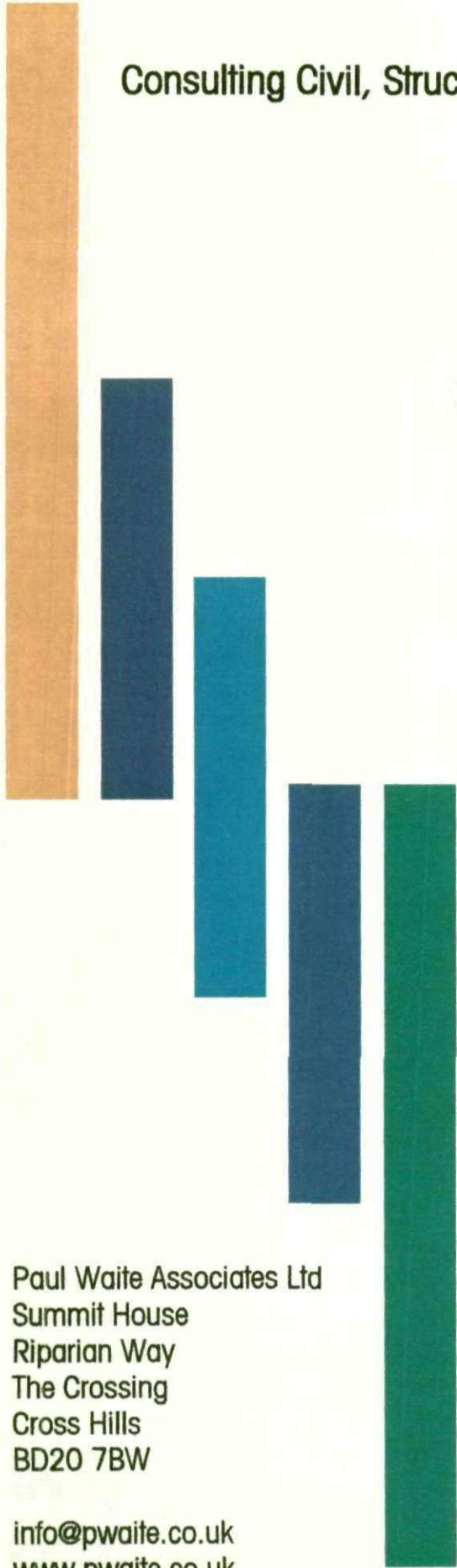




Consulting Civil, Structural & Geo-Environmental Engineers

Flood Risk Assessment

Site Address:
Residential
Development
High Street,
Royston

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Paul Waite Associates were instructed by Bellway Homes Ltd (the Client) to produce a Flood Risk Assessment Report for the site located off High Street in Royston.

Proposals for the site involve construction of 35No. residential units.

Clients Details

Bellway Homes Ltd
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Documents Revision Status

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Executive Summary

Paul Waite Associates have been commissioned by Bellway Homes Ltd to carry out a flood risk assessment for a proposed residential development located off High Street in the village of Royston, near Barnsley.

Proposals involve the construction of 36No. residential units.

The site is currently undeveloped and comprises 4No. disused buildings within the central and east part of the site. The site covers an area of 1.18 Hectares and for calculation purposes is considered to be 100% permeable.

The development is situated within Flood Zone 1 of the Environment Agency Flood Map (version 2.8.2), being the zone with risk of less than 1 in 1,000 year (<0.1% AEP) for river flooding or tidal/coastal flooding.

The primary flood risk to the development has been identified as surface water flooding.

The existing site is not currently drained. Following development, it is believed that both surface water and foul drainage will be directed to the existing public sewer network within High Street.

Post development, the impermeable area within the site is estimated to increase to 0.654 Hectares, hence 55% of the total site area. Therefore the associated increase in surface water runoff from the development will need to be managed to minimise the impact of this runoff on the development and the surrounding environment.

Surface water discharge from the proposed development will need to be restricted to existing greenfield runoff rates, estimated using IOH 124 to be 3.10l/s. However, due to potential

blockage of the required aperture to restrict flows to such a level, it is proposed that the maximum surface water discharge rate from the site is increased to 10l/s.

It is recommended that the drainage design engineer agrees the allowable surface water discharge rate from the development, during the detailed design phase of the project.

Using the Modified Rational Method, storage volumes within the pond for the 1 in 2 year, 30 year, 100 year and 100 year plus 30% climate change events have been calculated as 38m³; 176m³; 259m³ and 366m³ respectively.

The Environment Agency requires that surface water runoff should be controlled as near to its source as possible, through a sustainable drainage approach to surface water management (SUDS). This approach involves using a range of techniques such as soakaways, swales and green roofs to reduce flood risk by attenuating the rate and quantity of surface water runoff from the site. Such techniques are largely dependent upon the ground conditions within the development site.

Due to the ground conditions described in the site investigation carried out by Sirius in 2009, it is likely that disposal of surface water via infiltration methods will be unsuitable for this site.

However, PWA-Geo Ltd is at present carrying out additional site investigation works, including percolation testing. Following completion of this testing, the suitability of infiltration methods to dispose of surface water from the proposed development will be determined.

In addition, recent liaison with Yorkshire Water identified that the use of storage via source control methods such as shallow storage using geocellular cells to reduce the volume of on-line attenuation within the adoptable surface water system is not acceptable.

Therefore it is recommended that the preliminary drainage strategy for the site incorporates attenuation in the form of large diameter pipework. Calculations using the Source Control Module from MicroDrainage indicates that a 155m length of single 1200mm diameter pipe and 78m of twin 1200mm diameter pipe is suitable to accommodate the required attenuation volumes.

However, the size and length of the tank sewer will ultimately be governed by the invert level and cover depth requirements at the connection into the existing public sewer along High Street.

The most appropriate drainage system will be dependent upon the finalised development layout.

It is concluded that there is a low risk of flooding at the proposed residential development off High Street in Royston. The implementation of mitigation measures as described within this report will ensure that any risk of flooding at the proposed development may be reduced to an acceptable level.

1.0 Introduction

Bellway Homes Ltd is proposing to carry out works to develop a site located off Lee Lane in the village of Royston near Barnsley. The site covers an area of approximately 1.18 Hectares to provide 36No. residential units.

The development is situated within Flood Zone 1 of the Environment Agency Flood Map (version 2.8.2), being the zone with risk of less than 1 in 1,000 year (<0.1% AEP) for river flooding or tidal/coastal flooding.

The primary flood risk to the proposed development site is identified to be from surface water runoff, although other flood mechanisms have been considered within this assessment.

The existing site comprises an irregular shaped plot of rough grass with 4No. disused buildings situated within the central and east areas of the site.

It is usual for the Environment Agency to raise an objection to development applications within the functional floodplain or Zone 2 or 3 of the flood map until the question of flood risk has been properly evaluated. The Agency will also object to developments where the total site area is in excess of 1 hectare until suitable consideration has been given to surface water runoff.

Paul Waite Associates have been appointed to carry out an assessment of the site, implement appropriate consultations and prepare a Flood Risk and Drainage Impact Assessment Report in accordance with PPS25, to satisfy the requirements of the Environment Agency and Planning Authority.

2.0 Approach to the Flood Risk Assessment

2.1 Approach

An topographical survey of the site was carried out by HH Surveys Ltd in November 2007. It is understood that the survey has been calibrated to Ordnance Datum, and the resulting site levels have been used within this report.

The requirements for flood risk assessments are generally as set out in Annex E of PPS25. The detail and complexity of the study required should be appropriate to the scale and potential impact of the development. For the purposes of this study, the following have been considered:-

- Available information on historical flooding in the area.
- Site level information.
- Details of structures, which may influence hydraulics of the watercourse and consideration of the effect of blockage of structures.
- Estimates of design levels, equivalent to a 200-year (coastal/tidal) and a 100-year (fluvial) return period flood event.
- Allowances for increased flows resulting from the effects of climate change.
- Allowances for sea level rise resulting from the effects of climate change.
- Assess the existing runoff characteristics and the potential impact the proposed development will have on the runoff.

Further guidance is also provided in the CIRIA Research Project 624 "Development and Flood Risk: Guidance for the Construction Industry".

2.2 Application of the Sequential and Exceptions Test

The risk based sequential test should be applied at all stages of planning. Its aim is to steer new development to areas at the lowest probability of flooding, within zone 1. The flood zones are the starting point for the sequential approach.

The development is situated within Flood Zone 1 of the Environment Agency Flood Map (version 2.8.2), being the zone with risk of less than 1 in 1,000 year (<0.1% AEP) for river flooding or tidal/coastal flooding.

The proposed development comprises a residential development. As such Table D2 of Annex D within PPS25 indicates that the residential portion of the development is classified as 'more vulnerable'.

Utilising the Flood Risk Vulnerability Table as shown below, it is considered that the proposed development is suitable for the site.

Table 1: Flood Risk Vulnerability and Flood Zone 'Compatibility'

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

- ✓ Development is appropriate
- ✗ Development should not be permitted

3.0 Site Details

3.1 Location

The site is centred on ordnance survey grid reference SE 352 114.

An Ordnance Survey plan, indicating the location of the development is presented below.

Figure 1: Location Plan – Land off High Street, Royston



Image produced from the Ordnance Survey Get-a-map service.

Image reproduced with kind permission of Ordnance Survey and Ordnance Survey of Northern Ireland.

★ Proposed Development Site at Royston

3.2 Current Use

The site currently comprises an area of land which is largely undeveloped. There are 4No. disused outbuildings located within the central and east parts of the site, which have formerly been used as pigeon lofts and for storage of animal feed.

3.3 Boundaries

The proposed development is located at land off High Street within the village of Royston.

The site is generally surrounded by existing residential development, with agricultural farmland situated beyond the village to the north, south and west.

The development is located approximately 800 metres to the west of central Royston and 5 kilometres to the north of Barnsley Town centre.

Notton Wood Nature Reserve is situated approximately 800 metres to the west of the proposed development. The Barnsley Canal and associated Trans-Pennine Trail runs north-south through the east part of Royston village.

The proposed development is accessed directly off High Street.

3.4 Topography

From the topographical survey, ground levels within the existing development area fall generally towards the north.

The highest ground level within the site is identified as 78.790mAOD and is located at the south corner of the site. The lowest point within the site lies at a level of 76.19mAOD and is situated at the north west corner of the site.

3.5 Drainage

The existing site is currently undeveloped and is not positively drained, therefore it is considered to be 100% permeable.

The proposed development will significantly increase the impermeable area and consequently result in an increase in surface water runoff from the site. Therefore, consideration of changes to surface water runoff and attenuation within the site needs to be investigated further.

It is believed that foul and surface water flows from the surrounding residential area are directed to a public sewer system within High Street. Therefore following development it is understood that flows from the proposed residential development will be directed towards the public sewer network.

3.6 History of Flooding

A search on the British Hydrological Society Chronology of British Hydrological Events website (<http://www.dundee.ac.uk/geography/cbhe>) found a single record relating to flooding within the village of Royston. This flooding incident was due to the bursting of the Barnsley Canal, which occurred on 6th August 1861. No records relating to flooding at the proposed development off High Street were highlighted.

Undertaking an internet based search for flooding provided no further information relating to historical flooding within the vicinity of the proposed development.

