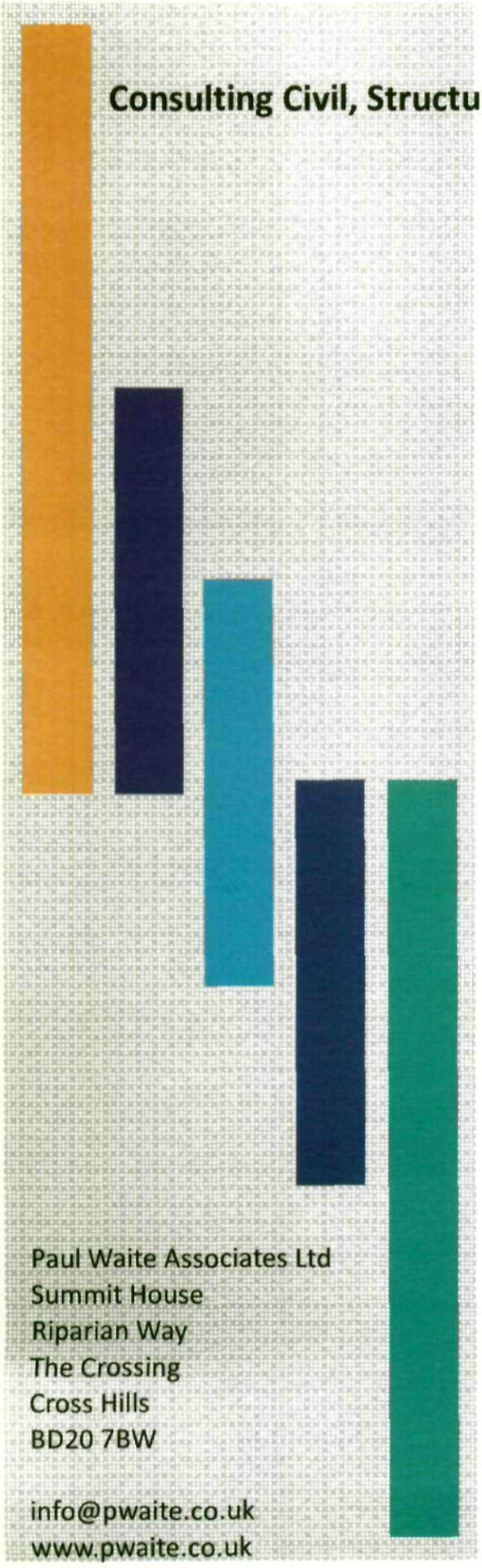


Consulting Civil, Structural & Geo-Environmental Engineers

Flood Risk Assessment

Site Address: Residential Development High Street, Royston

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Project Ref: 09259/i/01
June 2010

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Report Status Details

REPORT REF NO:	*09259/FRA/01*	
STATUS:	*FINAL*	*7 June 2010*

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 36No residential units.

Clients Details

Bellway Homes Ltd
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Documents Revision Status

ISSUE:	***DATE***	***COMMENTS***
01	February 24, 2010	Final
02	*June 7, 2010*	Final Sections 3.5; 4.1; 5.5; and 7.0 updated following information received from Yorkshire Water.

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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 0.619 Hectares, hence 52% 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

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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 5l/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 $52m^3$; $211m^3$; $301m^3$ and $426m^3$ 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 and the location of Standing groundwater recorded between 0.35 and 1.66m below ground level it is concluded that disposal of surface water via infiltration methods is unsuitable for this site.

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.

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Therefore it is recommended that the preliminary drainage strategy for the site incorporates attenuation in the form of large diameter pipework. Calculations using MicroDrainage indicates that a 40m length of 2100mm diameter pipe; along with a 28m length of 1800mm diameter pipe will be suitable to accommodate the required attenuation volumes.

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.

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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.

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2.0 Approach to the Flood Risk Assessment

2.1 Approach

A 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".

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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

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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

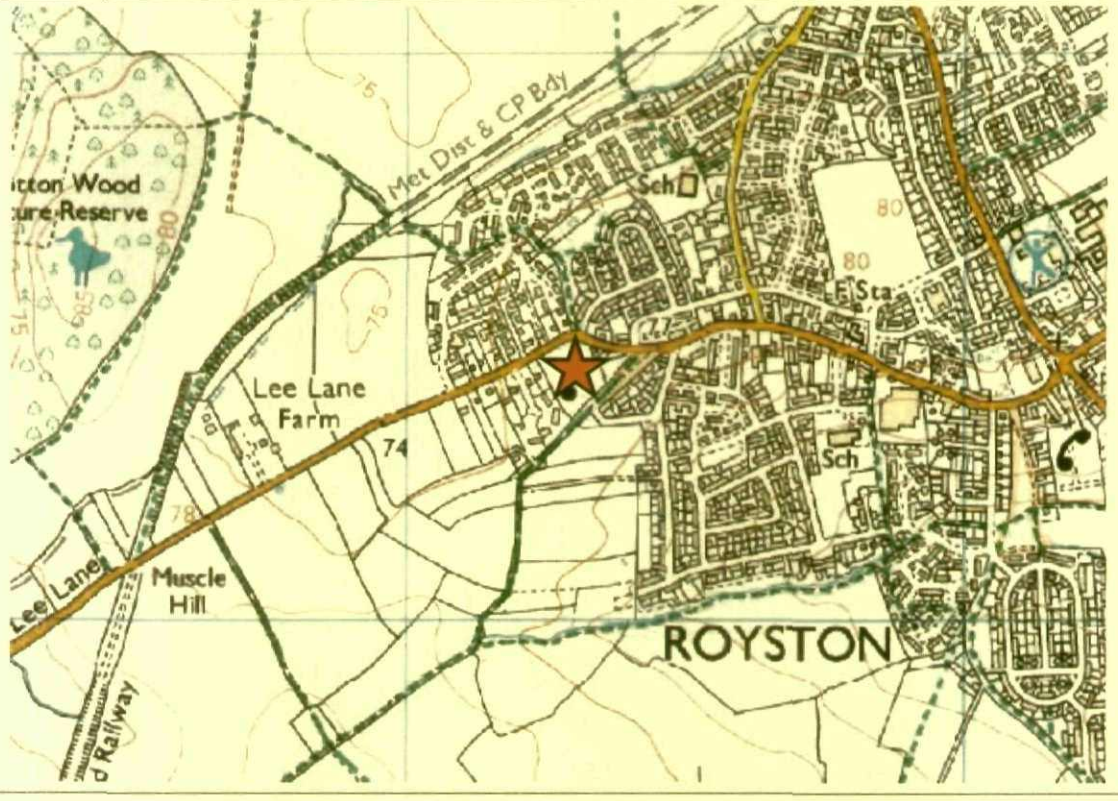


Image produced from the Ordnance Survey Get-a-map service.
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Proposed Development Site at Royston

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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.

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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 has been investigated further within this report.

From the Yorkshire Water sewer record plans, foul flow for the area situated to the west and north west of the proposed development, is directed by gravity to a foul water pumping station situated off Applehaigh Grove.

From the pumping station, foul flow is then directed eastwards along Lee Lane to a manhole located at the junction of Lee Lane; Westfields and High Street, where the system becomes gravity fed once more. From this point a 225mm diameter public foul sewer flows eastwards along High Street.

Foul water from residential property immediately to the south east of the proposed development at Westfield Crescent, is also directed towards the 225mm diameter public sewer along High Street.

Surface Water from the residential area to the north west is served by a public surface water sewer, which outfalls via a 450mm diameter outfall into a small watercourse or open channel land drain to the east side of Applehaigh View. This outfall is situated approximately 250 metres to the west of the development.

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The Yorkshire Water sewer records also indicate that surface water from the area incorporating Westfield Crescent, is directed into a small diameter combined sewer network, however details pertaining to this existing combined system are limited.

