "National Planning Policy Framework" with supporting technical guidance that seeks to reduce the impact of surface water runoff from development. This advice is generally followed by Local Authorities through both the Building Regulations (Approved Document H) and appropriate planning conditions. Furthermore, as of April 2015, the Lead Local Flood Authority (LLFA) will assume the role and responsibility for the management of surface water. Severn Trent welcomes this advice and supports such planning conditions that impose flow restrictions. It is considered that in accordance with current guidance, disposal of storm runoff from the development should be dealt with as follows:

1. By soakage into the site's subsoil. If ground soakage proves inadequate, evidence should be submitted to Severn Trent Water and the LLFA. The evidence should be either percolation test results (BRE Digest 365 – Soakaway Design) or a statement from the geotechnical consultant stating that soakaways would be ineffective. **A connection to public sewerage (existing or adoptable) would then be considered with flows assessed as:**

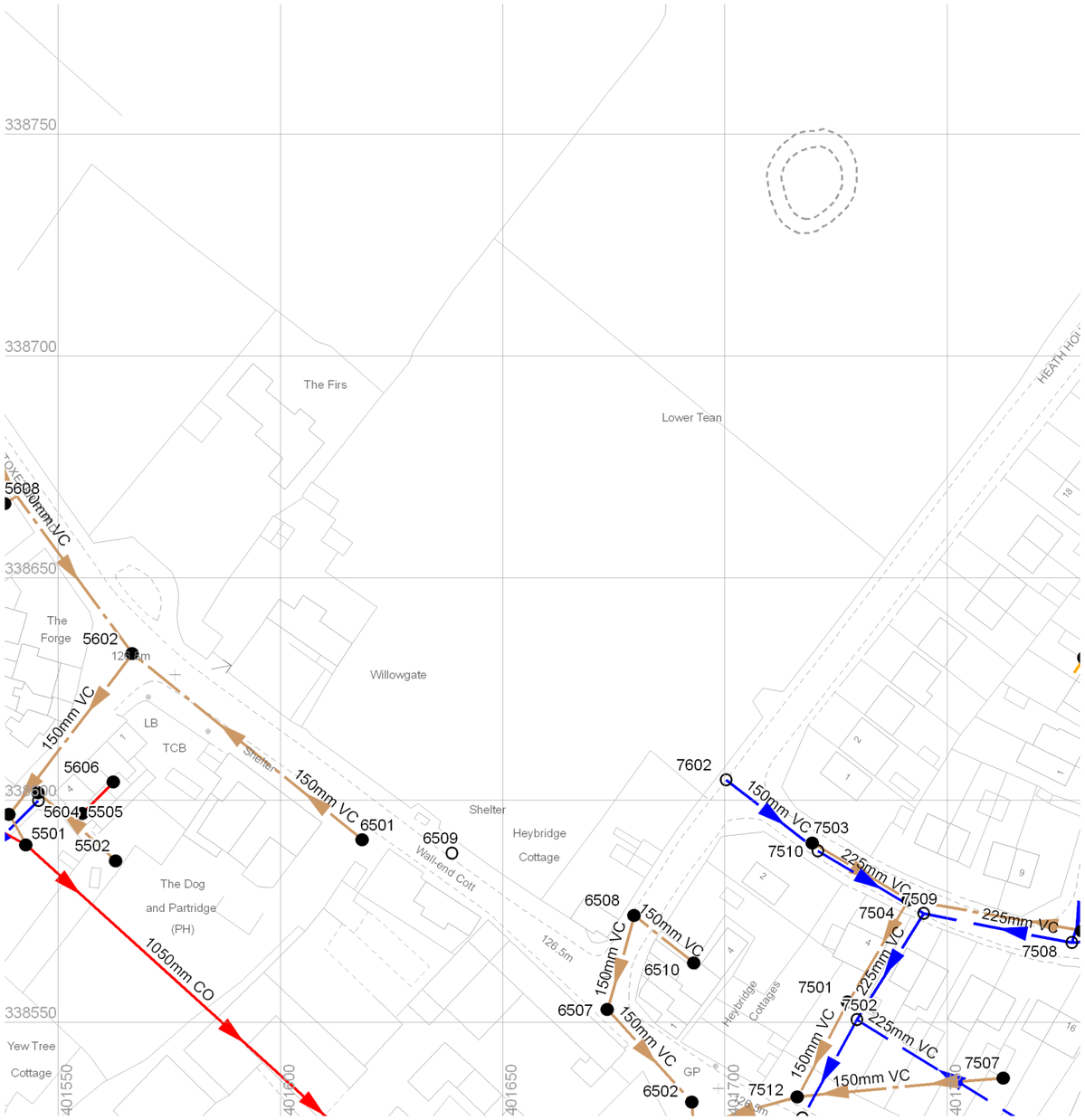
2. Brownfield development site: If storm runoff from the existing development is connected to the public sewerage system, then peak storm flows from the proposed development up to that generated from the previous connected impermeable area may be connected to the network subject to the details of the existing storm connection arrangements being submitted to Severn Trent Water. Existing flows should be assessed as the lower of $Q=2.78x50xA_{imp}$ l/s (A_{imp} ha), based on a 2 year storm return period, and the unsurcharged capacity of the outfall pipe(s).