4.0 Flooding Mechanisms

Table 2: Sources of Flooding

Source/Pathway	Significant?	Comment/Reason
Fluvial	No	
Tidal/Coastal	No	
Canal	No	
Pluvial (urban drainage)	Yes	Existing site is not positively drained.
Groundwater	No	
Overland flow	No	No elevated ground within the vicinity of the site.
Blockage	No	
Infrastructure failure	No	
Rainfall Ponding	No	

4.1 Increased Runoff Resulting from the Development

4.1.1 Existing Site

The existing site has a total area of 1.18Ha and is considered to be 100% permeable as the site is presently unused open land, which is overgrown with rough grass. The site does not currently have a formalised drainage system and local topography indicates that surface water runoff currently flows towards the north boundary of the development site.

Following development it is anticipated that surface water runoff from the roof, road and other paved areas will be drained to the existing public sewer network within High Street, located immediately to the north of the development.

In accordance with PPS25, the Environment Agency will request that the runoff from the proposed development is restricted to the existing 1 in 2 year peak greenfield runoff rate. They will further insist that the proposed 1 in 2 year runoff can be maintained and also insist that the 1 in 30 year event is not allowed to flood the surface; hence the water must remain within the

pipes, manholes, and storage systems. The 1 in 100 year plus 30% climate change event will be allowed to flood the surface but flood water will not be permitted to enter any of the buildings within the site. The 1 in 100 year plus climate change flood must also be limited to the development boundary and must not be allowed to migrate to adjacent properties.

In order to estimate the greenfield runoff rate from the development area, the IOH 124 Estimation for Small Catchments Method is considered to be appropriate. This method of calculation utilised the catchment characteristics obtained from the FEH CD-ROM, including the ground conditions, to determine surface water flows from areas which are largely undeveloped. The calculation results are tabulated below and the calculation spreadsheet is in Appendix C of this report.

Table 3: IOH 124 Runoff Calculations

Return Period	Surface Water Runoff (l/s)
1 in 2 year	3.10
1 in 30 year	5.80
1 in 100 year	6.88

Therefore, the allowable peak 1 in 2 year greenfield runoff rate for the total development site is 3.10l/s.

It is anticipated that due to a significant increase in roof and paved areas resulting from the development, surface water will need to be attenuated prior to discharge into the existing public sewer network.

Flows in excess of 3.10l/s would usually be restricted via a Hydrobrake or similar flow control device. However, due to maintenance issues and an increased susceptibility to blockage, for

calculation purposes surface water flows from the proposed development will be restricted to a minimum of 10l/s.

It is recommended that consultation with Yorkshire Water is undertaken by the drainage design engineer to agree a peak rate of surface water discharge from the site, during the detailed design phase of the project.

4.1.2 Proposed Site

As the proposed residential development will involve the construction of minor roads, footpaths and driveways to access the residential units, the total impermeable area within the site will be increased. Therefore surface water runoff from the site will increase and the issues regarding changes in surface water runoff will need to be considered.

Bellway Homes Ltd have provided a Concept Layout of the proposed development, which indicates that the impermeable area within the site following development will be approximately 55% of the total site area, hence 0.654 Hectares.

Using the Wallingford Procedure, Modified Rational Method the volume to be attenuated has been calculated for the 1 in 2 year, 30 year, 100 year and 100 year plus 30% climate change events.

The peak discharge for all four return period events was set at the 10l/s. Reference should be made to Appendix D where the spreadsheets used to calculate the volumes to be stored for each return period are provided.

The required attenuation volumes have been tabulated overleaf.

Table 4: Indicative Balance Volumes

Return Period	Balance Volume (m ³)
1 in 2 year	38
1 in 30 year	176
1 in 100 year	259
1 in 100 year + 30% climate change	366

Figure 2: Aerial Photograph of the Existing Site.



Photograph obtained from Google Maps.

It is normal practice to ensure that the 1 in 30 year event is maintained below the ground in the form of storage. Flows in excess of this are usually permitted to flood the surface as long as it can be demonstrated that there is no flooding to buildings. Any flood volume must not be allowed to migrate to adjacent property, hence contained within the site boundary i.e. within the car park areas and access roads throughout the proposed development area.

If the development is considered to be sensitive, the developer may choose to store the full 1 in 100 year plus 30% climate change balance volume below ground.

It is highlighted that the volume balance requirements should be established to a greater accuracy during the detailed design stage to reflect the actual development proposal, the extent of impermeable areas and associated runoff generated. Preliminary calculations have made no allowance for any additional storage available in the storm water sewer network & manholes, hence providing a 'worst case' scenario.

5.0 Material Consideration In Respect of PPS25

5.1 Climatic Change

Annex A of PPS25 suggests that winters will become wetter over the whole of the UK, by as much as 20% by the year 2050. In making an assessment of the impact of climatic change, flooding from rivers and land will give a peak flow allowance of up to 20% increase in rainfall for a given return period by 2050 and 30% by 2110. These considerations will provide an appropriate precautionary assessment for climatic change impact on flood flows and rainfall intensities.

The areas surrounding the site comprise existing development and therefore in terms of climatic change, only rainfall falling within the site will be considered.

The latest identified figures in Annex B of PPS25 identifies that increases in rainfall of around 30% are anticipated for developments extending beyond the year 2050. It will be necessary, therefore, to make allowance for this increased rainfall in any positive drainage system assumed on the site.

5.2 Environment Agency Flood Maps

The Environment Agency flood zone map indicates that the site lies within Flood Zone 1, of the Environment Agency Flood Map (version 2.8.2), being the zone with risk of less than 1 in 1,000 year (<0.1% AEP) for river flooding or tidal/coastal flooding.

Figure 3: Environment Agency Flood Map



Source: Environment Agency website (<http://www.environment-agency.gov.uk/subjects/flood>)

★ Proposed Development Site at Royston

5.3 Proposed Finished Floor Levels

The proposed development off High Street in Royston is located within Flood Zone 1 of the Environment Agency Map and therefore land raising within the site will not be required as a direct result of flood risk.

However it is recommended that the internal ground floor levels of the proposed residential units are elevated to a minimum of 150mm above the adjacent external finished ground levels to mitigate against any localised flooding which may be caused by heavy rainfall.

5.4 Emergency Access and Egress during Times of Flood

It is a requirement under Planning Policy Statement PPS25 that occupants should be able to gain access or egress to any building during times of flood, without being trapped by flood conditions.

The development is shown to lie completely within Flood Zone 1. As such, it is considered that safe access and egress from the site will be possible at all times.

5.5 Surface Water Attenuation

It is a requirement of any new development to ensure that surface water run-off from any has a negligible consequence on downstream areas as a result of sewer capacity or discharge to watercourse.

Following development it is believed that surface water will be directed to the existing public sewer network located within High Street, immediately to the north to the development site. It is also estimated that surface water from the site will be increased, due to the increase in roof, driveway, access road and other paved areas within the new development.

The 1 in 2 year greenfield runoff from the existing site is estimated to be 3.1l/s, however, due to the susceptibility for blockage of an aperture sized to restrict surface water flows to such a level, the maximum allowed discharge rate from the development has been increased to 10l/s.

It is highlighted that the maximum allowed surface water discharge rate from the development must be agreed with Yorkshire Water.

Surface water flows in excess of 10l/s will need to be attenuated on-site prior to discharge into the receiving sewer.

Indicative volumes for attenuation have been calculated for a range of return periods and are tabulated below.

Table 5: Indicative Volumes for Attenuation

Return Period	Balance Volumes: Total Development Area (m ³)
1 in 2 year	38
1 in 30 year	176
1 in 100 year	259
1 in 100 year + 30% climate change	366

5.6 Sustainable Urban Drainage

The impermeable area within the site will be increased following development. There will therefore be an increase in surface water runoff from the site when it is developed. The existing site is considered to be 'greenfield' in nature and as such, the Environment Agency, Yorkshire Water and the Local Authority will request that surface water runoff from the proposed development is restricted to greenfield runoff rates. The maximum outflow from the proposed development is therefore estimated to be 10l/s.

In addition, the Environment Agency requires that adequate pollution control is incorporated into the drainage system in order to prevent deterioration of the quality of the water environment. However, this is only applicable for surface water originating from access roads and communal parking areas, which needs to be passed through a petrol/oil interceptor or equivalent system prior to discharge into the existing public sewer or infiltration system.

It is noted however, that this will not apply to surface water originating from roof drainage.

To reduce the impact of surface water runoff from the development in accordance with the requirements of the Environment Agency, Yorkshire Water and Local Authority, the employment of SUDS techniques to limit runoff volumes and rates from the site are recommended. SUDS techniques can also be used to provide an appropriate level of treatment to the runoff.

It is normal practice to ensure that the 1 in 30 year event is maintained within the drainage system and the 1 in 100 year is permitted to flood the surface as long as there is no flooding to buildings and the flood volume is contained within the site boundary in specific areas proposed for this purpose.

The following section will provide some possible SUDS techniques which could be employed on the site to balance flows within the proposed development. SUDS techniques are also able to provide treatment to the runoff to remove a proportion of the pollution and protect the quality of the downstream watercourses. Following guidance from CIRIA Report C522 the following levels of treatment will be provided:

- Roofs – 1 level
- Driveways – 1 level
- Roads and communal parking areas – 2 levels.

The level of treatment indicates the number of SUDS techniques that will be used to treat pollution. For example if two levels are required the runoff may enter a filter drain that leads to a basin or pond before outfall.

It is recommended that source control techniques are used. In practice there will be little outflow from these techniques for a 1 in 2 year storm as most of the rainfall will be held within the system and will disperse via evapotranspiration. Further detail of the potential to use SUDS within this site is provided overleaf within Table 6. The precise combination of methods used will be dependent upon the site constraints identified at the final design stage.

With regards to the potential for infiltration methods to dispose of surface water from the development, the following information has been extracted from the Site Investigation Report as carried out by Sirius in July 2009 and confirmed by internal discussion with PWA-Geo Ltd, who are currently undertaking additional site investigation works.

'The site is recorded as being underlain by Boulder Clay (Glacial Till), overlying strata of the Middle Coal Measures, comprising Oaks Rock (sandstone) and undifferentiated mudstone, siltstone, sandstone and coal.'

As such it is considered that disposal of surface water from the development via infiltration methods may not be feasible.

This concurs with the catchment descriptors obtained from the Flood Estimation Handbook CD-ROM for the area containing the proposed development site. The SPRHOST (standard percentage runoff) for the catchment area is given as 31.2%, indicating that the ground conditions are unlikely to suit the use of infiltration techniques.

It is understood that percolation tests at the proposed development are currently being carried out by PWA-Geo Ltd in order to determine if infiltration methods can be utilised as part of the drainage strategy for the site.