In addition to this, it has been ascertained from the topographical survey that there are manholes located within the vicinity of the site which do not form part of the public sewer network. These manholes are situated within the carriageway and to the south side of Lee Lane.

It is believed that these additional manholes form part of an existing highway drainage system. Barnsley MBC's Land Drainage Department have been contacted in order to determine further information regarding the existing system; however no information had been received at the time of writing.

It is understood that additional survey work is currently being undertaken in order to ascertain further details of the highway drainage system.

Following liaison with Yorkshire Water, it is proposed that the foul system serving the new development will be directed to the existing 225mm diameter public foul sewer located within High Street.

Yorkshire Water has advised that the local surface water sewer network does not have the capacity to accept any discharge from the proposed development. As such, current proposals involve extension of the proposed surface water system westwards along Lee Lane, to connect into the existing 450mm diameter outfall adjacent to Applehaigh View.

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Alternatively, it may be possible to connect the proposed surface water drainage into the existing highway drainage system along Lee Lane; once more detailed information regarding the network is obtained.

It is proposed however, that the drainage design engineer will discuss all options with Yorkshire Water and Barnsley MDC's Land Drainage Team prior to finalising the foul and surface water drainage network for the new development.

Public Sewer Record Plans provided by Yorkshire Water are provided within Appendix C of this report.

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.

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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 either to the existing highway drainage system located within Lee Lane, or extended approximately 250 metres to the west of Lee Lane to a 450mm diameter outfall, adjacent to Applehaigh View.

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.

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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 D 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.

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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, it is recommended that surface water flows from the proposed development will be restricted to a minimum of 5l/s.

It is proposed however, that the design engineer will discuss all surface water drainage options and peak rates of discharge with Yorkshire Water and Barnsley MBC's Land Drainage Team prior to finalising the proposed surface water drainage network for the new development.

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 52% of the total site area, hence 0.619 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 5l/s. Reference should be made to Appendix E where the spreadsheets used to calculate the volumes to be stored for each return period are provided.

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The required attenuation volumes have been tabulated below.

Table 4: Indicative Balance Volumes

Return Period	Balance Volume (m^3)
1 in 2 year	52
1 in 30 year	211
1 in 100 year	301
1 in 100 year + 30% climate change	426

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.

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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.

It is highlighted that the volume balance requirements will be established to a greater accuracy during the detailed design in order to reflect the finalised 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.

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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.

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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.

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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 proposed that surface water will be directed either to the existing highway drainage system situated along Lee Lane, or extended approximately 250 metres to the west of the site to an existing 450mm diameter surface water outfall adjacent to Applehaigh View.

Determination of the outfall location will be undertaken following completion of additional survey works and further discussion/agreement with Yorkshire Water and Barnsley MDC's Land Drainage Team.

Following development, it is anticipated 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.

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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 5l/s.

It is highlighted that the maximum allowed surface water discharge rate from the development will need to be agreed with Yorkshire Water and Barnsley MDC's Land Drainage Team.

Surface water flows in excess of 5l/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	52
1 in 30 year	211
1 in 100 year	301
1 in 100 year + 30% climate change	426

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 5l/s.

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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.

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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 it 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.

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It is understood from the site investigation work undertaken by PWA-Geo, that the development is situated above a minor aquifer. In addition standing groundwater levels have been monitored at levels between 0.35m and 1.66m below ground level.

As such it is considered that disposal of surface water via infiltration is not suitable for this development site and an alternative discharge point will need to be adopted.

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	Site conditions are not suitable for the use of infiltration methods.
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	Site conditions are not suitable for the use of infiltration methods.
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

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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 0.619 Hectares, which equates to 52% 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 F of this report:

Table 6: Results from the SUDS Suitability Matrix

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

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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.

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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.

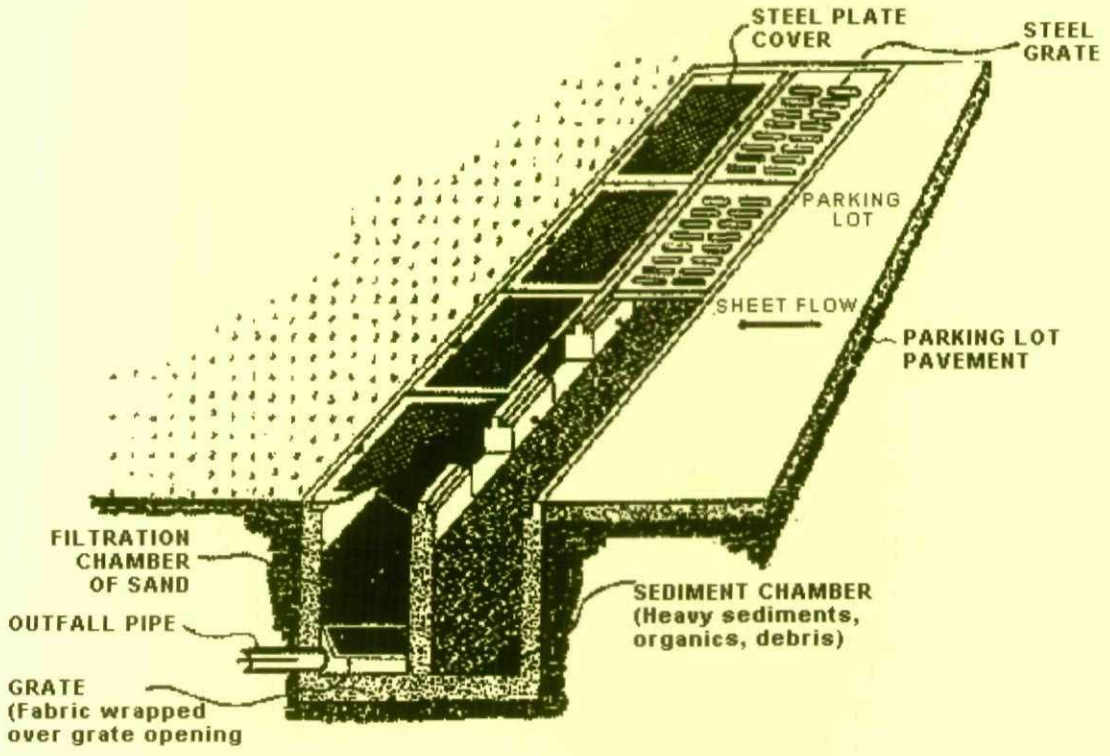
6.4 Filtration

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.

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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

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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.

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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.

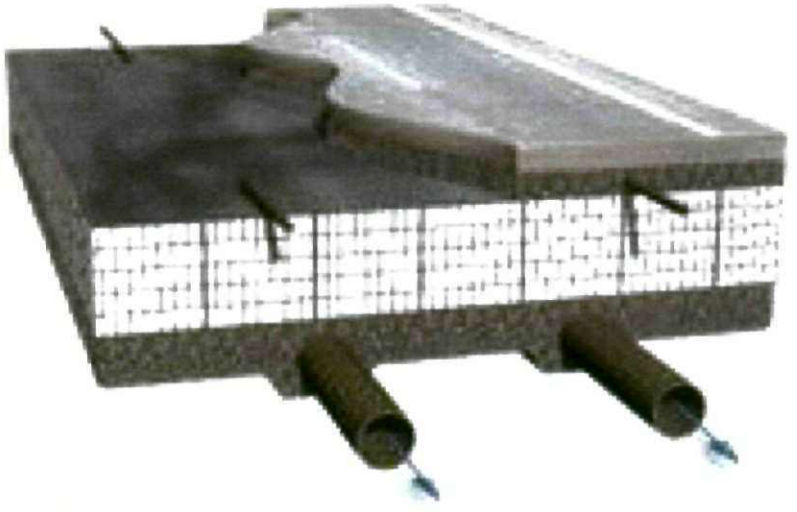
In areas where permeable surfaces were provided, there would be no need for traditional drainage ironwork or an oil interceptor.