   In addition to this restriction, for Brownfield developments, the Company would also request a minimum reduction in surface water flow to the public sewerage systems of 30% in line with current LLFA practice. It should be noted that the Company would like to see any flow attenuation based on a 30 year critical duration storm design in accordance with 'Sewers for Adoption' current edition unless the system connects directly to a watercourse in which case the Environment Agency (for main river) or LLFA will set the design storm criteria (usually 100 year plus climate change allowance)

   For existing storm connections to the public foul sewerage system, any new storm connection to the public storm sewerage system (if available) should be limited to 2 to 5 litres/second/hectare depending on the scale of development, to be agreed (option A) OR a peak flow to be determined by the Company from its developer-funded hydraulic modelling of the public storm sewerage system (option B). The developer may choose either option.

3. Greenfield development site: If the site is a green field development i.e. not involving any demolition of buildings or paved areas connected to the public sewerage system, then the storm runoff from the proposed development may be connected to the public sewerage system subject to peak storm flows (30 year storm return period) being limited to a green field runoff of 5 litres/sec/ha (subject to a minimum of 5 litres/sec for Adoptable systems), applied to the gross area of the site, subject to sufficient capacity in the network.

It is recommended to consult with the LLFA as early as possible to ensure sustainable surface water management is implemented effectively in new development. It should be noted that discharge rates for **all** sites should be agreed with the LLFA.



Sewer Node Sewer Pipe Data

REFERENCE	COVER LEVEL	INV LEVEL UPSTR	INV LEVEL DOWNSTR	PURP	MATL	SHAPE	MAX SIZE	MIN SIZE	GRADIENT	YEAR LAID
SK01385501	125.90	123.32	nil	C	CO	C	1050	nil	0.00	nill
SK01385502	125.94	125.02	124.49	F	VC	C	150	nil	42.77	nill
SK01385503	125.10	123.83	123.68	F	VC	C	150	nil	53.73	nill
SK01385505	125.89	125.30	nil	F	VC	C	100	nil	0.00	nill
SK01385602	126.62	124.42	123.89	F	VC	C	150	nil	86.06	nill
SK01385603	125.36	124.47	nil	F	VC	C	150	nil	0.00	nill
SK01385604	125.33	123.80	nil	S	VC	C	225	nil	0.00	nill
SK01385606	126.16	125.55	125.32	C	VC	C	100	nil	43.04	nill
SK01385608	127.42	126.22	nil	F	VC	C	100	nil	0.00	nill
SK01386501	126.33	124.91	124.52	F	VC	C	150	nil	171.38	nill
SK01386502	126.16	124.40	124.30	F	VC	C	150	nil	60.00	nill
SK01386507	126.38	124.77	124.41	F	VC	C	150	nil	78.67	nill
SK01386508	127.11	125.91	124.83	F	VC	C	150	nil	20.22	nill
SK01386510	126.95	126.33	125.92	F	VC	C	150	nil	40.00	nill
SK01387501	nil	nil	nil	F	VC	C	150	nil	0.00	nill
SK01387502	nil	nil	nil	S	nil	nil	nil	nil	0.00	nill
SK01387503	129.67	128.41	128.12	F	VC	C	150	nil	88.10	nill
SK01387504	130.10	128.05	nil	F	VC	C	150	nil	0.00	nill
SK01387507	nil	nil	nil	F	VC	C	150	nil	0.00	nill
SK01387508	131.15	129.17	127.80	S	VC	C	225	nil	25.20	nill
SK01387509	130.07	127.74	nil	S	VC	C	225	nil	0.00	nill
SK01387510	129.73	127.90	127.77	S	VC	C	225	nil	213.69	nill
SK01387512	nil	nil	124.30	F	VC	C	150	nil	0.00	nill
SK01387602	129.42	128.19	127.90	S	VC	C	150	nil	88.31	nill

- Abandoned Gravity Sewer
- Private Combined Gravity Sewer
- Private Foul Gravity Sewer
- Private Surface Water Gravity Sewer
- Public Combined Gravity Sewer
- Public Foul Gravity Sewer
- Public Surface Water Gravity Sewer
- Trunk Combined Gravity Sewer
- Trunk Foul Use Gravity Sewer
- Trunk Surface Water Gravity Sewer
- Combined Use Pressurised Sewer
- Foul Use Pressurised Sewer
- Surface Water Pressurised Sewer
- Highway Drain
- Combined Lateral Drain (SS)
- Foul Lateral Drain (SS)
- Surface Water Lateral Drain (SS)

All Private Sewers are shown in magenta
All section 104 sewers are shown in green
All Sewers that have been transferred to Severn Trent Water after the 1st October 2011, but have not been surveyed and confirmed by Severn Trent Water are shown in orange

- Culverted Watercourse
- Cable, Earthing
- Cable Junction
- Cable, Optical Fibre/Instrumentation
- Cable, Low Voltage
- Cable, High Voltage
- Cable, Other
- Housing, Building
- Housing, Kiosk
- Disposal Site
- Sewage Treatment Works
- Housing, Other
- Pipe Support Structure
- Sewage Pumping Facility
- Sewer Facility Connection Inlet / Outlet