Table 6: SUDS Techniques and Suitability of Use

Method	Description	Potential for use at site
Filter drains	Drainage trench filled with gravel and provided with a pipe	Suitability to be determined following results of percolation testing.
Swales	Shallow grass ditch	Current development layout does not permit the required space to effectively utilise swales.
Permeable surfaces	Pavement surfaces that allow water to pass through into underlying storage in sub base e.g. permeable concrete block paving or porous asphalt	May be considered suitable for use within the access road, driveway areas, and car park areas in order to reduce the volume for on-line attenuation
Ponds and basins	Open areas that are used to store and treat rainwater. Ponds are permanent bodies of water and basins are generally dry and occasionally store water	Space within the proposed development is limited and as such this SUDS technique is not considered practical
Green roofs	Roof system that is vegetated with plants (note sedum plants rather than grass so no mowing is required)	Suitability is dependent on design of buildings
Infiltration devices	Methods that allow rainwater to soak into the ground, e.g. soakaways	Suitability to be determined following results of percolation testing.
Storage tanks	Underground tanks that temporarily store water in the drainage system	These will be used as a last resort on this site if dictated by site constraints

6.0 Preliminary Drainage Strategy

6.1 General

The proposed development covers an overall area of 1.18 Hectares, and is to comprise residential development. A Concept Layout has been provided by Bellway Homes Ltd, which indicates that roof; road, driveway and other hardstanding areas cover an area of 0.654 Hectares, which equates to 55% of the development area.

Open green space within the proposed development is limited and therefore SUDS techniques such as retention or detention ponds and wetlands are considered impractical in this case.

Using the suitability matrix which has been adapted from CIRIA Report C697, the following SUDS techniques have been given further consideration for use at this site. The output tables are illustrated within Appendix E of this report:

Table 6: Results from the SUDS Suitability Matrix

SUDS Group	Residential
Retention	✓
Wetland	✓
Infiltration	x
Filtration	✓
Detention	x
Open Channel	x
Source Control	✓

6.2 Retention

6.2.1 Sub-surface Storage

Although not strictly SUDS, below ground storage tanks can be installed to attenuate peak runoff from the site with a hydrobrake or similar flow control structure limiting the discharge to an agreed rate.

The volume of storage achievable would depend on the area available for such a structure, which could be a concrete tank or a system of lightweight geocellular units, and on the depth of the receiving surface water sewer.

The use of underground storage tanks should be used to supplement other more sustainable urban drainage techniques should these prove not to be practical.

6.3 Wetland

Wetlands are structurally similar to wet ponds and incorporate wetland plants in a shallow pool.

As surface water runoff flows through the wetland, pollutant removal is achieved by settling and biological uptake.

Wetlands are among the most effective SUDS techniques in terms of pollutant removal, and also offer aesthetic value.

While natural wetlands can sometimes be used to treat surface water runoff that has been properly pretreated, surface water wetlands are fundamentally different from natural wetland systems.

Surface water wetlands are designed specifically for the purpose of treating runoff, and typically have less biodiversity than natural wetlands both in terms of plant and animal life.

There are several design variations of the stormwater wetland, each design differing in the relative amounts of shallow and deep water, and dry storage above the wetland.

6.3.1 Pocket Wetland

A pocket wetland is typically designed so that the bottom of the wetland intersects the groundwater within the site, which helps to maintain the permanent pool. Some evidence suggests that groundwater flows may reduce the overall effectiveness of surface water management practices. This option may be used when there is not significant drainage area to maintain a permanent pool for the surface water wetland.

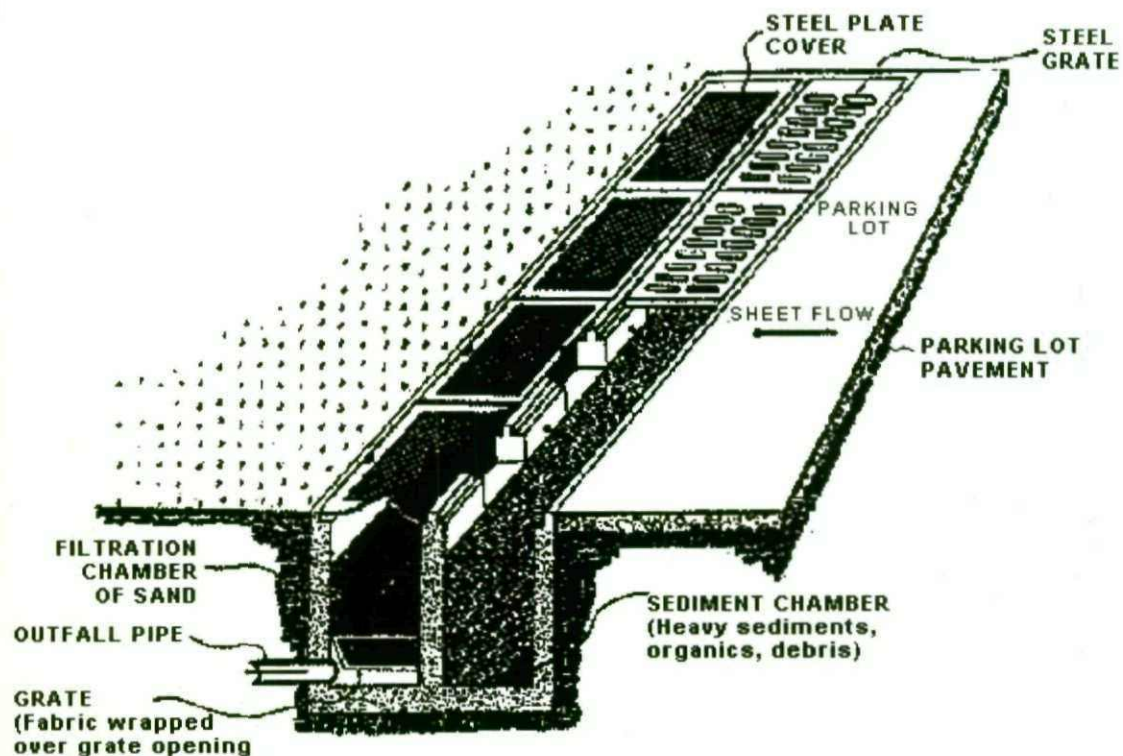
The available space within the proposed development in which such a feature may be accommodated is very limited. As such, this SUDS solution is not deemed to be suitable within the proposed development.

6.4 Filtration

6.4.1 Sub-surface Sand Filter

A sub-surface sand filter typically consists of a multi-chamber underground vault accessible by access holes or grate openings. This filtration system was designed to treat flow conveyed by a storm water sewer, and can be retrofitted within existing systems. Surface water flow is collected from an impervious area and is well suited to placement along parking areas.

Figure 4: Sketch Illustrating a Typical Sand Filter with Grated Inlets



During a storm, the water quality volume is temporarily stored in an underground chamber that provides for pre-treatment by settling. Over time the stored volume flows by gravity into a filter chamber where it moves through the sand filter. Filtered runoff is collected and then discharged into the receiving watercourse or sewer network. During large rainfall events any flow in excess of the filter's capacity is diverted around the sand filter by means of an overflow weir.

The underground sand filter works by a combination of sedimentation and filtration. The sedimentation serves as a pre-treatment measure by removing larger diameter suspended solids and capturing floating hydrocarbons. If the filter consists of a 450mm thick layer of sand the filter will trap up to 90 percent of the small particles in surface water runoff (diameters

between 6 to 41 microns). A lower level of removal will occur for any dissolved pollutants due to the adsorption capabilities of the sand medium.

The below ground sand filter is considered to be highly applicable to the urban setting and requires a small commitment of land area, provides dependable service, and is relatively effective at urban pollutant removal.

The design of the filter unit is flexible and the size and shape of the unit can be set based on local site constraints and has an effective life span of 5 to 20 years.

Below ground sand filters are relatively expensive to construct in comparison to other SUDS techniques and requires implementation of a regular maintenance regime. Inherent problems relating to this type of SUDS method include ponding; the accumulation of oil/grease within the settling chamber and clogging of the filter material due to siltation.

Therefore it is unlikely that such a method will be adopted within the drainage strategy for the site off High Street in Royston.

6.4.2 Filter Trench/Strips

Grassed filter strips are vegetated areas that are intended to treat sheet flow from adjacent impermeable areas. Filter strips function by slowing runoff velocities and filtering out sediment and other pollutants, and providing some infiltration into underlying soils.

Filter strips were originally used as an agricultural treatment practice, and have more recently evolved into an urban practice. With proper design and maintenance, filter strips can provide relatively high pollutant removal.

One challenge associated with filter strips, however, is that it is difficult to maintain sheet flow. Consequently, urban filter strips are often "short circuited" by concentrated flows, which results in little or no treatment of stormwater runoff.

Therefore it is concluded that this SUDS technique is unsuitable for use within the proposed development.

6.5 Source Control

6.5.1 Permeable Pavements

Permeable surfaces such as permeable block paving and porous resin bound gravel or asphalt can mimic soft landscaping, by allowing surface water to drain between the blocks and into either a granular sub base or plastic box sub base replacement system, such as Stormcell or similar.

Permeable surfaces should ideally discharge into the ground if conditions allow, however, if the infiltration rate is found to be insufficient, the permeable surfaces could be designed to discharge into the surface water drainage system by incorporating an impermeable membrane below the sub base layer.

The flow of water through a granular sub base, or plastic box sub base replacement system would allow the removal of oil and other contaminants in the water through natural biological action, improving the quality of water discharged into the existing surface water sewer.

In areas where permeable surfaces were provided, there would be no need for traditional drainage ironwork or an oil interceptor.

This method is considered to present an ideal solution in order to reduce the volume of on-line attenuation required within the adoptable sewer network.

However, recent discussions with Yorkshire Water have indicated that this method of attenuation is not acceptable and as such this SUDS solution has not been considered for use within the preliminary drainage strategy for the proposed development.

Figure 5: Typical Cross Section through Geocellular Stormcell Units



6.5.2 Rainwater Harvesting and Green Roofs

Rainwater harvesting and green roofs provide both attenuation of surface water and reuse within the site. In doing so, they reduce the demand on potable water resources whilst minimising runoff from the development.

There are many benefits to the use of green roofs within new development. However, the primary benefit is the reduction of storm water runoff. As urban development continues, many areas can no longer accommodate the volume of water discarded from roof, road and other impervious surfaces.

Green roofs hold rain like a sponge, and allow nature to dissipate the moisture naturally rather than rely on traditional surface water sewer systems. Other benefits include reduces air and noise pollution, provides urban micro-climates, provides useable outdoor patio spaces, and provides protection from heat, ultraviolet radiation, and physical damage caused by the climate. The suitability of such a SUDS technique within the proposed development off High Street in Royston is dependant upon the design of the buildings.

Harvesting of rainwater is simply the collection of water for domestic or commercial use that would otherwise be discharged into the nearest receiving watercourse or sewer.

Various techniques have been practised to collect and store water, especially in areas of low rainfall. Modern rainwater harvesting systems can be installed in both new and existing buildings and can range from a quick, cheap water butt to a more complex system.

Rainwater can be used for the garden, washing the car, showering, flushing the toilet, the washing machine, and even drinking if treated with UV light.

The inclusion of rainwater harvesting and/or green roof technology within the drainage strategy for the proposed development presents the developer with issues regarding future maintenance and as such it is unlikely that the technology will be utilised within the drainage strategy for the development.

6.6 Conclusion

A preliminary drainage strategy for the proposed development at Royston has been devised by Paul Waite Associates.

Due to the limited space and poor infiltration characteristics of the underlying geology within the site, the strategy incorporates the conveyance of surface water runoff via a piped network to an oversized pipe situated within the access road.

6.7 Calculations

A preliminary drainage design has been carried out using MicroDrainage.

During the 1 in 30 year event, the required volume of attenuation is estimated to be 176m³, which creates a storage provision of 155 metres of single 1200mm diameter pipe or 78 metres of twin 1200mm diameter pipe.