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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



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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.

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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 211m^3, which creates a storage provision of 28 metres of single 1800mm diameter pipe; along with an additional 40 metres of 2100mm diameter pipe.

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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 52% of the total area, hence 0.619 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 5l/s. Flows in excess if this will need to be attenuated on-site.

7.7 Surface water discharge from the new development will either be to the existing highway drainage system located within Lee Lane. Alternatively, the proposed drainage system will need to be extended approximately 250 metres to the west of the site to enable connection to an existing 450mm diameter outfall, adjacent to Applehaigh View. Determination of the final outfall location will be carried out following additional survey of the highway drainage system.

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7.8 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.

7.9 It is estimated that the volume of attenuation required for the 1 in 30 year event is approximately 211m^3, 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.

7.10 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

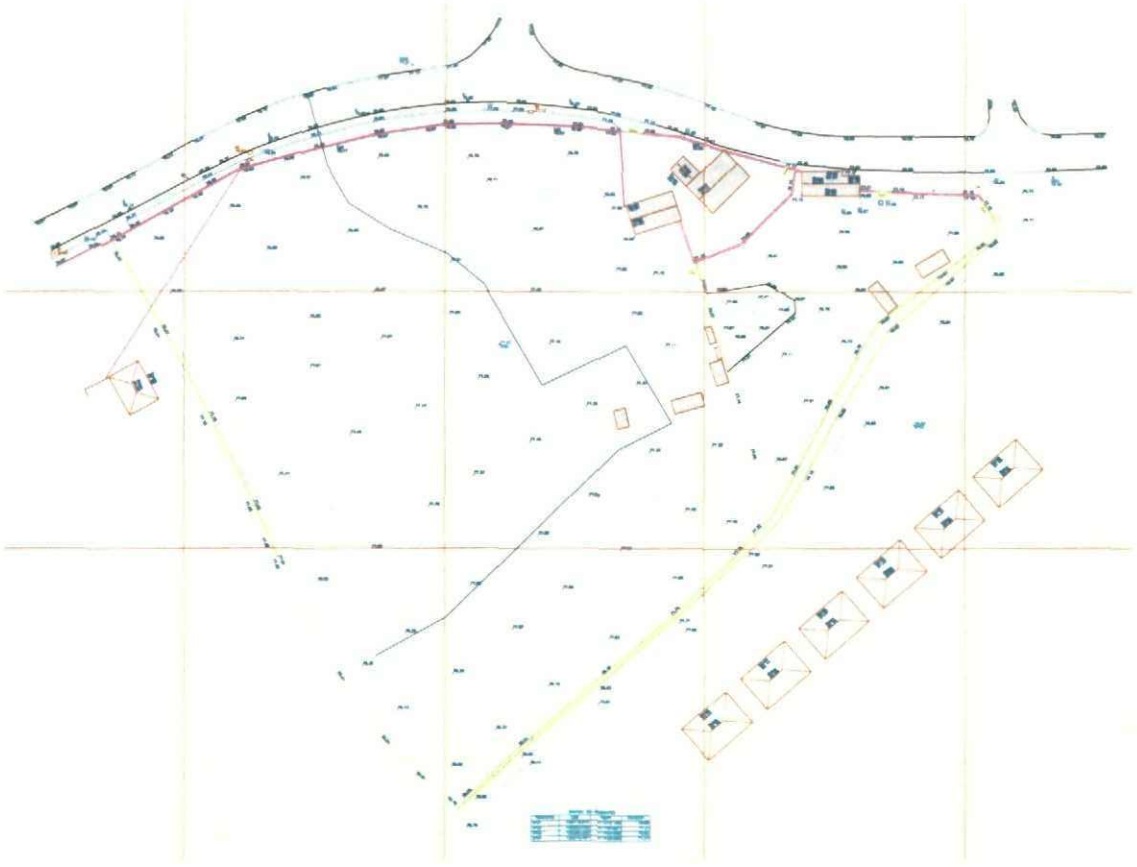
7.11 In order to mitigate against localised flooding caused by heavy rainfall, it is recommended that the internal ground floor level of the proposed residential properties are raised a minimum of 150mm above the finished external ground levels within the site.

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APPENDIX A

EXISTING SITE PLAN

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N
Indicative

Abbreviation & Symbol Key

Control & Datum Information

Grid - OS National Grid
Using the OS GPS Network

Datum - OS Level Datum
Using the OS GPS Network

OS Grid @50m to cover Site

Revision	Description	By	Date

Surv.	Drawn	Date	Chkd	Date	Apprd	Date
GH,KH	SH	12/11/07				

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Client

Sheldale Developments Ltd

Title SITE PLAN

Site High Street
Royston
Barnsley

HH SURVEYS LTD
41 Brampton Crescent
Wombwell
Barnsley
Yorkshire S73 0SZ
Tel: 01226 734099 Fax: 01226 734102
Email: stephen@hhsurveys.co.uk

THIS IS A CAD DRAWING - DO NOT ALTER

Dwg No. SHELD/300/SP

Sheet No.

SCALE 1:500 REV

APPENDIX B

PROPOSED DEVELOPMENT:

CONCEPT LAYOUT PLAN

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& Knapton.©

Bellway



ACCOMODATION 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	win	3	3	1141	3423	8
2	Darwin	da	3	3	822	2466	8
2.5	Darwin	da(2.5)	3	3	1168	3504	8
2	Milbeck	mi	7	4	1066	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*	*ch(2.5)*	*1*	*5*	2064	2064	3
		Total	**36**		**Total Sq.Ft**	**40650**	**100**