- Blind Shaft
- Combined Use Manhole
- Flushing Chamber
- Foul Use Manhole
- Grease Trap
- Head Node
- Hydrobrake
- Lamphole
- Outfall
- Overflow
- Penstock
- Petrol Interceptor

- Sewer Chemical Injection Point
- Sewer Junction
- Sewerage Air Valve
- Sewerage Hatch Box Point
- Sewerage Isolation Valve
- Soakaway
- Surface Water Manhole
- Vent Column
- Waste Water Storage
- Pre-1937 Properties

TABULAR KEY

A. Sewer pipe data refers to downstream sewer pipe.

B. Where the node bifurcates (splits) X and Y indicates downstream sewer pipe.

C. Gradient is stated a 1 in...

MATERIALS

- - NONE
- AC - ASBESTOS CEMENT
- BR - BRICK
- CC - CONCRETE BOX CULVERT
- CI - CAST IRON
- CO - CONCRETE
- CSB - CONCRETE SEGMENTS (BOLTED)
- CSU - CONCRETE SEGMENTS (UNBOLTED)
- DI - DUCTILE IRON
- GRC - GLASS REINFORCED CONCRETE
- GRP - GLASS REINFORCED PLASTIC
- MAC - MASONRY IN REGULAR COURSES
- MAR - MASONRY RANDOMLY COURSED
- PE - POLYETHLENE
- PF - PITCH
- PP - POLYPROPYLENE
- PSC - PLASTIC STEEL COMPOSITE
- PVC - POLYVINYL CHLORIDE
- RPM - REINFORCED PLASTIC MATRIX
- SI - SPUN (GREY) IRON
- ST - STEEL
- U - UNKNOWN
- VC - VITRIFIED CLAY
- XXX - OTHER

SHAPE

- C - CIRCULAR
- E - EGG SHAPED
- O - OTHER
- R - RECTANGLE
- S - SQUARE
- T - TRAPEZOIDAL
- U - UNKNOWN

PURPOSE

- C - COMBINED
- E - FINAL EFFLUENT
- F - FOUL
- L - SLUDGE
- S - SURFACE WATER

CATEGORIES

N W E S

- W - WEIR
- C - CASCADE
- DB - DAMBOARD
- SE - SIDE ENTRY
- FV - FLAP VALVE
- BD - BACK DROP
- S - SIPHON
- HD - HIGHWAY DRAIN
- S104 - SECTION 104

SEVERN TRENT WATER

Severn Trent Water Limited
Asset Data Management
PO Box 5344
Coventry
CV3 9FT
Telephone: 0845 601 6616

SEWER RECORD (Tabular)

O/S Map scale:	1:1250	**This map is centred upon: O / S Grid reference:**	
Date of issue:	02.09.15	**x :**	401659
Sheet No.	1 of 1	**y :**	338654

Disclaimer Statement:
1. Do not scale off this Map.
2. This map and any information supplied with it is furnished as a general guide, is only valid at the date of issue and no warranty as to its correctness is given or implied. In particular this Map and any information shown on it must not be relied upon in the event of any development or works (including but not limited to excavations) in the vicinity of Severn Trent Water's assets or for the purposes of determining the suitability of a point of connection to the sewerage or distribution systems.
3. On **1 October 2011** most private sewers and private lateral drains in Severn Trent Water's sewerage area, which were connected to a public sewer as at 1 July 2011, transferred to the ownership of Severn Trent Water and became public sewers and public lateral drains. A further transfer takes place on 1 October 2012 (date to be confirmed).
Private pumping stations, which form part of these sewers or lateral drains, will transfer to the ownership of Severn Trent Water on or before 1 October 2016.
Severn Trent Water does not possess complete records of these assets.
These assets may not be displayed on this Map.
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APPENDIX 3 – 1 in 100 Year (+cc) Storage Volumes Assuming Infiltration

KRS Environmental Limited.
www.krsenvironmental.com

29a Green Abbey, Hade Edge
Holmfirth
Huddersfield HD9 2SH
Tel:01484 684565 Mob: 07857 264 376
email: keelan@krsenvironmental.com

Job No.		
Sheet no.	1	
Date	01/03/16	
By	Checked	Reviewed

MasterDrain SW

Project

Title **1 in 100 Year (+CC) Storage Volume**

Data:-

Hydrology:-

Grid reference = SK0933
M5-60 (mm) = 19
WRAP/Soil = 3 / 0.40
Return period = 100
Climate change factor = 30%
Pipeline storage = 0.0 m³
Offline storage = 0.0 m³

Location = UTTOXETER
r = 0.33
SAAR (mm/yr) = 760
Mean intensity = 15.2mm/hr for a 6 hour storm

Available MH storage = 0.0 m³

Percentage runoff = 100.0% (manual setting)

Imperv. area = 5600 m²
Total area = 5600 m²
Total runoff = 509.2 m³
Storage (m³) = 414.2 m³ (Sum of all balance quantities)
Total rainfall depth = 90.9 mm

Pervious area = 0 m²
Equiv area = 5600 m² (Tot. area x % runoff).
Discharge rate = 5.000 l/s