However, the final size and length of the tank sewer will ultimately be governed by the invert level and cover depth requirements at the connection into the existing public sewer along High Street.

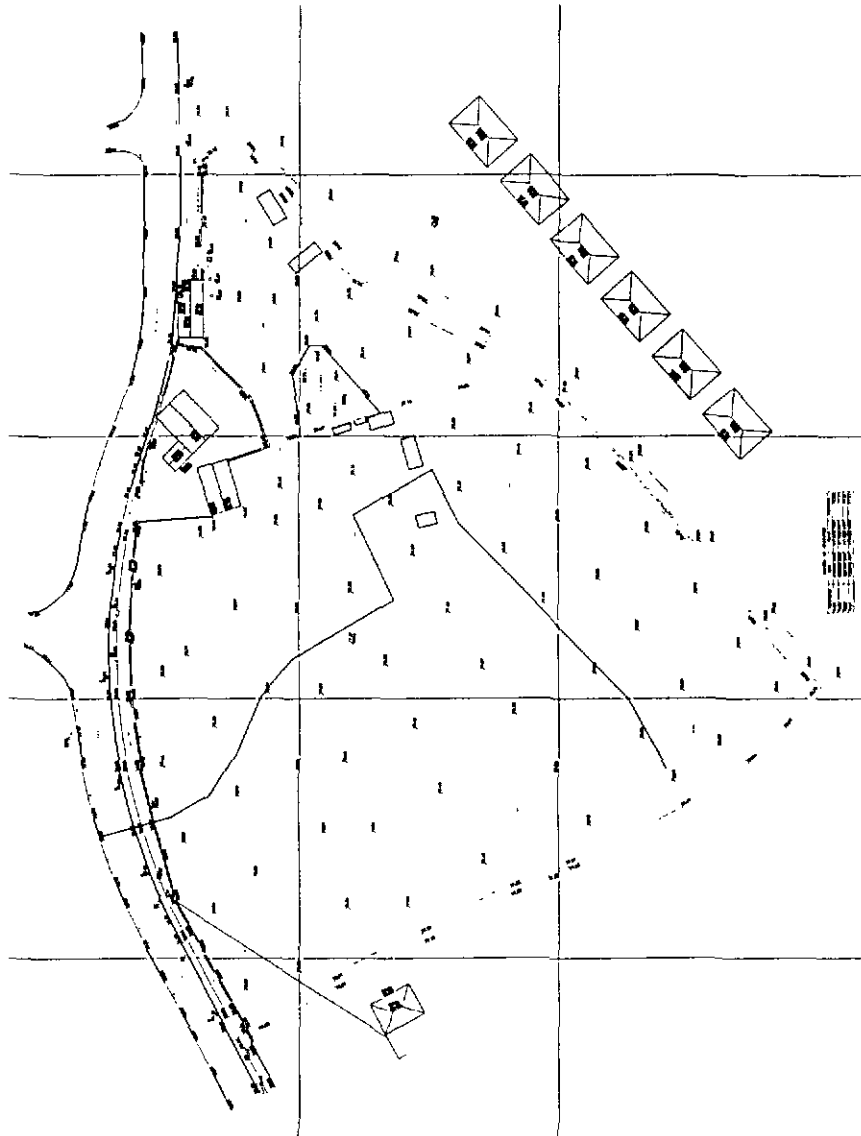
7.0 Conclusions and Recommendations

- 7.1 The proposed development is located within Flood Zone 1 of the Environment Agency's Flood Map.
- 7.2 The primary flood risk to the development is from surface water runoff.
- 7.3 Current proposals for the development incorporate the construction of 36No residential development.
- 7.4 Following development the impermeable area within the site will increase to 55% of the total area, hence 0.654 Hectares..
- 7.5 The existing site is considered to be 100% permeable, and as such, surface water discharge from the proposed development must be restricted to existing greenfield runoff rates.
- 7.6 The existing greenfield runoff rate has been estimated using IOH 124 to be 3.10l/s. However, due to the susceptibility for blockage for an aperture required to limit surface water runoff to this rate, the maximum design discharge rate has been increased to 10l/s. Flows in excess of this will need to be attenuated on-site.
- 7.7 It is recommended that the design surface water discharge rate from the development is agreed with Yorkshire Water during the detailed design stage of the project.
- 7.8 It is estimated that the volume of attenuation required for the 1 in 30 year event is approximately 176m³, although this volume balance requirement should be recalculated during the detailed design stage to reflect the actual development proposal, the extent of impermeable areas and runoff to be generated.

- 7.9 The preliminary drainage strategy for the development involves conveyance of surface water runoff via a piped network to an oversized pipe situated within the access road
- 7.10 In order to mitigate against localised flooding caused by heavy rainfall, it is recommended that the internal ground floor level of the proposed residential properties are raised a minimum of 150mm above the finished external ground levels within the site.

APPENDIX A

EXISTING SITE PLAN



APPENDIX B

PROPOSED DEVELOPMENT:

CONCEPT LAYOUT PLAN



ACCOMMODATION SCHEDULE

SITE: Royston

DRAWING NUMBER:

Storey	House Type	Abb	No	Bedrooms	Sq/ft	Total sqft	%age
2	Milton	mil	4	2	642	2568	11
3	Winchester	wm	3	3	1141	3423	8
2	Darwin	da	3	3	822	2466	8
2.5	Darwin	dal(2.5)	3	3	1168	3504	8
2	Milbeck	mi	7	4	1096	7462	19
2	Brampton	br	10	4	1184	11840	28
2	Holmrook	ho	3	4	1469	4407	8
2	Chatsworth	ch	2	4	1458	2916	6
2.5	Chatsworth	chl(2.5)	1	5	2064	2064	3
Total			36			Total Sq.Ft 40650	100



Chart
Site
Plan

APPENDIX C

IOH 124: GREENFIELD

RUNOFF CALCULATION

INSTITUTE OF HYDROLOGY REPORT 124 FLOOD ESTIMATION ON SMALL CATCHMENTS

This spreadsheet is suitable for estimating design flows on small rural catchments (less than 25 km²) using the IH Report 124 equation for QBAR plus the FSR regional growth curves. Rural can be taken as meaning URBAN less than 0.05, or equivalently URBEX

Key

	User Input
	Header (do not change)
	Formula cell (do not change)

Step 1: Enter catchment descriptors and calculate QBAR

AREA	From FEH CD-ROM	0.0118	km2
SAAR4170	From FEH CD-ROM	661	mm
SOIL	From FSR WRAP maps	0.312	Enter fraction of catchment covered by each WRAP class:
	</		

QBAR	0.003	m3/s
------	-------	------

Step 2: Use a FSR regional growth curve to estimate design flows

Choose your region from the map. Enter a number, or I for Ireland or GB for Great Britain

3

Return period	Design flow (m ³ /s)	Specific runoff (l/s/ha)
2	0.00310	2.63
2.33	0.00329	2.79
5	0.00412	3.49
10	0.00479	4.06
20	0.00543	4.60
25	0.00563	4.77
30	0.00580	4.91
50	0.00626	5.31
75	0.00663	5.61
100	0.00688	5.83
150	0.00725	6.14
200	0.00750	6.36



APPENDIX D

MODIFIED RATIONAL METHOD:

INDICATIVE BALANCE

VOLUMES

Modified Rational Method

Length (m)	185	m
Area (ha)	0.654	Ha
Max Height	78.4	mAOD
Min Height	76.5	mAOD
DeltaH	1.8	
Slope (%)	0.99	
Te (mins)	14.94	mins
ARF	0.998	
SAAR	648.000	mm
UCWI	65	mm
PIMP	100.0	%
SOIL	0.31	
Percentage Runoff PR	75.07	
DEEPSTOR	0.71	

Cv	0.7507	
Cr	1.3	
Allowable outflow		
2 year	0.01	m s
		m3
Storage	RT years	Storage
	2	38

Post Development		Return Period	flood	2	years					
		Rainfall	2	years						
Rainfall Duration (hours)	Rainfall Duration (days)	Rainfall Depth (mm)	Effective Depth (mm)	Rainfall Intensity (mm/hr)	FLOW (l/s)	FLOW (l/s/ha)	RUN-OFF		Allowable Outflow (m³)	Difference (m³)
							FLOW (m³)	RAIN (m³)		
0.25	0.010	6.87	6.7	27.5	48.8	74.6	44	44	9.00	35
0.5	0.021	8.84	8.6	17.7	31.4	48.0	56	56	18.00	38
0.75	0.031	10.24	10.0	13.7	24.2	37.0	65	65	27.00	38
1	0.042	11.35	11.1	11.4	20.1	30.8	72	72	36.00	36
1.25	0.052	12.3	12.0	9.8	17.5	26.7	79	79	45.00	34
1.5	0.063	13.13	12.8	8.8	15.5	23.7	84	84	54.00	30
1.75	0.073	13.87	13.5	7.9	14.1	21.5	89	89	63.00	26
2	0.083	14.54	14.2	7.3	12.9	19.7	93	93	72.00	21
2.25	0.094	15.17	14.8	6.7	12.0	18.3	97	97	81.00	16
2.5	0.104	15.75	15.4	6.3	11.2	17.1	101	101	90.00	11
2.75	0.115	16.29	15.9	5.9	10.5	16.1	104	104	99.00	5
3	0.125	16.8	16.4	5.6	9.9	15.2	107	107	108.00	-1
3.25	0.135	17.28	16.9	5.3	9.4	14.4	110	110	117.00	-7
3.5	0.146	17.74	17.3	5.1	9.0	13.8	113	113	126.00	-13
3.75	0.156	18.18	17.7	4.8	8.6	13.2	116	116	135.00	-19
4	0.167	18.6	18.2	4.7	8.3	12.6	119	119	144.00	-25
4.25	0.177	19.01	18.6	4.5	7.9	12.1	121	121	153.00	-32
4.5	0.188	19.4	18.9	4.3	7.6	11.7	124	124	162.00	-38
4.75	0.198	19.77	19.3	4.2	7.4	11.3	126	126	171.00	-45
5	0.208	20.13	19.6	4.0	7.1	10.9	129	128	180.00	-52
5.25	0.219	20.48	20.0	3.9	6.9	10.6	131	131	189.00	-58
5.5	0.229	20.82	20.3	3.8	6.7	10.3	133	133	198.00	-65
5.75	0.240	21.15	20.6	3.7	6.5	10.0	135	135	207.00	-72
6	0.250	21.47	21.0	3.6	6.3	9.7	137	137	216.00	-79
6.25	0.260	21.78	21.3	3.5	6.2	9.5	139	139	225.00	-86
6.5	0.271	22.09	21.6	3.4	6.0	9.2	141	141	234.00	-93
6.75	0.281	22.38	21.8	3.3	5.9	9.0	143	143	243.00	-100
7	0.292	22.67	22.1	3.2	5.7	8.8	145	145	252.00	-107
7.25	0.302	22.95	22.4	3.2	5.6	8.6	147	146	261.00	-115
7.5	0.313	23.23	22.7	3.1	5.5	8.4	148	148	270.00	-122
7.75	0.323	23.5	22.9	3.0	5.4	8.2	150	150	279.00	-129
8	0.333	23.77	23.2	3.0	5.3	8.1	152	152	288.00	-136
8.25	0.344	24.02	23.4	2.9	5.2	7.9	153	153	297.00	-144
8.5	0.354	24.28	23.7	2.9	5.1	7.7	155	155	306.00	-151
8.75	0.365	24.53	23.9	2.8	5.0	7.6	157	157	315.00	-158
9	0.375	24.77	24.2	2.8	4.9	7.5	158	158	324.00	-166
9.25	0.385	25.01	24.4	2.7	4.8	7.3	160	160	333.00	-173
9.5	0.396	25.25	24.6	2.7	4.7	7.2	161	161	342.00	-181
9.75	0.406	25.48	24.9	2.6	4.6	7.1	163	163	351.00	-188
10	0.417	25.71	25.1	2.6	4.6	7.0	164	164	360.00	-196