Scale: 1:500
Date: 20/07/09
Drg No: M/PRE/001

North

Client: Bellway Homes Ltd.
Site: Royston
Plan: Planning Layout 1:500

Created By:
KNAPTON
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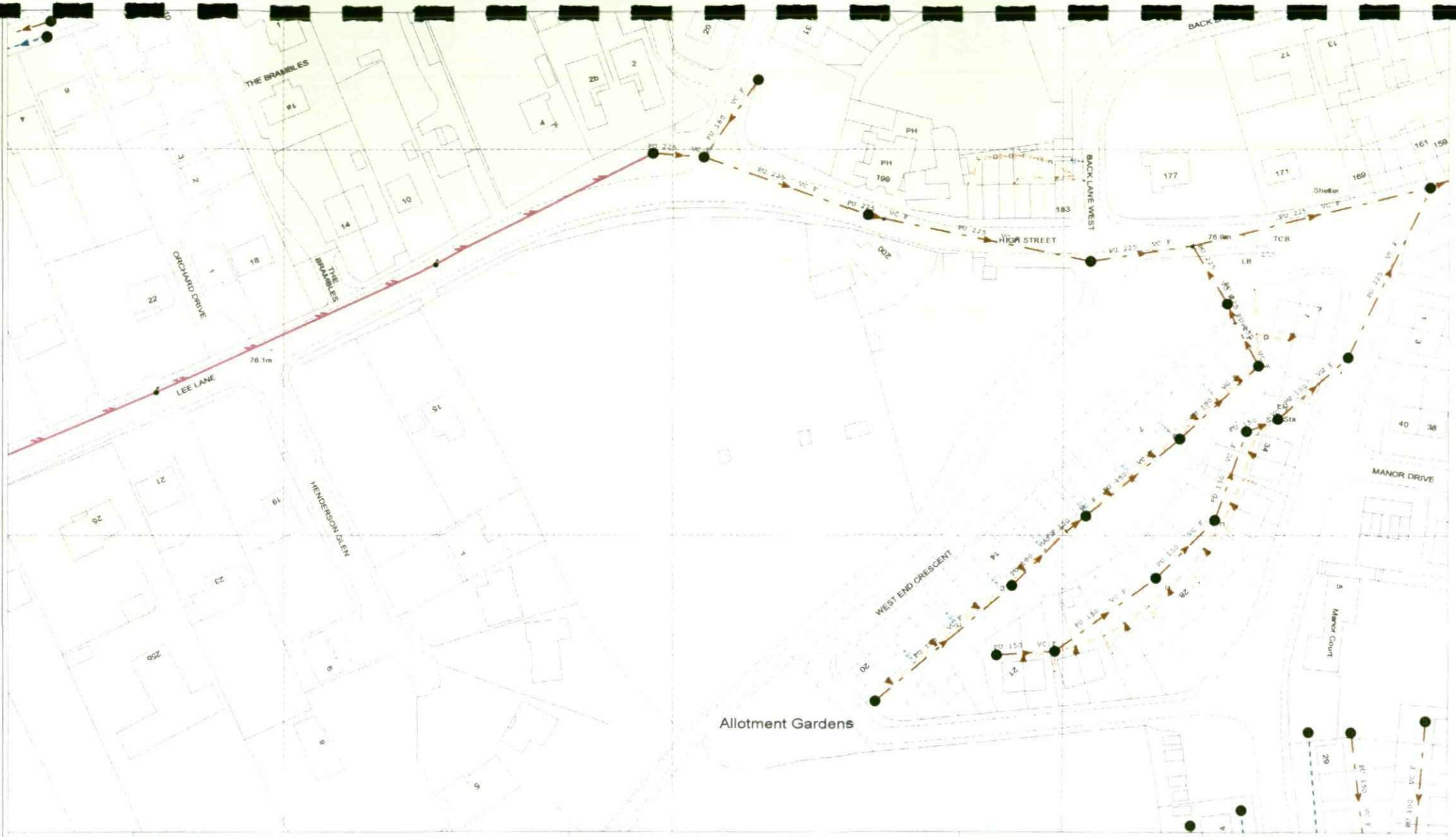
•Dean Hay Country Business Park • Unit 12 • Craggs Road • Mytholmroyd • Hebden Bridge • HX7 5RU • +44 (0)1422 884448 • www.knaptonandknapton.co.uk •

APPENDIX C

YORKSHIRE WATER SEWER

RECORD PLANS

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435118 411303

Map Name SE3511SW

Yorkshire Water
PO Box 500,
Halifax Road,
Bradford BD6 2LZ
Contact Name
K KHAN
Contact Tel

Title

Notes

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Partial Key

Foul Sewer = F
Combined Sewer = C
Surface Water Sewer = SW
Trade Sewer = TD
Partially Separate = PS

This plan is furnished as a general guide only and no warranty as to its correctness is given or implied. This plan must not be relied upon in the event of excavations or other works made in the vicinity of public sewers. No house or property connection