Calculations :-

Time (hrs)	%Mean intens	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)	Cumulative (m3)
0.060	20.0	3.0	1.018	1.080	0.000	0.000
0.120	20.0	3.0	1.018	1.080	0.000	0.000
0.180	21.0	3.2	1.069	1.080	0.000	0.000
0.240	21.0	3.2	1.069	1.080	0.000	0.000
0.300	22.0	3.3	1.120	1.080	0.040	0.040
0.360	23.0	3.5	1.171	1.080	0.091	0.131
0.420	24.0	3.6	1.222	1.080	0.142	0.274
0.480	26.0	3.9	1.324	1.080	0.244	0.517
0.540	27.0	4.1	1.375	1.080	0.295	0.812
0.600	29.0	4.4	1.477	1.080	0.397	1.209
0.660	31.0	4.7	1.579	1.080	0.499	1.708
0.720	32.0	4.8	1.629	1.080	0.549	2.257
0.780	33.0	5.0	1.680	1.080	0.600	2.857
0.840	34.0	5.2	1.731	1.080	0.651	3.509
0.900	36.0	5.5	1.833	1.080	0.753	4.262
0.960	38.0	5.8	1.935	1.080	0.855	5.117
1.020	39.0	5.9	1.986	1.080	0.906	6.023
1.080	40.0	6.1	2.037	1.080	0.957	6.980
1.140	42.0	6.4	2.139	1.080	1.059	8.038
1.200	45.0	6.8	2.291	1.080	1.211	9.250
1.260	49.0	7.4	2.495	1.080	1.415	10.665
1.320	53.0	8.0	2.699	1.080	1.619	12.283
1.380	57.0	8.6	2.902	1.080	1.822	14.106
1.440	62.0	9.4	3.157	1.080	2.077	16.183
1.500	66.0	10.0	3.361	1.080	2.281	18.464
1.560	71.0	10.8	3.615	1.080	2.535	20.999
1.620	77.0	11.7	3.921	1.080	2.841	23.840
1.680	84.0	12.7	4.277	1.080	3.197	27.037
1.740	91.0	13.8	4.634	1.080	3.554	30.591
1.800	98.0	14.9	4.990	1.080	3.910	34.501
1.860	105.0	15.9	5.347	1.080	4.267	38.768
1.920	114.0	17.3	5.805	1.080	4.725	43.493
1.980	125.0	18.9	6.365	1.080	5.285	48.778
2.040	135.0	20.5	6.874	1.080	5.794	54.572
2.100	143.0	21.7	7.282	1.080	6.202	60.774
2.160	154.0	23.3	7.842	1.080	6.762	67.536
2.220	164.0	24.9	8.351	1.080	7.271	74.807
2.280	173.0	26.2	8.809	1.080	7.729	82.536
2.340	183.0	27.7	9.318	1.080	8.238	90.774
2.400	194.0	29.4	9.879	1.080	8.799	99.573

MasterDrain SW

KRS Environmental Limited.
www.krsenvironmental.com

29a Green Abbey, Hade Edge
Holmfirth
Huddersfield HD9 2SH
Tel:01484 684565 Mob: 07857 264 376
email: keelan@krsenvironmental.com