Modified Rational Method

Length (m)	185	m
Area (ha)	0.654	Ha
Max Height	78.4	mAOD
Min Height	76.5	mAOD
DeltaH	1.8	
Slope (%)	0.99	
Te (mins)	14.94	mins
ARF	0.998	
SAAR	648.000	mm
UCWI	65	mm
PIMP	100.0	%
SOIL	0.31	
Percentage Runoff PR	75.07	
DEEPSTOR	0.71	

Cv	0.7507	
Cr	1.3	
Microbial Growth Factor		
30 year return period	0.01	m/s
		m3
Storage	RT years	Storage
	30	176

Return Period		flood	30	years						
Post Development		Rainfall	50	years						
Rainfall Duration (hours)	Rainfall Duration (days)	Rainfall Depth (mm)	Effective Depth (mm)	Rainfall Intensity (mm/hr)	FLOW (l/s)	FLOW (l/s/ha)	RUN-OFF		Allowable Outflow (m³)	Difference (m³)
							FLOW (m³)	RAIN (m³)		
0.25	0.010	21.84	21.3	87.4	155.0	237.0	140	139	9.00	130
0.5	0.021	26.52	25.9	53.0	84.1	143.9	169	169	18.00	151
0.75	0.031	29.66	28.9	39.5	70.2	107.3	189	189	27.00	162
1	0.042	32.1	31.3	32.1	57.0	87.1	205	205	36.00	169
1.25	0.052	34.12	33.3	27.3	48.4	74.1	218	218	45.00	173
1.5	0.063	35.86	35.0	23.9	42.4	64.9	229	229	54.00	175
1.75	0.073	37.4	36.5	21.4	37.9	58.0	239	239	63.00	176
2	0.083	38.78	37.8	19.4	34.4	52.6	248	248	72.00	176
2.25	0.094	40.03	39.1	17.8	31.6	48.3	256	255	81.00	174
2.5	0.104	41.19	40.2	16.5	29.2	44.7	263	263	90.00	173
2.75	0.115	42.27	41.3	15.4	27.3	41.7	270	270	99.00	171
3	0.125	43.27	42.2	14.4	25.6	39.1	276	276	108.00	168
3.25	0.135	44.22	43.2	13.6	24.1	36.9	282	282	117.00	165
3.5	0.146	45.11	44.0	12.9	22.9	35.0	288	288	126.00	162
3.75	0.156	45.96	44.9	12.3	21.7	33.3	294	293	135.00	158
4	0.167	46.76	45.6	11.7	20.7	31.7	299	298	144.00	154
4.25	0.177	47.53	46.4	11.2	19.8	30.3	304	303	153.00	150
4.5	0.188	48.27	47.1	10.7	19.0	29.1	308	308	162.00	146
4.75	0.198	48.98	47.8	10.3	18.3	28.0	313	313	171.00	142
5	0.208	49.66	48.5	9.9	17.6	26.9	317	317	180.00	137
5.25	0.219	50.31	49.1	9.6	17.0	26.0	321	321	189.00	132
5.5	0.229	50.94	49.7	9.3	16.4	25.1	325	325	198.00	127
5.75	0.240	51.56	50.3	9.0	15.9	24.3	329	329	207.00	122
6	0.250	52.15	50.9	8.7	15.4	23.6	333	333	216.00	117
6.25	0.260	52.72	51.4	8.4	15.0	22.9	337	336	225.00	111
6.5	0.271	53.28	52.0	8.2	14.5	22.2	340	340	234.00	106
6.75	0.281	53.82	52.5	8.0	14.1	21.6	344	344	243.00	101
7	0.292	54.35	53.0	7.8	13.8	21.1	347	347	252.00	95
7.25	0.302	54.86	53.5	7.6	13.4	20.5	350	350	261.00	89
7.5	0.313	55.36	54.0	7.4	13.1	20.0	354	353	270.00	83
7.75	0.323	55.85	54.5	7.2	12.8	19.6	357	356	279.00	77
8	0.333	56.33	55.0	7.0	12.5	19.1	360	360	288.00	72
8.25	0.344	56.79	55.4	6.9	12.2	18.7	363	362	297.00	65
8.5	0.354	57.25	55.9	6.7	12.0	18.3	366	365	306.00	59
8.75	0.365	57.7	56.3	6.6	11.7	17.9	369	368	315.00	53
9	0.375	58.13	56.7	6.5	11.5	17.5	371	371	324.00	47
9.25	0.385	58.56	57.1	6.3	11.2	17.2	374	374	333.00	41
9.5	0.396	58.98	57.6	6.2	11.0	16.8	377	376	342.00	34
9.75	0.406	59.39	58.0	6.1	10.8	16.5	379	379	351.00	28
10	0.417	59.79	58.3	6.0	10.6	16.2	382	382	360.00	22

Modified Rational Method

Length (m)	185	m
Area (ha)	0.654	Ha
Max Height	78.4	mAOD
Min Height	76.5	mAOD
DeltaH	1.8	
Slope (%)	0.99	
Te (mins)	14.94	mins
ARF	0.998	
SAAR	648.000	mm
UCWI	65	mm
PIMP	100.0	%
SOIL	0.31	
Percentage Runoff PR	75.07	
DEEPSTOR	0.71	

Cv	0.7507	
Cr	1.3	
100,year	0.01	m s
		m3
Storage	RT years	Storage
	100	259

Post Development		Return Period	flood	100	years					
		Rainfall	140	years						
Rainfall Duration (hours)	Rainfall Duration (days)	Rainfall Depth (mm)	Effective Depth (mm)	Rainfall Intensity (mm/hr)	FLOW (l/s)	FLOW (l/s/ha)	RUN-OFF		Allowable Outflow (m³)	Difference (m³)
							FLOW (m³)	RAIN (m³)		
0.25	0.010	30.66	29.9	122.6	217.6	332.7	196	196	9.00	187
0.5	0.021	36.59	35.7	73.2	129.8	198.5	234	234	18.00	216
0.75	0.031	40.51	39.5	54.0	95.8	146.5	259	259	27.00	232
1	0.042	43.53	42.5	43.5	77.2	118.1	278	278	36.00	242
1.25	0.052	46.01	44.9	36.8	65.3	99.9	294	294	45.00	249
1.5	0.063	48.14	47.0	32.1	56.9	87.1	307	307	54.00	253
1.75	0.073	50.01	48.8	28.6	50.7	77.5	319	319	63.00	256
2	0.083	51.69	50.4	25.8	45.9	70.1	330	330	72.00	258
2.25	0.094	53.21	51.9	23.6	42.0	64.2	340	340	81.00	259
2.5	0.104	54.6	53.3	21.8	38.8	59.3	349	348	90.00	258
2.75	0.115	55.9	54.6	20.3	36.1	55.1	357	357	99.00	258
3	0.125	57.1	55.7	19.0	33.6	51.6	365	364	108.00	256
3.25	0.135	58.23	56.8	17.9	31.8	48.6	372	372	117.00	255
3.5	0.146	59.3	57.9	16.9	30.1	46.0	379	378	126.00	252
3.75	0.156	60.31	58.9	16.1	28.5	43.6	385	385	135.00	250
4	0.167	61.27	59.8	15.3	27.2	41.6	391	391	144.00	247
4.25	0.177	62.18	60.7	14.6	26.0	39.7	397	397	153.00	244
4.5	0.188	63.06	61.5	14.0	24.9	38.0	403	402	162.00	240
4.75	0.198	63.89	62.4	13.5	23.9	36.5	408	408	171.00	237
5	0.208	64.7	63.1	12.9	23.0	35.1	413	413	180.00	233
5.25	0.219	65.47	63.9	12.5	22.1	33.8	418	418	189.00	229
5.5	0.229	66.22	64.6	12.0	21.4	32.7	423	423	198.00	225
5.75	0.240	66.94	65.3	11.6	20.7	31.6	428	427	207.00	220
6	0.250	67.64	66.0	11.3	20.0	30.6	432	432	216.00	216
6.25	0.260	68.31	66.7	10.9	19.4	30	436	436	225.00	211
6.5	0.271	68.97	67.3	10.6	18.8	29	441	440	234.00	206
6.75	0.281	69.6	67.9	10.3	18.3	28	445	444	243.00	201
7	0.292	70.22	68.5	10.0	17.8	27	449	448	252.00	196
7.25	0.302	70.82	69.1	9.8	17.3	27	452	452	261.00	191
7.5	0.313	71.41	69.7	9.5	16.9	26	456	456	270.00	186
7.75	0.323	71.98	70.2	9.3	16.5	25	460	459	279.00	180
8	0.333	72.54	70.8	9.1	16.1	25	463	463	288.00	175
8.25	0.344	73.08	71.3	8.9	15.7	24	467	466	297.00	169
8.5	0.354	73.61	71.8	8.7	15.4	23	470	470	306.00	164
8.75	0.365	74.13	72.3	8.5	15.0	23	474	473	315.00	158
9	0.375	74.64	72.8	8.3	14.7	23	477	476	324.00	152
9.25	0.385	75.14	73.3	8.1	14.4	22	480	480	333.00	147
9.5	0.396	75.63	73.8	8.0	14.1	22	483	483	342.00	141
9.75	0.406	76.1	74.3	7.8	13.8	21	486	486	351.00	135
10	0.417	76.57	74.7	7.7	13.6	21	489	489	360.00	129

Modified Rational Method

Length (m)	185	m
Area (ha)	0.654	Ha
Max Height	78.4	mAOD
Min Height	76.5	mAOD
DeltaH	1.8	
Slope (%)	0.99	
Te (mins)	14.94	mins
ARF	0.998	
SAAR	848,000	mm
UCWI	65	mm
PIMP	100.0	%
SOIL	0.31	
Percentage Runoff PR	75.07	
DEEPSTOR	0.71	

Cv	0.7507	
Cr	1.3	
allowable runoff (mm/hr)		
100 year return period	0.01	m/s
		m3
Storage	RT years	Storage
	100+CC	366