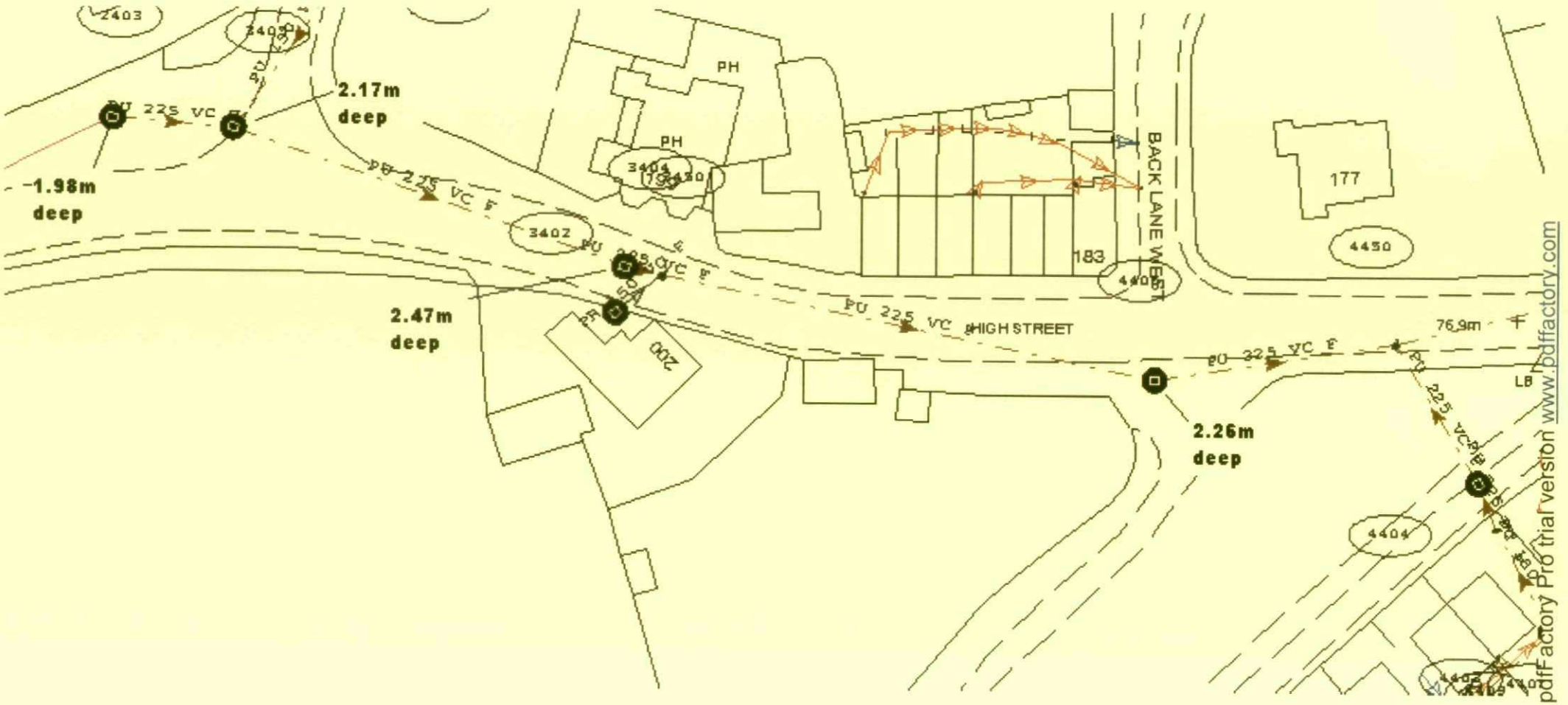
Date Req 04/06/2010, 11:13:02

Date Gen 04/06/2010, 11:13:05

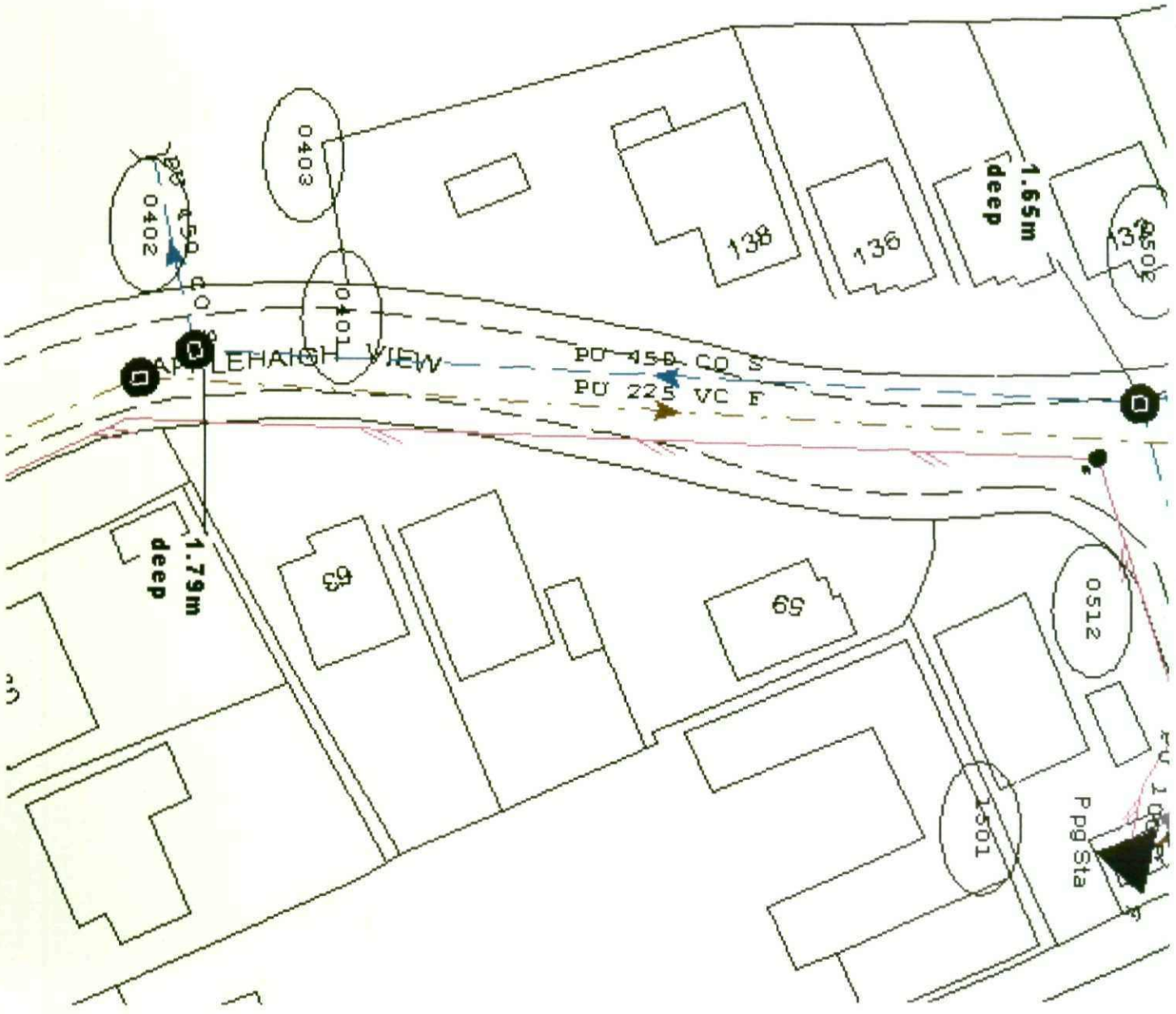
Source Sewer Network Enquiry

UPN Undefined

Originator K KHAN, New Development - Waste Water,



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INCOMING E-MAIL MESSAGE

File Ref.: 3

Project No.: 09259
Client: Bellway Homes (Yorkshire) Ltd
Description: Rd, Sewers and Foundations
Location: Barnsley

From: Kashif.Khan@yorkshirewater.co.uk
Subject: Fw: High Street/ Lee Lane Royston - Pre-Planning Sewerage Enquiry -Residential

To: Donna Metcalf;
Attachments: PWA.PDF;
Reply Ref.: EML/09259/3/19 **Filed:**
Sent: Fri. 4 Jun 2010 at 11:13 **Received:** Fri. 4 Jun 2010 at 11:18

Message:

Donna,

please see below.

Regards,

Kashif.,

(See attached file: PWA.PDF)
----- Forwarded by Kashif Khan/Waste Water/YWS/Yorkshire Water on 04/06/2010 11:11 -----

Yorkshire Water
Developer Services Team
Western House
Halifax Road
PO Box 500
Bradford
BD6 2SZ

Tel: 0845 120 8482
Fax: (01274) 372 834

Email:
Planning.Sewerage@yorkshirewater.co.uk

Paul Waite Associates
Summit House
Riparian Way
The Crossings
Cross Hill
Keighley
BD20 7BW

For the attention of Donna Metcalf

For telephone enquiries ring:

Kashif Khan on (0845)120 8482

Your Ref: EML09259/13
Our Ref: L003420

4th June 2010

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Dear Madam,

High Street/ Lee Lane Royston - Pre-Planning Sewerage Enquiry -Residential

Thank you for your enquiry received 26th May 2010. Our charge of £60.00 (plus VAT) will be added to your account with us, reference PWA070. You will receive an invoice for your account in due course.

Please find enclosed a complimentary extract from the Statutory Sewer Map. This indicates the recorded position of the public sewers. The following comments reflect our view, with regard to the public sewer network only, based on a 'desk top' study of the site:

Development of the site should take place with separate systems for foul and surface water drainage. The separate system should extend to the public sewer.

Foul water should discharge to the 225 mm diameter public foul sewer recorded in High Street, at a point adjacent to the site.

The developer's attention is drawn to Requirement H3 of the Building Regulations 2000. This establishes a preferred hierarchy for surface water disposal. Consideration should firstly be given to discharge to soakaway, infiltration system and watercourse in that priority order.

Sustainable Drainage Systems (SUDS), for example the use of soakaways and/or permeable hardstanding etc., may be a suitable solution for surface water disposal appropriate in this situation. You are advised to seek comments on the suitability of SUDS in this instance from the appropriate authorities.

Where appropriate, soakaways, swales and infiltration trenches (SUDS) may be adopted as part of the public sewer network. For general conditions for the adoption of SUDS please see the attached sheet. Further information may be seen in the DEFRA publication 'Interim Code of Practice for Sustainable Drainage Systems' (ISBN 0-86017-904-4). If the developer is considering adoption of SUDS they should contact our Developer Services Team on 0845 120 84 82.

The local public sewer network does not have capacity to accept any discharge of surface water from the proposal site. The developer is advised to contact the Environment Agency/local Land Drainage Authority with a view to establishing a suitable watercourse (if any nearby) for discharge.

Please note further restrictions on surface water disposal from the site may be imposed by other parties. You are strongly advised to seek advice/comments from the Environment Agency/Land Drainage Authority/Internal Drainage Board, with regard to surface water disposal from the site.

Prospectively adoptable sewers and pumping stations must be designed and constructed in accordance with the WRc publication "Sewers for Adoption - a design and construction guide for developers" 6th Edition as supplemented by Yorkshire Water's requirements, pursuant to an agreement under Section 104 of the Water Industry Act 1991. An application to enter into a Section 104 agreement must be made in writing prior to any works commencing on site. Please contact our Developer Services Team (telephone 0845 120 84 82) for further information.

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The public sewer network is for domestic sewage purposes. This generally means foul water for domestic purposes and, where a suitable surface water or combined sewer is available, surface water from the roofs of buildings together with surface water from paved areas of land appurtenant to those buildings. Land and highway drainage have no right of connection to the public sewer network. Land drainage will not be allowed into a public sewer. Highway drainage, however, may be accepted under certain circumstances; for instance, if SUDS are not a viable option and there is no highway drain available and if capacity is available within the public sewer network. In this event, a formal agreement for highway drainage discharge to public sewer, under Services under Section 115 Water Industry Act 1991, will be required.

No land drainage to be connected/discharged to public sewer.

Any new connection to an existing public sewer will require the approval of Yorkshire Water. You may obtain an application form from our website (www.yorkshirewater.com) or by telephoning 0845 120 84 82.

All the above comments are based upon the information and records available at the present time. The information contained in this letter together with that shown on any extract from the Statutory Sewer Map that may be enclosed is believed to be correct and is supplied in good faith. Please note that capacity in the public sewer network is not reserved for specific future development. It is used up on a 'first come, first served' basis. You should visit the site and establish the line and level of any public sewers affecting your proposals before the commencement of any design work.