Job No.		
Sheet no.	2	
Date	01/03/16	
By	Checked	Reviewed

Project

Title **1 in 100 Year (+CC) Storage Volume**

Calculations (cont.) :-

Time (hrs)	%Mean intens	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)	Cumulative (m3)
2.460	204.0	30.9	10.388	1.080	9.308	108.881
2.520	212.0	32.1	10.795	1.080	9.715	118.596
2.580	219.0	33.2	11.152	1.080	10.072	128.667
2.640	226.0	34.3	11.508	1.080	10.428	139.096
2.700	233.0	35.3	11.864	1.080	10.784	149.880
2.760	239.0	36.2	12.170	1.080	11.090	160.970
2.820	244.0	37.0	12.425	1.080	11.345	172.315
2.880	248.0	37.6	12.628	1.080	11.548	183.863
2.940	249.0	37.7	12.679	1.080	11.599	195.462
3.000	250.0	37.9	12.730	1.080	11.650	207.112
3.060	250.0	37.9	12.730	1.080	11.650	218.762
3.120	249.0	37.7	12.679	1.080	11.599	230.362
3.180	248.0	37.6	12.628	1.080	11.548	241.910
3.240	244.0	37.0	12.425	1.080	11.345	253.255
3.300	239.0	36.2	12.170	1.080	11.090	264.345
3.360	233.0	35.3	11.864	1.080	10.784	275.129
3.420	226.0	34.3	11.508	1.080	10.428	285.557
3.480	219.0	33.2	11.152	1.080	10.072	295.629
3.540	212.0	32.1	10.795	1.080	9.715	305.344
3.600	204.0	30.9	10.388	1.080	9.308	314.652
3.660	194.0	29.4	9.879	1.080	8.799	323.450
3.720	183.0	27.7	9.318	1.080	8.238	331.689
3.780	173.0	26.2	8.809	1.080	7.729	339.418
3.840	164.0	24.9	8.351	1.080	7.271	346.689
3.900	154.0	23.3	7.842	1.080	6.762	353.451
3.960	143.0	21.7	7.282	1.080	6.202	359.652
4.020	135.0	20.5	6.874	1.080	5.794	365.447
4.080	125.0	18.9	6.365	1.080	5.285	370.732
4.140	114.0	17.3	5.805	1.080	4.725	375.457
4.200	105.0	15.9	5.347	1.080	4.267	379.723
4.260	98.0	14.9	4.990	1.080	3.910	383.633
4.320	91.0	13.8	4.634	1.080	3.554	387.187
4.380	84.0	12.7	4.277	1.080	3.197	390.384
4.440	77.0	11.7	3.921	1.080	2.841	393.225
4.500	71.0	10.8	3.615	1.080	2.535	395.761
4.560	66.0	10.0	3.361	1.080	2.281	398.042
4.620	62.0	9.4	3.157	1.080	2.077	400.119
4.680	57.0	8.6	2.902	1.080	1.822	401.941
4.740	53.0	8.0	2.699	1.080	1.619	403.560
4.800	49.0	7.4	2.495	1.080	1.415	404.975
4.860	45.0	6.8	2.291	1.080	1.211	406.186
4.920	42.0	6.4	2.139	1.080	1.059	407.245
4.980	40.0	6.1	2.037	1.080	0.957	408.202
5.040	39.0	5.9	1.986	1.080	0.906	409.108
5.100	38.0	5.8	1.935	1.080	0.855	409.963
5.160	36.0	5.5	1.833	1.080	0.753	410.716
5.220	34.0	5.2	1.731	1.080	0.651	411.367
5.280	33.0	5.0	1.680	1.080	0.600	411.968
5.340	32.0	4.8	1.629	1.080	0.549	412.517
5.400	31.0	4.7	1.579	1.080	0.499	413.016
5.460	29.0	4.4	1.477	1.080	0.397	413.412
5.520	27.0	4.1	1.375	1.080	0.295	413.707
5.580	26.0	3.9	1.324	1.080	0.244	413.951
5.640	24.0	3.6	1.222	1.080	0.142	414.093
5.700	23.0	3.5	1.171	1.080	0.091	414.184
5.760	22.0	3.3	1.120	1.080	0.040	414.225
5.820	21.0	3.2	1.069	1.080	0.000	414.214
5.880	21.0	3.2	1.069	1.080	0.000	414.203
5.940	20.0	3.0	1.018	1.080	0.000	414.142
6.000	20.0	3.0	1.018	1.080	0.000	414.080

Storage volume (m^3) = 414.2 m^3 (Sum of all balance quantities)

KRS Environmental Limited.
www.krsenvironmental.com

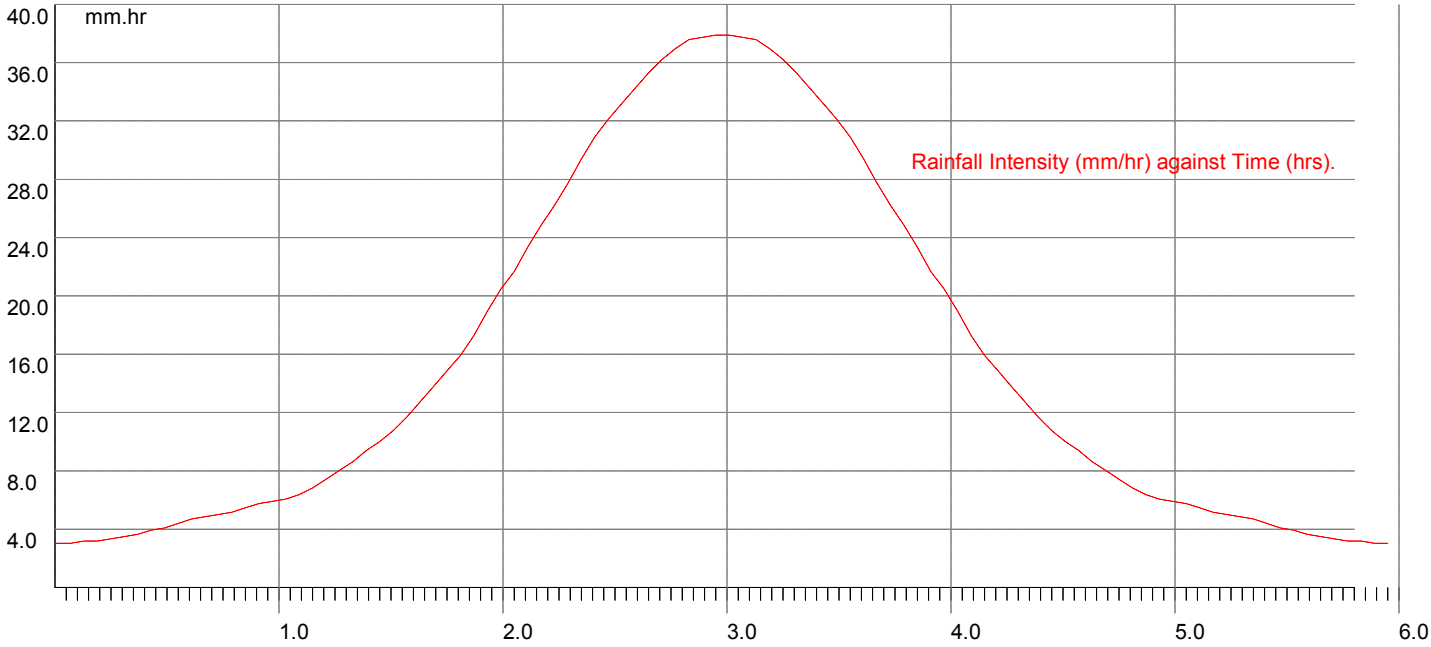
29a Green Abbey, Hade Edge
Holmfirth
Huddersfield HD9 2SH
Tel:01484 684565 Mob: 07857 264 376
email: keelan@krsenvironmental.com