Return Period		flood		100+20%cc		years									
Post Development		Rainfall		140		years									
Rainfall Duration (hours)	Rainfall Duration (days)	Rainfall Depth (mm)	30% increase	Effective Depth (mm)	Rainfall Intensity (mm/hr)	FLOW (l/s)	FLOW (l/s/ha)	RUN-OFF		Allowable Outflow (m³)	Difference (m³)				
								FLOW (m³)	RAIN (m³)						
0.25	0.010	30.66	39.858	38.9	122.6	217.6	332.7	198	254	9.00	245				
0.5	0.021	36.59	47.567	46.4	73.2	129.8	198.5	234	304	18.00	286				
0.75	0.031	40.51	52.663	51.4	54.0	95.8	146.5	259	336	27.00	309				
1	0.042	43.53	56.589	55.2	43.5	77.2	118.1	278	361	36.00	325				
1.25	0.052	46.01	59.813	58.4	36.8	65.3	99.9	294	382	45.00	337				
1.5	0.063	48.14	62.582	61.1	32.1	56.9	87.1	307	399	54.00	345				
1.75	0.073	50.01	65.013	63.4	28.6	50.7	77.5	319	415	63.00	352				
2	0.083	51.69	67.197	65.6	25.8	45.9	70.1	330	429	72.00	357				
2.25	0.094	53.21	69.173	67.5	23.6	42.0	64.2	340	441	81.00	360				
2.5	0.104	54.6	70.98	69.3	21.8	38.8	59.3	349	453	90.00	363				
2.75	0.115	55.9	72.67	70.9	20.3	36.1	55.1	357	464	99.00	365				
3	0.125	57.1	74.23	72.4	19.0	33.8	51.6	365	474	108.00	366				
3.25	0.135	58.23	75.699	73.9	17.9	31.8	48.6	372	483	117.00	366				
3.5	0.146	59.3	77.09	75.2	16.9	30.1	46.0	379	492	126.00	366				
3.75	0.156	60.31	78.403	76.5	16.1	28.5	43.6	385	500	135.00	365				
4	0.167	61.27	79.651	77.7	15.3	27.2	41.6	391	508	144.00	364				
4.25	0.177	62.18	80.834	78.9	14.6	26.0	39.7	397	516	153.00	363				
4.5	0.188	63.06	81.978	80.0	14.0	24.9	38.0	403	523	162.00	361				
4.75	0.198	63.89	83.057	81.1	13.5	23.9	36.5	408	530	171.00	359				
5	0.208	64.7	84.11	82.1	12.9	23.0	35.1	413	537	180.00	357				
5.25	0.219	65.47	85.111	83.1	12.5	22.1	33.8	418	543	189.00	354				
5.5	0.229	66.22	86.086	84.0	12.0	21.4	32.7	423	549	198.00	351				
5.75	0.240	66.94	87.022	84.8	11.6	20.7	31.6	428	555	207.00	348				
6	0.250	67.64	87.932	85.8	11.3	20.0	30.6	432	561	216.00	345				
6.25	0.260	68.31	88.803	86.7	10.9	19.4	29.7	436	567	225.00	342				
6.5	0.271	68.97	89.661	87.5	10.6	18.8	28.8	441	572	234.00	338				
6.75	0.281	69.6	90.48	88.3	10.3	18.3	28.0	445	577	243.00	334				
7	0.292	70.22	91.286	89.1	10.0	17.8	27.2	449	583	252.00	331				
7.25	0.302	70.82	92.066	89.8	9.8	17.3	26.5	452	588	261.00	327				
7.5	0.313	71.41	92.833	90.6	9.5	16.9	25.8	456	593	270.00	323				
7.75	0.323	71.98	93.574	91.3	9.3	16.5	25.2	460	597	279.00	318				
8	0.333	72.54	94.302	92.0	9.1	16.1	24.6	463	602	288.00	314				
8.25	0.344	73.08	95.004	92.7	8.9	15.7	24.0	467	606	297.00	309				
8.5	0.354	73.61	95.693	93.4	8.7	15.4	23.5	470	611	306.00	305				
8.75	0.365	74.13	96.369	94.0	8.5	15.0	23.0	474	615	315.00	300				
9	0.375	74.64	97.032	94.7	8.3	14.7	22.5	477	619	324.00	295				
9.25	0.385	75.14	97.682	95.3	8.1	14.4	22.0	480	623	333.00	290				
9.5	0.396	75.63	98.319	96.0	8.0	14.1	21.6	483	628	342.00	286				
9.75	0.406	76.1	98.93	96.5	7.8	13.8	21.2	486	631	351.00	280				
10	0.417	76.57	99.541	97.1	7.7	13.6	20.8	489	635	360.00	275				

APPENDIX E

SUDS SUITABILITY MATRIX

SUDS SUITABILITY MATRIX ADAPTED FROM CIRIA REPORT C697 'THE MANUAL FOR SUDS'