Yours faithfully

Developer Services Team

Find out how our new character Numptee is causing all sorts of problems by putting the wrong things down his toilet and drains - check out his videos and look at what you can do to help keep your drains running free.

Visit http://www.yorkshirewater.com/binit

The information in this e-mail is confidential and may also be legally privileged. The contents are intended for recipient only and are subject to the legal notice available at http://www.keldagroup.com/email.htm Yorkshire Water Services Limited
Registered Office Western House Halifax Road Bradford BD6 2SZ
Registered in England and Wales No 2366682

Notes:

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Paul Waite Associates

APPENDIX D

IOH 124: GREENFIELD

RUNOFF CALCULATION

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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 km^2) 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:

1	2	3	4	5
			1	

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 E

MODIFIED RATIONAL METHOD:

INDICATIVE BALANCE

VOLUMES

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Modified Rational Method

Length (m)	70	m
Area (ha)	0.619	Ha
Max Height	78.4	mAOD
Min Height	76.5	mAOD
DeltaH	1.8	
Slope (%)	2.61	
Te (mins)	10.06	mins
ARF	0.998	
SAAR	648.000	mm
UCWI	65	mm
PIMP	100.0	%
SOIL	0.31	
Percentage Runoff PR	75.07	
DEEPSTOR	0.45	

Cv	0.7507	
Cr	1.3	
Allowable outflow		
2 year	0.005	m^s

Storage	RT years	Storage
	2	52

m3

Return Period flood 2 years

Post Development 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 (m^3)	Difference (m^3)
							FLOW (m^3)	RAIN (m^3)		
0.25	0.010	6.87	6.7	27.5	46.1	74.6	42	42	4.50	37
0.5	0.021	8.84	8.6	17.7	29.7	48.0	53	53	9.00	44
0.75	0.031	10.24	10.0	13.7	22.9	37.0	62	62	13.50	48
1	0.042	11.35	11.1	11.4	19.1	30.8	69	69	18.00	51
1.25	0.052	12.3	12.0	9.8	16.5	26.7	74	74	22.50	52
1.5	0.063	13.13	12.8	8.8	14.7	23.7	79	79	27.00	52
1.75	0.073	13.87	13.5	7.9	13.3	21.5	84	84	31.50	52
2	0.083	14.54	14.2	7.3	12.2	19.7	88	88	36.00	52
2.25	0.094	15.17	14.8	6.7	11.3	18.3	92	92	40.50	51
2.5	0.104	15.75	15.4	6.3	10.6	17.1	95	95	45.00	50
2.75	0.115	16.29	15.9	5.9	9.9	16.1	98	98	49.50	49
3	0.125	16.8	16.4	5.6	9.4	15.2	102	101	54.00	47
3.25	0.135	17.28	16.9	5.3	8.9	14.4	104	104	58.50	46
3.5	0.146	17.74	17.3	5.1	8.5	13.8	107	107	63.00	44
3.75	0.156	18.18	17.7	4.8	8.1	13.2	110	110	67.50	42
4	0.167	18.6	18.2	4.7	7.8	12.6	112	112	72.00	40
4.25	0.177	19.01	18.6	4.5	7.5	12.1	115	115	76.50	38
4.5	0.188	19.4	18.9	4.3	7.2	11.7	117	117	81.00	36
4.75	0.198	19.77	19.3	4.2	7.0	11.3	120	119	85.50	34
5	0.208	20.13	19.6	4.0	6.8	10.9	122	122	90.00	32
5.25	0.219	20.48	20.0	3.9	6.6	10.6	124	124	94.50	29
5.5	0.229	20.82	20.3	3.8	6.4	10.3	126	126	99.00	27
5.75	0.240	21.15	20.6	3.7	6.2	10.0	128	128	103.50	24
6	0.250	21.47	21.0	3.6	6.0	9.7	130	130	108.00	22
6.25	0.260	21.78	21.3	3.5	5.9	9.5	132	132	112.50	19
6.5	0.271	22.09	21.6	3.4	5.7	9.2	134	133	117.00	16
6.75	0.281	22.38	21.8	3.3	5.6	9.0	135	135	121.50	14
7	0.292	22.67	22.1	3.2	5.4	8.8	137	137	126.00	11
7.25	0.302	22.95	22.4	3.2	5.3	8.6	139	139	130.50	8
7.5	0.313	23.23	22.7	3.1	5.2	8.4	140	140	135.00	5
7.75	0.323	23.5	22.9	3.0	5.1	8.2	142	142	139.50	2
8	0.333	23.77	23.2	3.0	5.0	8.1	144	144	144.00	0
8.25	0.344	24.02	23.4	2.9	4.9	7.9	145	145	148.50	-3
8.5	0.354	24.28	23.7	2.9	4.8	7.7	147	147	153.00	-6
8.75	0.365	24.53	23.9	2.8	4.7	7.6	148	148	157.50	-9
9	0.375	24.77	24.2	2.8	4.6	7.5	150	150	162.00	-12
9.25	0.385	25.01	24.4	2.7	4.5	7.3	151	151	166.50	-15
9.5	0.396	25.25	24.6	2.7	4.5	7.2	153	153	171.00	-18
9.75	0.406	25.48	24.9	2.6	4.4	7.1	154	154	175.50	-22
10	0.417	25.71	25.1	2.6	4.3	7.0	155	155	180.00	-25

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Modified Rational Method

Length (m)	70	m
Area (ha)	0.619	Ha
Max Height	78.4	mAOD
Min Height	76.5	mAOD
DeltaH	1.8	
Slope (%)	2.61	
Te (mins)	10.06	mins
ARF	0.998	
SAAR	648.000	mm
UCWI	65	mm
PIMP	100.0	%
SOIL	0.31	
Percentage Runoff PR	75.07	
DEEPSTOR	0.45	

Cv	0.7507	
Cr	1.3	
allowable outflow		
30 year	0.005	m^3/s

Storage	RT years	Storage
		m3
	30	211

Post Development — Return Period: flood 30 years; 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 (m^3)	Difference (m^3)
							FLOW (m^3)	RAIN (m^3)		
0.25	0.010	21.84	21.3	87.4	146.7	237.0	132	132	4.50	127
0.5	0.021	26.52	25.9	53.0	89.1	143.9	160	160	9.00	151
0.75	0.031	29.66	28.9	39.5	66.4	107.3	179	179	13.50	166
1	0.042	32.1	31.3	32.1	53.9	87.1	194	194	18.00	176
1.25	0.052	34.12	33.3	27.3	45.8	74.1	206	206	22.50	184
1.5	0.063	35.86	35.0	23.9	40.1	64.9	217	217	27.00	190
1.75	0.073	37.4	36.5	21.4	35.9	58.0	226	226	31.50	194
2	0.083	38.78	37.8	19.4	32.6	52.6	234	234	36.00	198
2.25	0.094	40.03	39.1	17.8	29.9	48.3	242	242	40.50	201
2.5	0.104	41.19	40.2	16.5	27.7	44.7	249	249	45.00	204
2.75	0.115	42.27	41.3	15.4	25.8	41.7	256	255	49.50	206
3	0.125	43.27	42.2	14.4	24.2	39.1	262	261	54.00	207
3.25	0.135	44.22	43.2	13.6	22.8	36.9	267	267	58.50	209
3.5	0.146	45.11	44.0	12.9	21.6	35.0	273	273	63.00	210
3.75	0.156	45.96	44.9	12.3	20.6	33.3	278	278	67.50	210
4	0.167	46.76	45.6	11.7	19.6	31.7	283	282	72.00	210
4.25	0.177	47.53	46.4	11.2	18.8	30.3	287	287	76.50	211
4.5	0.188	48.27	47.1	10.7	18.0	29.1	292	292	81.00	211
4.75	0.198	48.98	47.8	10.3	17.3	28.0	296	296	85.50	210
5	0.208	49.66	48.5	9.9	16.7	26.9	300	300	90.00	210
5.25	0.219	50.31	49.1	9.6	16.1	26.0	304	304	94.50	209
5.5	0.229	50.94	49.7	9.3	15.6	25.1	308	308	99.00	209
5.75	0.240	51.56	50.3	9.0	15.1	24.3	312	311	103.50	208
6	0.250	52.15	50.9	8.7	14.6	23.6	315	315	108.00	207
6.25	0.260	52.72	51.4	8.4	14.2	22.9	319	318	112.50	206
6.5	0.271	53.28	52.0	8.2	13.8	22.2	322	322	117.00	205
6.75	0.281	53.82	52.5	8.0	13.4	21.6	325	325	121.50	204
7	0.292	54.35	53.0	7.8	13.0	21.1	329	328	126.00	202
7.25	0.302	54.86	53.5	7.6	12.7	20.5	332	331	130.50	201
7.5	0.313	55.36	54.0	7.4	12.4	20.0	335	334	135.00	199
7.75	0.323	55.85	54.5	7.2	12.1	19.6	338	337	139.50	198
8	0.333	56.33	55.0	7.0	11.8	19.1	341	340	144.00	196
8.25	0.344	56.79	55.4	6.9	11.6	18.7	343	343	148.50	195
8.5	0.354	57.25	55.9	6.7	11.3	18.3	346	346	153.00	193
8.75	0.365	57.7	56.3	6.6	11.1	17.9	349	349	157.50	191
9	0.375	58.13	56.7	6.5	10.8	17.5	351	351	162.00	189
9.25	0.385	58.56	57.1	6.3	10.6	17.2	354	354	166.50	187
9.5	0.396	58.98	57.6	6.2	10.4	16.8	357	356	171.00	185
9.75	0.406	59.39	58.0	6.1	10.2	16.5	359	359	175.50	183
10	0.417	59.79	58.3	6.0	10.0	16.2	361	361	180.00	181