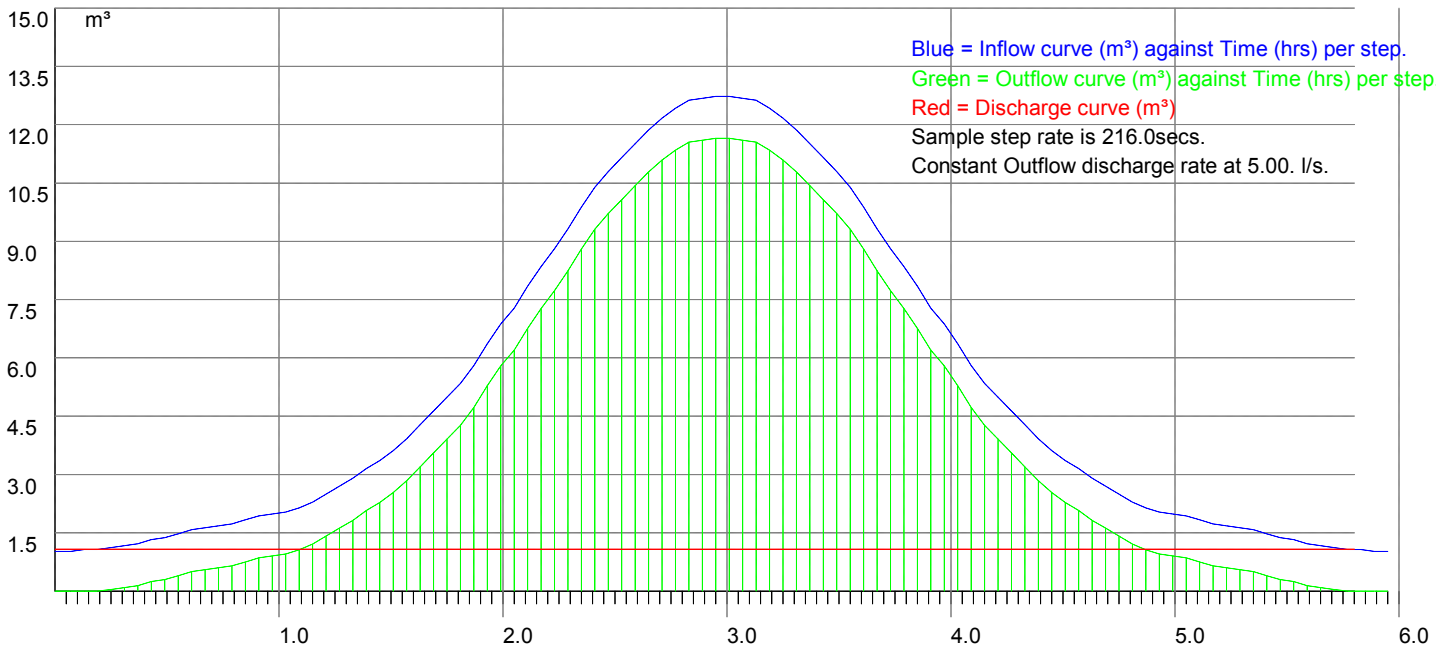
Job No.	
Sheet no.	3
Date	01/03/16

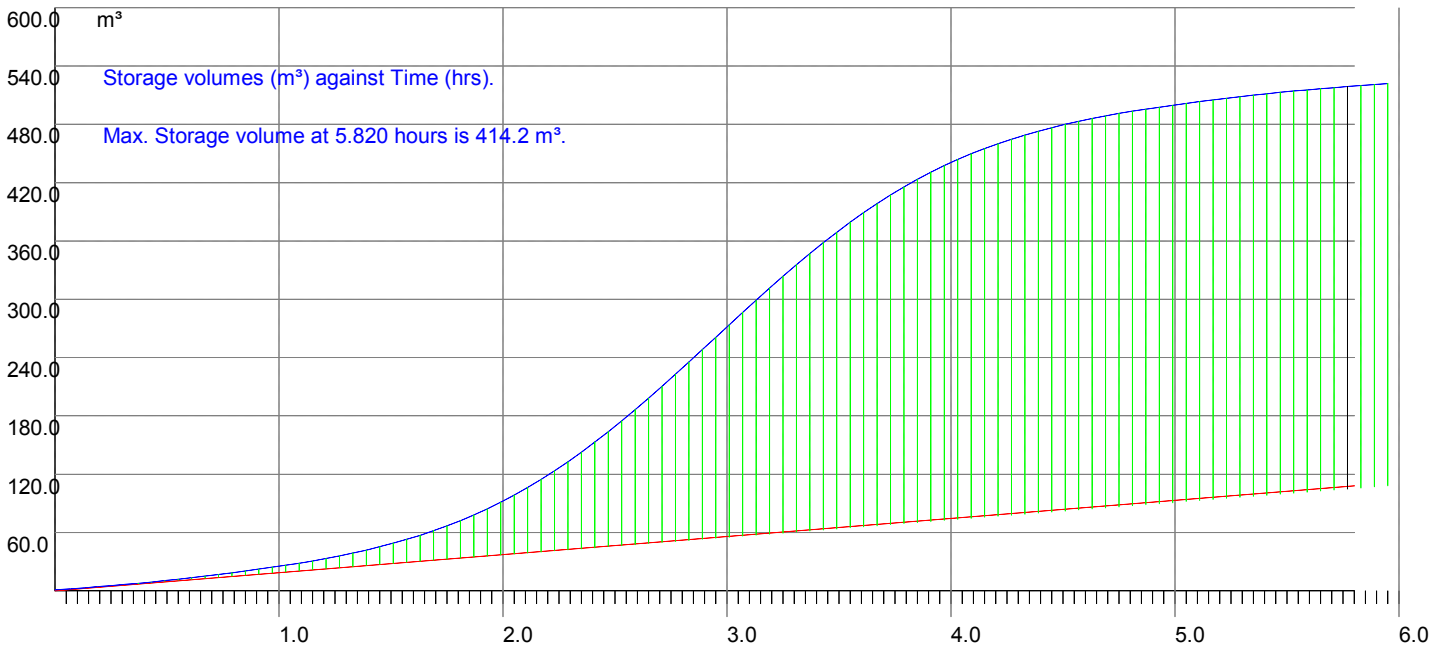
MasterDrain SW

Project	By	Checked	Reviewed

Title 1 in 100 Year (+CC) Storage Volume







MasterDrain SW

KRS Environmental Limited.
www.krsenvironmental.com

29a Green Abbey, Hade Edge
Holmfirth
Huddersfield HD9 2SH
Tel:01484 684565 Mob: 07857 264 376
email: keelan@krsenvironmental.com

Job No.		
Sheet no.	4	
Date	01/03/16	
By	Checked	Reviewed

Project

Title **1 in 100 Year (+CC) Storage Volume**

Explanatory notes for Peak Flow Storage

1) This system uses the rainfall intensity/ duration curve calculated using either the Wallingford or FEH method as selected.
2) The outflow is regarded as constant for the duration of the storm; i.e. no allowance is made for the changing head behind the flow restrictor.*
3) The balance is calculated from the inflow minus the outflow.
4) The storage volume is the maximum value of the balance curve.
5) This method was described by Davis (1963) - see Butler & Davies, 2nd edition, p294
6) References to 'storm duration' relate only to the hydrograph method (qv).
7) There are always 600 steps in the calculation process, thus a 'run' time of 10 hours will be sampled every minute,

Explanatory notes for Hydrograph Storage

1) The user has the choice of Summer or Winter curves
2) The mean intensity varies with the duration of the storm curve
3) There are always 120 steps in the calculation process, irrespective of storm duration.
4) The outflow is regarded as constant for the duration of the storm; i.e. no allowance is made for the changing head behind the flow restrictor.*
5) The balance is calculated from the inflow minus the outflow.