Matrix Selections		Land Use								Site Characteristics								Community & Environmental				Quantity & Quality Performances														
SUDS Group	Technique	Low Density	Residential	Local Roads	Commercial	Hotspots	Construction Site	Brownfield	Contaminated Land	Soil	Area Draining to Single SUDS Component		Minimum depth to Water Table	Site Slope	Available Head		Available Space		Maintenance	Community Acceptability	Cost	Habitat Creation Potential	Water Quality Treatment Potential					Hydraulic Control								
											Impermeable	Permeable			0 – 2 ha	> 2 ha	0 – 1 m	> 1 m					0 – 5 %	> 5 %	0 – 1 m	1 – 2 m	Low	High	Total Suspended Solids Removal	Heavy Metals Removal	Nutrient (Phosphorous, Nitrogen) Removal	Bacteria Removal (*)	Capacity to treat Fine Suspended Sediments & Dissolved Pollutants	Runoff Volume Reduction	0.5 (1/2yr)	0.1 - 0.03 (10/30yr)
											Y	Y	Y ¹	Y ²	Y ²	Y ³	Y	Y ²					Y	Y ¹	Y	Y ⁵	Y	Y ³	Y	Y	Y	Y	Y	M	H*	M
Retention	Retention Pond	Y	Y	Y ¹	Y ²	Y ²	Y ³	Y	Y ²	Y	Y ¹	Y	Y ⁵	Y	Y	Y	Y	Y	Y	M <td>H*<td>M<td>H<td>H<td>M<td>M<td>M<td>H<td>L<td>H<td>H<td>H</td></td></td></td></td></td></td></td></td></td></td></td>	H* <td>M<td>H<td>H<td>M<td>M<td>M<td>H<td>L<td>H<td>H<td>H</td></td></td></td></td></td></td></td></td></td></td>	M <td>H<td>H<td>M<td>M<td>M<td>H<td>L<td>H<td>H<td>H</td></td></td></td></td></td></td></td></td></td>	H <td>H<td>M<td>M<td>M<td>H<td>L<td>H<td>H<td>H</td></td></td></td></td></td></td></td></td>	H <td>M<td>M<td>M<td>H<td>L<td>H<td>H<td>H</td></td></td></td></td></td></td></td>	M <td>M<td>M<td>H<td>L<td>H<td>H<td>H</td></td></td></td></td></td></td>	M <td>M<td>H<td>L<td>H<td>H<td>H</td></td></td></td></td></td>	M <td>H<td>L<td>H<td>H<td>H</td></td></td></td></td>	H <td>L<td>H<td>H<td>H</td></td></td></td>	L <td>H<td>H<td>H</td></td></td>	H <td>H<td>H</td></td>	H <td>H</td>	H				
	Sub-surface Storage	Y	Y	Y	Y	Y	Y ³	Y	Y	Y	Y	Y	Y ⁵	Y	Y	Y	Y	Y	Y	L <td>H*<td>M<td>L<td>L<td>L<td>L<td>L<td>L<td>L<td>H<td>H<td>H</td></td></td></td></td></td></td></td></td></td></td></td>	H* <td>M<td>L<td>L<td>L<td>L<td>L<td>L<td>L<td>H<td>H<td>H</td></td></td></td></td></td></td></td></td></td></td>	M <td>L<td>L<td>L<td>L<td>L<td>L<td>L<td>H<td>H<td>H</td></td></td></td></td></td></td></td></td></td>	L <td>L<td>L<td>L<td>L<td>L<td>L<td>H<td>H<td>H</td></td></td></td></td></td></td></td></td>	L <td>L<td>L<td>L<td>L<td>L<td>H<td>H<td>H</td></td></td></td></td></td></td></td>	L <td>L<td>L<td>L<td>L<td>H<td>H<td>H</td></td></td></td></td></td></td>	L <td>L<td>L<td>L<td>H<td>H<td>H</td></td></td></td></td></td>	L <td>L<td>L<td>H<td>H<td>H</td></td></td></td></td>	L <td>L<td>H<td>H<td>H</td></td></td></td>	L <td>H<td>H<td>H</td></td></td>	H <td>H<td>H</td></td>	H <td>H</td>	H				
Wetland	Shallow Wetland	Y	Y	Y ¹	Y ²	Y ²	N	Y	Y ²	Y ²	Y ⁴	Y ⁴	Y ⁶	Y ²	Y ²	Y	N	Y	Y	H <td>H*<td>H<td>H<td>H<td>M<td>H</td><td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td></td></td></td></td></td>	H* <td>H<td>H<td>H<td>M<td>H</td><td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td></td></td></td></td>	H <td>H<td>H<td>M<td>H</td><td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td></td></td></td>	H <td>H<td>M<td>H</td><td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td></td></td>	H <td>M<td>H</td><td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td></td>	M <td>H</td> <td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td>	H	M <td>H<td>L<td>H<td>M<td>L</td></td></td></td></td>	H <td>L<td>H<td>M<td>L</td></td></td></td>	L <td>H<td>M<td>L</td></td></td>	H <td>M<td>L</td></td>	M <td>L</td>	L				
	Extended Detention Wetland	Y	Y	Y ¹	Y ²	Y ²	N	Y	Y ²	Y ²	Y ⁴	Y ⁴	Y ⁶	Y ²	Y ²	Y	N	Y	Y	H <td>H*<td>H<td>H<td>H<td>M<td>H</td><td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td></td></td></td></td></td>	H* <td>H<td>H<td>H<td>M<td>H</td><td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td></td></td></td></td>	H <td>H<td>H<td>M<td>H</td><td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td></td></td></td>	H <td>H<td>M<td>H</td><td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td></td></td>	H <td>M<td>H</td><td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td></td>	M <td>H</td> <td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td>	H	M <td>H<td>L<td>H<td>M<td>L</td></td></td></td></td>	H <td>L<td>H<td>M<td>L</td></td></td></td>	L <td>H<td>M<td>L</td></td></td>	H <td>M<td>L</td></td>	M <td>L</td>	L				
	Pond/ Wetland	Y	Y	Y ¹	Y ²	Y ²	N	Y	Y ²	Y ²	Y ⁴	Y ⁴	Y ⁶	Y ²	Y ²	Y	N	Y	Y	H <td>H*<td>H<td>H<td>H<td>M<td>H</td><td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td></td></td></td></td></td>	H* <td>H<td>H<td>H<td>M<td>H</td><td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td></td></td></td></td>	H <td>H<td>H<td>M<td>H</td><td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td></td></td></td>	H <td>H<td>M<td>H</td><td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td></td></td>	H <td>M<td>H</td><td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td></td>	M <td>H</td> <td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td>	H	M <td>H<td>L<td>H<td>M<td>L</td></td></td></td></td>	H <td>L<td>H<td>M<td>L</td></td></td></td>	L <td>H<td>M<td>L</td></td></td>	H <td>M<td>L</td></td>	M <td>L</td>	L				
	Pocket Wetland	Y	Y	Y ¹	Y ²	Y ²	N	Y	Y ²	Y ²	Y ⁴	Y ⁴	N	Y ³	Y ²	Y	N	Y	Y	H <td>M*<td>H<td>H<td>H<td>M<td>H</td><td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td></td></td></td></td></td>	M* <td>H<td>H<td>H<td>M<td>H</td><td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td></td></td></td></td>	H <td>H<td>H<td>M<td>H</td><td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td></td></td></td>	H <td>H<td>M<td>H</td><td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td></td></td>	H <td>M<td>H</td><td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td></td>	M <td>H</td> <td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td>	H	M <td>H<td>L<td>H<td>M<td>L</td></td></td></td></td>	H <td>L<td>H<td>M<td>L</td></td></td></td>	L <td>H<td>M<td>L</td></td></td>	H <td>M<td>L</td></td>	M <td>L</td>	L				
	Submerged Gravel Wetland	Y	Y	Y ¹	Y ²	Y ²	N	Y	Y ²	Y ²	Y ⁴	Y ⁴	Y ⁶	Y ²	Y ²	Y	N	Y	Y	M <td>L<td>H</td><td>M<td>H<td>M<td>H</td><td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td></td></td></td></td>	L <td>H</td> <td>M<td>H<td>M<td>H</td><td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td></td></td></td>	H	M <td>H<td>M<td>H</td><td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td></td></td>	H <td>M<td>H</td><td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td></td>	M <td>H</td> <td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td>	H	M <td>H<td>L<td>H<td>M<td>L</td></td></td></td></td>	H <td>L<td>H<td>M<td>L</td></td></td></td>	L <td>H<td>M<td>L</td></td></td>	H <td>M<td>L</td></td>	M <td>L</td>	L				
Infiltration	Wetland Channel	Y	Y	Y ¹	Y ²	Y ²	N	Y	Y ²	Y ²	Y ⁴	Y ⁴	Y ⁶	Y ²	Y ²	Y	N	Y	Y	H <td>H*<td>H<td>H<td>H<td>M<td>H</td><td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td></td></td></td></td></td>	H* <td>H<td>H<td>H<td>M<td>H</td><td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td></td></td></td></td>	H <td>H<td>H<td>M<td>H</td><td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td></td></td></td>	H <td>H<td>M<td>H</td><td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td></td></td>	H <td>M<td>H</td><td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td></td>	M <td>H</td> <td>M<td>H<td>L<td>H<td>M<td>L</td></td></td></td></td></td>	H	M <td>H<td>L<td>H<td>M<td>L</td></td></td></td></td>	H <td>L<td>H<td>M<td>L</td></td></td></td>	L <td>H<td>M<td>L</td></td></td>	H <td>M<td>L</td></td>	M <td>L</td>	L				
	Infiltration Trench	Y	Y	Y ¹	Y ²	N	N	Y	Y ⁴	N	Y	Y	N	N	Y	Y	Y	Y	N	L <td>M*<td>L<td>L<td>L<td>H</td><td>H</td><td>M<td>H<td>H</td><td>H</td><td>H</td><td>L</td></td></td></td></td></td></td>	M* <td>L<td>L<td>L<td>H</td><td>H</td><td>M<td>H<td>H</td><td>H</td><td>H</td><td>L</td></td></td></td></td></td>	L <td>L<td>L<td>H</td><td>H</td><td>M<td>H<td>H</td><td>H</td><td>H</td><td>L</td></td></td></td></td>	L <td>L<td>H</td><td>H</td><td>M<td>H<td>H</td><td>H</td><td>H</td><td>L</td></td></td></td>	L <td>H</td> <td>H</td> <td>M<td>H<td>H</td><td>H</td><td>H</td><td>L</td></td></td>	H	H	M <td>H<td>H</td><td>H</td><td>H</td><td>L</td></td>	H <td>H</td> <td>H</td> <td>H</td> <td>L</td>	H	H	H	L				
Filtration	Infiltration Basin	Y	Y	Y ¹	Y ²	N	N	Y	Y ⁴	N	Y	Y	Y ⁵	N	Y	Y	Y	Y	N	M <td>H*<td>L</td><td>M<td>H</td><td>H</td><td>M<td>M<td>H<td>H</td><td>H</td><td>H</td><td>H</td></td></td></td></td></td>	H* <td>L</td> <td>M<td>H</td><td>H</td><td>M<td>M<td>H<td>H</td><td>H</td><td>H</td><td>H</td></td></td></td></td>	L	M <td>H</td> <td>H</td> <td>M<td>M<td>H<td>H</td><td>H</td><td>H</td><td>H</td></td></td></td>	H	H	M <td>M<td>H<td>H</td><td>H</td><td>H</td><td>H</td></td></td>	M <td>H<td>H</td><td>H</td><td>H</td><td>H</td></td>	H <td>H</td> <td>H</td> <td>H</td> <td>H</td>	H	H	H	H				
	Soakaway	Y	Y	Y ¹	Y ²	N	N	Y	Y ⁴	N	Y	Y	N	N	Y	Y	Y	Y	Y	L <td>M</td> <td>M</td> <td>L<td>H</td><td>H</td><td>M<td>M<td>H<td>H</td><td>H</td><td>H</td><td>L</td></td></td></td></td>	M	M	L <td>H</td> <td>H</td> <td>M<td>M<td>H<td>H</td><td>H</td><td>H</td><td>L</td></td></td></td>	H	H	M <td>M<td>H<td>H</td><td>H</td><td>H</td><td>L</td></td></td>	M <td>H<td>H</td><td>H</td><td>H</td><td>L</td></td>	H <td>H</td> <td>H</td> <td>H</td> <td>L</td>	H	H	H	L				
	Surface Sand Filter	N	Y	Y ¹	Y ²	Y ²	N	Y	Y ²	Y	Y	Y	Y ⁵	N	Y	Y	N	N	Y	M <td>L<td>H</td><td>M<td>H</td><td>H</td><td>M<td>H</td><td>L<td>H</td><td>M</td><td>L</td></td></td></td></td>	L <td>H</td> <td>M<td>H</td><td>H</td><td>M<td>H</td><td>L<td>H</td><td>M</td><td>L</td></td></td></td>	H	M <td>H</td> <td>H</td> <td>M<td>H</td><td>L<td>H</td><td>M</td><td>L</td></td></td>	H	H	M <td>H</td> <td>L<td>H</td><td>M</td><td>L</td></td>	H	L <td>H</td> <td>M</td> <td>L</td>	H	M	L					
	Sub-surface Sand Filter	N	Y	Y ¹	Y ²	Y ²	N	Y	Y ²	Y	Y	Y	N	N	Y	Y	N	Y	Y	M <td>L<td>H</td><td>L<td>H</td><td>H</td><td>M<td>H</td><td>L<td>H</td><td>M</td><td>L</td></td></td></td></td>	L <td>H</td> <td>L<td>H</td><td>H</td><td>M<td>H</td><td>L<td>H</td><td>M</td><td>L</td></td></td></td>	H	L <td>H</td> <td>H</td> <td>M<td>H</td><td>L<td>H</td><td>M</td><td>L</td></td></td>	H	H	M <td>H</td> <td>L<td>H</td><td>M</td><td>L</td></td>	H	L <td>H</td> <td>M</td> <td>L</td>	H	M	L					
	Perimeter Sand Filter	N	N	Y ¹	Y ²	Y ²	N	Y	Y ²	Y	Y	Y	N	N	Y	Y	N	Y	Y	M <td>L<td>H</td><td>L<td>H</td><td>H</td><td>M<td>H</td><td>L<td>H</td><td>M</td><td>L</td></td></td></td></td>	L <td>H</td> <td>L<td>H</td><td>H</td><td>M<td>H</td><td>L<td>H</td><td>M</td><td>L</td></td></td></td>	H	L <td>H</td> <td>H</td> <td>M<td>H</td><td>L<td>H</td><td>M</td><td>L</td></td></td>	H	H	M <td>H</td> <td>L<td>H</td><td>M</td><td>L</td></td>	H	L <td>H</td> <td>M</td> <td>L</td>	H	M	L					
Detention	Bioretention/ Filter Strip	Y	Y	Y ¹	Y ²	Y ²	N	Y	Y ²	Y	Y	Y	N	N	Y	Y	N	Y	Y	H <td>H<td>M</td><td>H<td>H</td><td>H</td><td>M<td>H</td><td>L<td>H</td><td>M</td><td>L</td></td></td></td></td>	H <td>M</td> <td>H<td>H</td><td>H</td><td>M<td>H</td><td>L<td>H</td><td>M</td><td>L</td></td></td></td>	M	H <td>H</td> <td>H</td> <td>M<td>H</td><td>L<td>H</td><td>M</td><td>L</td></td></td>	H	H	M <td>H</td> <td>L<td>H</td><td>M</td><td>L</td></td>	H	L <td>H</td> <td>M</td> <td>L</td>	H	M	L					
	Filter Trench	Y	Y	Y ¹	Y ²	Y ²	N	Y	Y ²	Y	Y ¹	Y	N	N	Y	Y	N	Y	Y	M <td>M<td>M</td><td>L<td>H</td><td>H</td><td>M<td>H<td>L<td>H</td><td>H</td><td>L</td></td></td></td></td></td>	M <td>M</td> <td>L<td>H</td><td>H</td><td>M<td>H<td>L<td>H</td><td>H</td><td>L</td></td></td></td></td>	M	L <td>H</td> <td>H</td> <td>M<td>H<td>L<td>H</td><td>H</td><td>L</td></td></td></td>	H	H	M <td>H<td>L<td>H</td><td>H</td><td>L</td></td></td>	H <td>L<td>H</td><td>H</td><td>L</td></td>	L <td>H</td> <td>H</td> <td>L</td>	H	H	L					
Open Channels	Detention Basin	Y	Y	Y ¹	Y ²	Y ^{1,2}	Y ³	Y	Y ²	Y	Y ¹	Y	Y ⁵	N	Y	Y	Y	N	Y	L <td>H*<td>L<td>M<td>M<td>M</td><td>L</td><td>L</td><td>L</td><td>L<td>H<td>H</td><td>H</td></td></td></td></td></td></td>	H* <td>L<td>M<td>M<td>M</td><td>L</td><td>L</td><td>L</td><td>L<td>H<td>H</td><td>H</td></td></td></td></td></td>	L <td>M<td>M<td>M</td><td>L</td><td>L</td><td>L</td><td>L<td>H<td>H</td><td>H</td></td></td></td></td>	M <td>M<td>M</td><td>L</td><td>L</td><td>L</td><td>L<td>H<td>H</td><td>H</td></td></td></td>	M <td>M</td> <td>L</td> <td>L</td> <td>L</td> <td>L<td>H<td>H</td><td>H</td></td></td>	M	L	L	L	L <td>H<td>H</td><td>H</td></td>	H <td>H</td> <td>H</td>	H	H				
	Conveyance Swale	Y	Y	Y ¹	Y ²	Y ²	Y ³	Y	Y ²	Y	Y	Y	N	N	Y	Y	N ³	Y	N	L <td>M*<td>L<td>M<td>H</td><td>M</td><td>M</td><td>M<td>H<td>M<td>H</td><td>H</td></td></td></td></td></td></td>	M* <td>L<td>M<td>H</td><td>M</td><td>M</td><td>M<td>H<td>M<td>H</td><td>H</td></td></td></td></td></td>	L <td>M<td>H</td><td>M</td><td>M</td><td>M<td>H<td>M<td>H</td><td>H</td></td></td></td></td>	M <td>H</td> <td>M</td> <td>M</td> <td>M<td>H<td>M<td>H</td><td>H</td></td></td></td>	H	M	M	M <td>H<td>M<td>H</td><td>H</td></td></td>	H <td>M<td>H</td><td>H</td></td>	M <td>H</td> <td>H</td>	H	H					
	Enhanced Dry Swale	Y	Y	Y ¹	Y ²	Y ²	Y ³	Y	Y ²	Y	Y	Y	N	N	Y	Y	N ³	Y	N	L <td>M*<td>M</td><td>M<td>H</td><td>H</td><td>M<td>H<td>M<td>H</td><td>H</td><td>H</td></td></td></td></td></td>	M* <td>M</td> <td>M<td>H</td><td>H</td><td>M<td>H<td>M<td>H</td><td>H</td><td>H</td></td></td></td></td>	M	M <td>H</td> <td>H</td> <td>M<td>H<td>M<td>H</td><td>H</td><td>H</td></td></td></td>	H	H	M <td>H<td>M<td>H</td><td>H</td><td>H</td></td></td>	H <td>M<td>H</td><td>H</td><td>H</td></td>	M <td>H</td> <td>H</td> <td>H</td>	H	H	H					
Source Control	Enhanced Wet Swale	Y	Y	Y ¹	Y ²	Y ¹	Y ³	Y	Y ²	Y ³	Y ⁴	Y	N	Y	Y	Y	N ³	Y	N	M <td>M*<td>M</td><td>H<td>H</td><td>M</td><td>H<td>H</td><td>L<td>H</td><td>H</td><td>H</td></td></td></td></td>	M* <td>M</td> <td>H<td>H</td><td>M</td><td>H<td>H</td><td>L<td>H</td><td>H</td><td>H</td></td></td></td>	M	H <td>H</td> <td>M</td> <td>H<td>H</td><td>L<td>H</td><td>H</td><td>H</td></td></td>	H	M	H <td>H</td> <td>L<td>H</td><td>H</td><td>H</td></td>	H	L <td>H</td> <td>H</td> <td>H</td>	H	H	H					
	Green Roof	Y	Y	N	Y ²	Y	N	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	H <td>H<td>H<td>H</td><td>n/a</td><td>n/a</td><td>n/a</td><td>n/a</td><td>H<td>H<td>H</td><td>L</td></td></td></td></td>	H <td>H<td>H</td><td>n/a</td><td>n/a</td><td>n/a</td><td>n/a</td><td>H<td>H<td>H</td><td>L</td></td></td></td>	H <td>H</td> <td>n/a</td> <td>n/a</td> <td>n/a</td> <td>n/a</td> <td>H<td>H<td>H</td><td>L</td></td></td>	H	n/a	n/a	n/a	n/a	H <td>H<td>H</td><td>L</td></td>	H <td>H</td> <td>L</td>	H	L					
	Rain Water Harvesting	Y	Y	N	Y ²	N	N	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	H <td>M*<td>H<td>L</td><td>M</td><td>L</td><td>L</td><td>L</td><td>n/a</td><td>M</td><td>M</td><td>H</td><td>L</td></td></td>	M* <td>H<td>L</td><td>M</td><td>L</td><td>L</td><td>L</td><td>n/a</td><td>M</td><td>M</td><td>H</td><td>L</td></td>	H <td>L</td> <td>M</td> <td>L</td> <td>L</td> <td>L</td> <td>n/a</td> <td>M</td> <td>M</td> <td>H</td> <td>L</td>	L	M	L	L	L	n/a	M	M	H	L					
	Permeable Pavements	Y	Y	N	Y ²	Y ¹	N	Y	Y ²	Y	Y	Y	Y	N	Y	Y	N	Y	Y	M <td>M<td>M</td><td>L</td><td>H<td>H</td><td>H</td><td>H</td><td>H<td>H</td><td>H</td><td>L</td></td></td></td>	M <td>M</td> <td>L</td> <td>H<td>H</td><td>H</td><td>H</td><td>H<td>H</td><td>H</td><td>L</td></td></td>	M	L	H <td>H</td> <td>H</td> <td>H</td> <td>H<td>H</td><td>H</td><td>L</td></td>	H	H	H	H <td>H</td> <td>H</td> <td>L</td>	H	H	L					
Y: Yes N: No										Y: Yes N: No										H: High M: Medium L: Low				* Limited Data Available n/a: not applicable												
¹ May require two treatment train stages, depending on type and intensity of road use and receiving water sensitivity.										¹ With liner										[*] There may be some public safety concerns associated with open water that require address at design stage				H: High Potential M: Medium Potential L: Low Potential												
² May require three treatment train stages, depending on receiving watercourse sensitivity.										² With surface baseflow																										
³ Will require draw-down rehabilitation following construction activities, prior to use as a permanent drainage system.										³ Unless follows contours																										
⁴ providing designs prevent mobilisation of contamination.										⁴ With liner constant surface baseflow, or high ground water table																										
										⁵ Possible, but not recommended (implies appropriate management train not in place).																										
										⁶ Where high flows are diverted around SUDS component.																										
																																				