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Modified Rational Method

Length (m)	70	m
Area (ha)	0.619	Ha
Max Height	78.4	mAOD
Min Height	76.5	mAOD
DeltaH	1.8	
Slope (%)	2.61	
Te (mins)	10.06	mins
ARF	0.998	
SAAR	648.000	mm
UCWI	65	mm
PIMP	100.0	%
SOIL	0.31	
Percentage Runoff PR	75.07	
DEEPSTOR	0.45	

Cv	0.7507	
Cr	1.3	
allowable outflow		
100 year	0.005	m^3/s

Storage	RT years	Storage (m3)
	100	301

Return Period flood 100 years

Post Development 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 (m^3)	Difference (m^3)
							FLOW (m^3)	RAIN (m^3)		
0.25	0.010	30.66	29.9	122.6	206.0	332.7	185	185	4.50	181
0.5	0.021	36.59	35.7	73.2	122.9	198.5	221	221	9.00	212
0.75	0.031	40.51	39.5	54.0	90.7	146.5	245	245	13.50	231
1	0.042	43.53	42.5	43.5	73.1	118.1	263	263	18.00	245
1.25	0.052	46.01	44.9	36.8	61.8	99.9	278	278	22.50	255
1.5	0.063	48.14	47.0	32.1	53.9	87.1	291	291	27.00	264
1.75	0.073	50.01	48.8	28.6	48.0	77.5	302	302	31.50	271
2	0.083	51.69	50.4	25.8	43.4	70.1	313	312	36.00	276
2.25	0.094	53.21	51.9	23.6	39.7	64.2	322	321	40.50	281
2.5	0.104	54.6	53.3	21.8	36.7	59.3	330	330	45.00	285
2.75	0.115	55.9	54.6	20.3	34.1	55.1	338	338	49.50	288
3	0.125	57.1	55.7	19.0	32.0	51.6	345	345	54.00	291
3.25	0.135	58.23	56.8	17.9	30.1	48.6	352	352	58.50	293
3.5	0.146	59.3	57.9	16.9	28.5	46.0	359	358	63.00	295
3.75	0.156	60.31	58.9	16.1	27.0	43.6	365	364	67.50	297
4	0.167	61.27	59.8	15.3	25.7	41.6	370	370	72.00	298
4.25	0.177	62.18	60.7	14.6	24.6	39.7	376	376	76.50	299
4.5	0.188	63.06	61.5	14.0	23.5	38.0	381	381	81.00	300
4.75	0.198	63.89	62.4	13.5	22.6	36.5	386	386	85.50	300
5	0.208	64.7	63.1	12.9	21.7	35.1	391	391	90.00	301
5.25	0.219	65.47	63.9	12.5	20.9	33.8	396	395	94.50	301
5.5	0.229	66.22	64.6	12.0	20.2	32.7	400	400	99.00	301
5.75	0.240	66.94	65.3	11.6	19.6	31.6	405	404	103.50	301
6	0.250	67.64	66.0	11.3	18.9	30.6	409	409	108.00	301
6.25	0.260	68.31	66.7	10.9	18.4	30	413	413	112.50	300
6.5	0.271	68.97	67.3	10.6	17.8	29	417	417	117.00	300
6.75	0.281	69.6	67.9	10.3	17.3	28	421	420	121.50	299
7	0.292	70.22	68.5	10.0	16.8	27	425	424	126.00	298
7.25	0.302	70.82	69.1	9.8	16.4	27	428	428	130.50	297
7.5	0.313	71.41	69.7	9.5	16.0	26	432	431	135.00	296
7.75	0.323	71.98	70.2	9.3	15.6	25	435	435	139.50	295
8	0.333	72.54	70.8	9.1	15.2	25	439	438	144.00	294
8.25	0.344	73.08	71.3	8.9	14.9	24	442	441	148.50	293
8.5	0.354	73.61	71.8	8.7	14.5	23	445	445	153.00	292
8.75	0.365	74.13	72.3	8.5	14.2	23	448	448	157.50	290
9	0.375	74.64	72.8	8.3	13.9	23	451	451	162.00	289
9.25	0.385	75.14	73.3	8.1	13.6	22	454	454	166.50	287
9.5	0.396	75.63	73.8	8.0	13.4	22	457	457	171.00	286
9.75	0.406	76.1	74.3	7.8	13.1	21	460	460	175.50	284
10	0.417	76.57	74.7	7.7	12.9	21	463	463	180.00	283

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Modified Rational Method

Length (m)	70	m
Area (ha)	0.619	Ha
Max Height	78.4	mAOD
Min Height	76.5	mAOD
DeltaH	1.8	
Slope (%)	2.61	
Te (mins)	10.06	mins
ARF	0.998	
SAAR	648.000	mm
UCWI	65	mm
PIMP	100.0	%
SOIL	0.31	
Percentage Runoff PR	75.07	
DEEPSTOR	0.45	