6) The storage volume is the sum of the balance values for each step.
7) Varying durations should be tried to find the maximum storage value - this can be narrowed down very closely.

*Modelling using the flow characteristics of the restrictor is available using Vortex Control modelling function. Please be aware that this function needs the full design data file to function.

Why do the two methods give different results?

The rainfall characteristics for each method are very different.

The Peak flow (using the Intensity/Duration/Frequency curve) does not model the actual rainfall. This curve is joined points which represent the mean intensity of a storm at a given duration i.e. a value of 19.5 mm/hr for a 60 minute storm indicates that over the sixty minute period, the mean intensity was 19.5 mm/hr. The calculation method samples the IDF curve for a given location and frequency (Return Period) and calculates the storage for that rate and duration less the outflow volume. The maximum value is displayed as the 'worst case' storage.

The hydrograph method uses a standard curve for either Winter or Summer storms. Traditionally these are symmetrical about the central peak. UK rainfall does not fit into this convenient curve, so the calculations are dealing with a stylised set of data. The mean intensity for the storm is calculated from the IDF curve and applied to the curve data, calculating the storage for that step less the outflow volume. The final storage volume is the sum of the storage for all the steps.

It can be seen that these two methods are very different, and the user may have the choice of which result to use. This is not an exact science, though is often treated as such by those that do not understand the principles of the calculations.