APPENDIX F

MICRODRAINAGE SOURCE

CONTROL: PRELIMINARY

ATTENUATION CALCULATION

RESULTS

Summit House

Riparian Way

Keighley BD20 7BW

Date 23 FEB 2010

File 1 in 30 year storage.src

Micro Drainage

RESIDENTIAL DEVELOPMENT

HIGH STREET

ROYSTON

Designed By DM

Checked By

Source Control W.11.2



Summary of Results for 30 year Return Period

Storm Duration (mins)	Maximum Control (l/s)	Maximum Outflow (l/s)	Maximum Water Level (m OD)	Maximum Depth (m)	Maximum Volume (m³)	Status
15 Summer	7.8	7.8	1.6998	0.6998	78.2	O K
30 Summer	8.3	8.3	1.8148	0.8148	99.4	O K
60 Summer	8.8	8.8	1.9093	0.9093	116.6	O K
120 Summer	9.0	9.0	1.9493	0.9493	123.7	O K
180 Summer	8.9	8.9	1.9443	0.9443	122.8	O K
240 Summer	8.9	8.9	1.9293	0.9293	120.1	O K
360 Summer	8.7	8.7	1.8948	0.8948	114.0	O K
480 Summer	8.6	8.6	1.8613	0.8613	107.9	O K
600 Summer	8.4	8.4	1.8278	0.8278	101.9	O K
720 Summer	8.2	8.2	1.7953	0.7953	95.8	O K
960 Summer	7.9	7.9	1.7323	0.7323	84.2	O K
1440 Summer	7.4	7.4	1.6198	0.6198	63.6	O K
2160 Summer	6.8	6.8	1.4752	0.4752	38.7	O K
2880 Summer	6.7	6.7	1.3492	0.3492	20.0	O K
4320 Summer	6.4	6.4	1.1953	0.1952	5.0	O K
5760 Summer	5.2	5.2	1.1483	0.1483	2.5	O K
7200 Summer	4.4	4.4	1.1168	0.1168	1.4	O K
8640 Summer	3.8	3.8	1.0963	0.0963	0.9	O K
10080 Summer	3.4	3.4	1.0858	0.0858	0.7	O K
15 Winter	8.0	8.0	1.7548	0.7548	88.4	O K
30 Winter	8.7	8.7	1.8893	0.8893	113.0	O K
60 Winter	9.2	9.2	2.0083	1.0083	133.7	O K
120 Winter	9.5	9.5	2.0753	1.0753	144.5	O K
180 Winter	9.5	9.5	2.0663	1.0663	143.2	O K

Storm Duration (mins)	Rain (mm/hr)	Time-Peak (mins)
15 Summer	69.50	18
30 Summer	46.05	32
60 Summer	29.24	62
120 Summer	18.03	112
180 Summer	13.44	142
240 Summer	10.85	174
360 Summer	8.01	244
480 Summer	6.46	312
600 Summer	5.46	382
720 Summer	4.75	450
960 Summer	3.82	580
1440 Summer	2.81	838
2160 Summer	2.06	1208
2880 Summer	1.65	1556
4320 Summer	1.21	2204
5760 Summer	0.97	2936
7200 Summer	0.81	3656
8640 Summer	0.71	4280
10080 Summer	0.63	5040
15 Winter	69.50	18
30 Winter	46.05	32
60 Winter	29.24	60
120 Winter	18.03	116
180 Winter	13.44	148

Summit House

Riparian Way

Keighley BD20 7BW

Date 23 FEB 2010

File I in 30 year storage.src

Micro Drainage

RESIDENTIAL DEVELOPMENT

HIGH STREET

ROYSTON

Designed By DM

Checked By

Source Control W.11.2



Summary of Results for 30 year Return Period

Storm Duration (mins)	Maximum Control (l/s)	Maximum Outflow (l/s)	Maximum Water Level (m OD)	Maximum Depth (m)	Maximum Volume (m ³)	Status
240 Winter	9.4	9.4	2.0458	1.0458	139.9	O K
360 Winter	9.2	9.2	1.9913	0.9913	130.9	O K
480 Winter	8.9	8.9	1.9363	0.9363	121.4	O K
600 Winter	8.7	8.7	1.8833	0.8833	111.9	O K
720 Winter	8.4	8.4	1.8323	0.8323	102.6	O K
960 Winter	8.0	8.0	1.7378	0.7378	85.2	O K
1440 Winter	7.2	7.2	1.5728	0.5728	55.2	O K
2160 Winter	6.7	6.7	1.3447	0.3447	19.3	O K
2880 Winter	6.3	6.3	1.1933	0.1932	4.8	O K
4320 Winter	4.7	4.7	1.1288	0.1288	1.8	O K
5760 Winter	3.7	3.7	1.0953	0.0953	0.9	O K
7200 Winter	3.2	3.2	1.0803	0.0803	0.6	O K
8640 Winter	2.7	2.7	1.0698	0.0698	0.4	O K
10080 Winter	2.4	2.4	1.0618	0.0618	0.3	O K

Storm Duration (mins)	Rain (mm/hr)	Time-Peak (mins)
240 Winter	10.85	186
360 Winter	8.01	264
480 Winter	6.46	338
600 Winter	5.46	412
720 Winter	4.75	484
960 Winter	3.82	624
1440 Winter	2.81	892
2160 Winter	2.06	1232
2880 Winter	1.65	1472
4320 Winter	1.21	2200
5760 Winter	0.97	2848
7200 Winter	0.81	3632
8640 Winter	0.71	4328
10080 Winter	0.63	4984

Summit House

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Micro Drainage

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Circular Pipe Details

Diameter (m) 1.200 Length (m) 155.000 Cover Level (m) 3.400
 Slope (1:x) 500.0 Invert Level (m) 1.000

Hydro-Brake Outflow Control

Design Head (m) 1.200 Hydro-Brake Type MD5 Invert Level (m) 1.000
 Design Flow (l/s) 10.0 Diameter (mm) 124

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.10	3.9	0.80	8.3	2.00	13.0	4.00	18.4	7.00	24.3
0.20	6.5	1.00	9.2	2.20	13.7	4.50	19.5	7.50	25.2
0.30	6.7	1.20	10.1	2.40	14.3	5.00	20.6	8.00	26.0
0.40	6.7	1.40	10.9	2.60	14.8	5.50	21.6	8.50	26.8
0.50	6.9	1.60	11.6	3.00	15.9	6.00	22.5	9.00	27.6
0.60	7.3	1.80	12.3	3.50	17.2	6.50	23.5	9.50	28.4