Cv	0.7507	
Cr	1.3	
allowable outflow		
100 year	0.005	m^3/s

m3

Storage	RT years	Storage
	100+CC	426

Post Development — Return Period: flood Rainfall — 100+30%cc: 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 FLOW (m^3)	RUN-OFF RAIN (m^3)	Allowable Outflow (m^3)	Difference (m^3)
0.25	0.010	30.66	39.858	38.9	122.6	206.0	332.7	185	241	4.50	236
0.5	0.021	36.59	47.567	46.4	73.2	122.9	198.5	221	287	9.00	278
0.75	0.031	40.51	52.663	51.4	54.0	90.7	146.5	245	318	13.50	305
1	0.042	43.53	56.589	55.2	43.5	73.1	118.1	263	342	18.00	324
1.25	0.052	46.01	59.813	58.4	36.8	61.8	99.9	278	361	22.50	339
1.5	0.063	48.14	62.582	61.1	32.1	53.9	87.1	291	378	27.00	351
1.75	0.073	50.01	65.013	63.4	28.6	48.0	77.5	302	393	31.50	361
2	0.083	51.69	67.197	65.6	25.8	43.4	70.1	313	406	36.00	370
2.25	0.094	53.21	69.173	67.5	23.6	39.7	64.2	322	418	40.50	377
2.5	0.104	54.6	70.98	69.3	21.8	36.7	59.3	330	429	45.00	384
2.75	0.115	55.9	72.67	70.9	20.3	34.1	55.1	338	439	49.50	389
3	0.125	57.1	74.23	72.4	19.0	32.0	51.6	345	448	54.00	394
3.25	0.135	58.23	75.699	73.9	17.9	30.1	48.6	352	457	58.50	399
3.5	0.146	59.3	77.09	75.2	16.9	28.5	46.0	359	466	63.00	403
3.75	0.156	60.31	78.403	76.5	16.1	27.0	43.6	365	474	67.50	406
4	0.167	61.27	79.651	77.7	15.3	25.7	41.6	370	481	72.00	409
4.25	0.177	62.18	80.834	78.9	14.6	24.6	39.7	376	488	76.50	412
4.5	0.188	63.06	81.978	80.0	14.0	23.5	38.0	381	495	81.00	414
4.75	0.198	63.89	83.057	81.1	13.5	22.6	36.5	386	502	85.50	416
5	0.208	64.7	84.11	82.1	12.9	21.7	35.1	391	508	90.00	418
5.25	0.219	65.47	85.111	83.1	12.5	20.9	33.8	396	514	94.50	420
5.5	0.229	66.22	86.086	84.0	12.0	20.2	32.7	400	520	99.00	421
5.75	0.240	66.94	87.022	84.9	11.6	19.6	31.6	405	526	103.50	422
6	0.250	67.64	87.932	85.8	11.3	18.9	30.6	409	531	108.00	423
6.25	0.260	68.31	88.803	86.7	10.9	18.4	29.7	413	536	112.50	424
6.5	0.271	68.97	89.661	87.5	10.6	17.8	28.8	417	542	117.00	425
6.75	0.281	69.6	90.48	88.3	10.3	17.3	28.0	421	547	121.50	425
7	0.292	70.22	91.286	89.1	10.0	16.8	27.2	425	551	126.00	425
7.25	0.302	70.82	92.066	89.8	9.8	16.4	26.5	428	556	130.50	426
7.5	0.313	71.41	92.833	90.6	9.5	16.0	25.8	432	561	135.00	426
7.75	0.323	71.98	93.574	91.3	9.3	15.6	25.2	435	565	139.50	426
8	0.333	72.54	94.302	92.0	9.1	15.2	24.6	439	570	144.00	426
8.25	0.344	73.08	95.004	92.7	8.9	14.9	24.0	442	574	148.50	425
8.5	0.354	73.61	95.693	93.4	8.7	14.5	23.5	445	578	153.00	425
8.75	0.365	74.13	96.369	94.0	8.5	14.2	23.0	448	582	157.50	425
9	0.375	74.64	97.032	94.7	8.3	13.9	22.5	451	586	162.00	424
9.25	0.385	75.14	97.682	95.3	8.1	13.6	22.0	454	590	166.50	424
9.5	0.396	75.63	98.319	96.0	8.0	13.4	21.6	457	594	171.00	423
9.75	0.406	76.1	98.93	96.5	7.8	13.1	21.2	460	598	175.50	422
10	0.417	76.57	99.541	97.1	7.7	12.9	20.8	463	601	180.00	421

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APPENDIX F

SUDS SUITABILITY MATRIX

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

Matrix Selections		Land Use								Site Characteristics										Community & Environmental				Quantity & Quality Performances								
										Soil		Area Draining to Single SUDS Component		Minimum depth to Water Table		Site Slope		Available Head		Available Space								Water Quality Treatment Potential					Hydraulic Control			
SUDS Group	Technique	Low Density	Residential	Local Roads	Commercial	Hotspots	Construction Site	Brownfield	Contaminated Land	Impermeable	Permeable	0 – 2 ha	> 2 ha	0 – 1 m	> 1 m	0 – 5 %	> 5 %	0 – 1 m	1 – 2 m	Low	High	Maintenance	Community Acceptability	Cost	Habitat Creation Potential	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)	0.01 (100 yr)
Retention	Retention Pond	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	N	Y	M	H *	M	H	H	M	M	M	H	L	H	H	H
	Sub-surface Storage	Y	Y	Y	Y	Y	Y[3]	Y	Y	Y	Y	Y	Y[5]	Y	Y	Y	Y	Y	Y	Y	Y	L	H *	M	L	L	L	L	L	L	L	H	H	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	N	Y	H	H *	H	H	H	M	H	M	H	L	H	M	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	N	Y	H	H *	H	H	H	M	H	M	H	L	H	M	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	N	Y	H	H *	H	H	H	M	H	M	H	L	H	M	L
	Pocket Wetland	Y	Y	Y[1]	Y[2]	Y[2]	N	Y	Y[2]	Y[2]	Y[4]	Y[4]	N	Y[2]	Y[2]	Y	N	Y	Y	Y	Y	H	M *	H	H	H	M	H	M	H	L	H	M	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	N	Y	M	L	H	M	H	M	H	M	H	L	H	M	L
	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	N	Y	H	H *	H	H	H	M	H	M	H	L	H	M	L
Infiltration	Infiltration Trench	Y	Y	Y[1]	Y[2]	N	N	Y	Y[4]	N	Y	Y	N	N	Y	Y	Y	Y	N	Y	Y	L	M *	L	L	H	H	H	M	H	H	H	H	L
	Infiltration Basin	Y	Y	Y[1]	Y[2]	N	N	Y	Y[4]	N	Y	Y	Y[5]	N	Y	Y	Y	Y	N	N	Y	M	H *	L	M	H	H	H	M	H	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	N	Y	Y	L	M	M	L	H	H	H	M	H	H	H	H	L
Filtration	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	N	Y	M	L	H	M	H	H	H	M	H	L	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	N	Y	Y	Y	M	L	H	L	H	H	H	M	H	L	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	Y	Y	M	L	H	L	H	H	H	M	H	L	H	M	L
	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	N	Y	H	H	M	H	H	H	H	M	H	L	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	Y	Y	M	M	M	L	H	H	H	M	H	L	H	H	L
Detention	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	N	Y	L	H *	L	M	M	M	L	L	L	L	H	H	H
Open Channels	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	N	Y	L	M *	L	M	H	M	M	M	H	M	H	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	N	Y	L	M *	M	M	H	H	H	M	H	M	H	H	H
	Enhanced Wet Swale	Y	Y	Y[1]	Y[2]	Y[1]	Y[3]	Y	Y[2]	Y[2]	Y[4]	Y	N	Y	Y	Y	N[3]	Y	N	N	Y	M	M *	M	H	H	H	M	H	H	L	H	H	H
Source Control	Green Roof	Y	Y	N	Y[2]	Y	N	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	H	H	H	H	n/a	n/a	n/a	n/a	H	H	H	H	L
	Rain Water Harvesting	Y	Y	N	Y[2]	N	N	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y				H	M *	H	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	Y	Y	M	M	M	L	H	H	H	H	H	H	H	H	L

Y Yes N No

[1] May require two treatment train stages, depending on type and intensity of road use and receiving water sensitivity

[2] May require three treatment rain stages, depending on receiving watercourse sensitivity

[3] Will require draw-down rehabilitation following construction activities, prior to use as a permanent drainage system

[4] providing designs prevent mobilisation of contamination

Y Yes N No

[1] With liner

[2] With surface baseflow

[3] Unless follows contours

[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

H: High
M: Medium
L: Low

* There may be some public safety concerns associated with open water that require address at design stage

* Limited Data Available

n/a not applicable

H: High Potential
M: Medium Potential
L: Low Potential

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