APPENDIX 4 – 1 in 100 Year (+cc) Storage Volumes Assuming No Infiltration

Rectangular soakaway 1	
Width (m)	7
Length (m)	100
Soakaway base area (m2)	700

Porosity	0.3
Infiltration coefficient (m/h)	0.108
Factor of safety	10

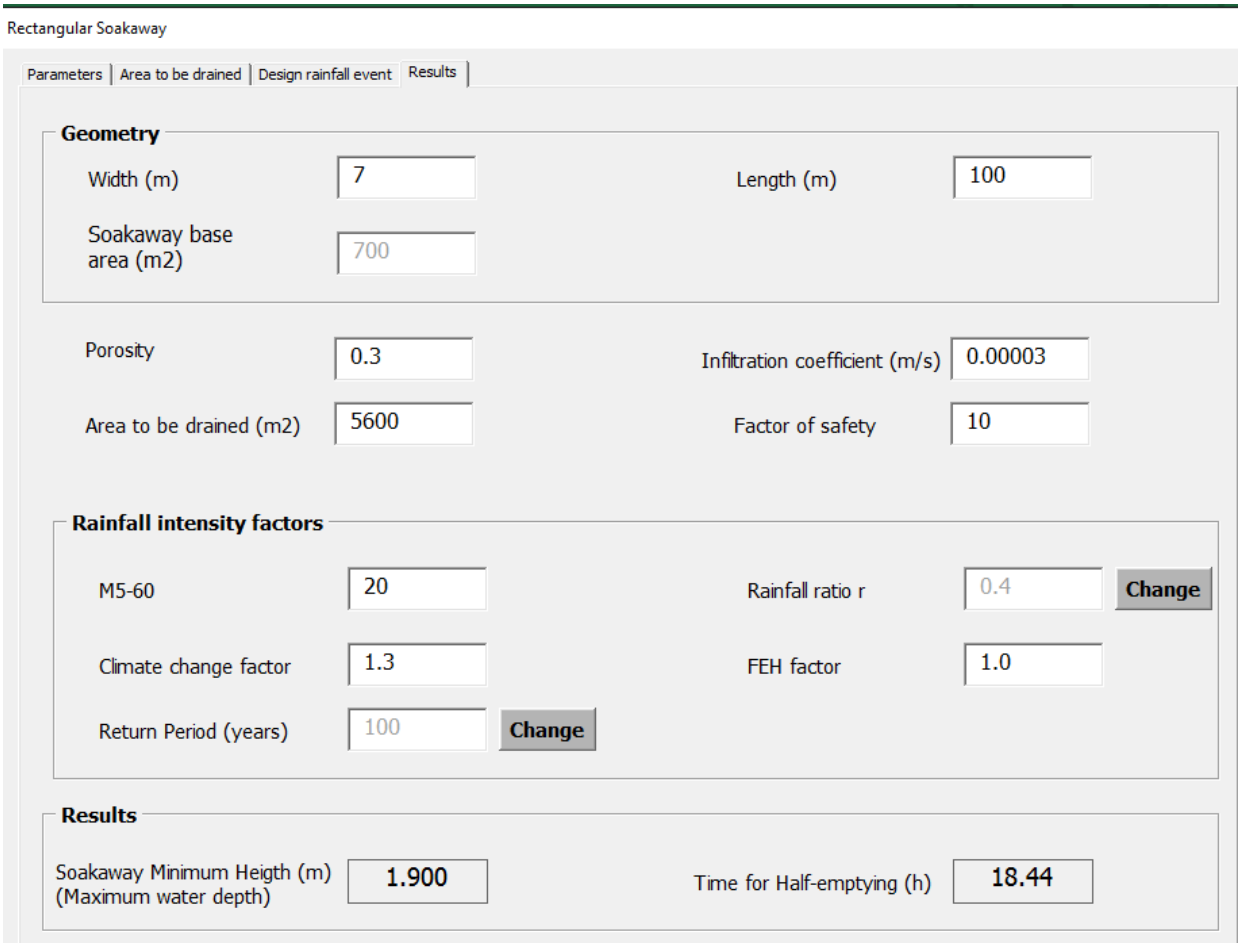
Contributing area	
	5600
Total area (m2)	5600

M5-60 rainfall depth (mm)	20
Rainfall ratio r	0.4
Climate change factor	1.3
FEH factor	1
Return period (years)	100

Rainfall Duration (h)	**Intensity (mm/h)**
0.083333333	223.47
0.166666667	156.429
0.25	131.213
0.5	83.198
1	52.78
2	31.487
4	18.414
6	13.616

10	8.826
24	4.582

Maximum water depth (m)	1.9
Time for half-emptying (h)	18.44


Rectangular Soakaway
Parameters
Area to be drained
Design rainfall event
Results
Geometry
Width (m)
7
Length (m)
100
Soakaway base area (m2)
700
Porosity
0.3
Infiltration coefficient (m/s)
0.00003
Area to be drained (m2)
5600
Factor of safety
10
Rainfall intensity factors
M5-60
20
Rainfall ratio r
0.4
Change
Climate change factor
1.3
FEH factor
1.0
Return Period (years)
100
Change
Results
Soakaway Minimum Heigth (m) (Maximum water depth)
1.900
Time for Half-emptying (h)
18.44



KRS Environmental Ltd

Mob: 07857 264 376

Tel: 01686 668957

Tel: 01484 437420

Email: keelan@krsenvironmental.com

Web: www.krsenvironmental.com