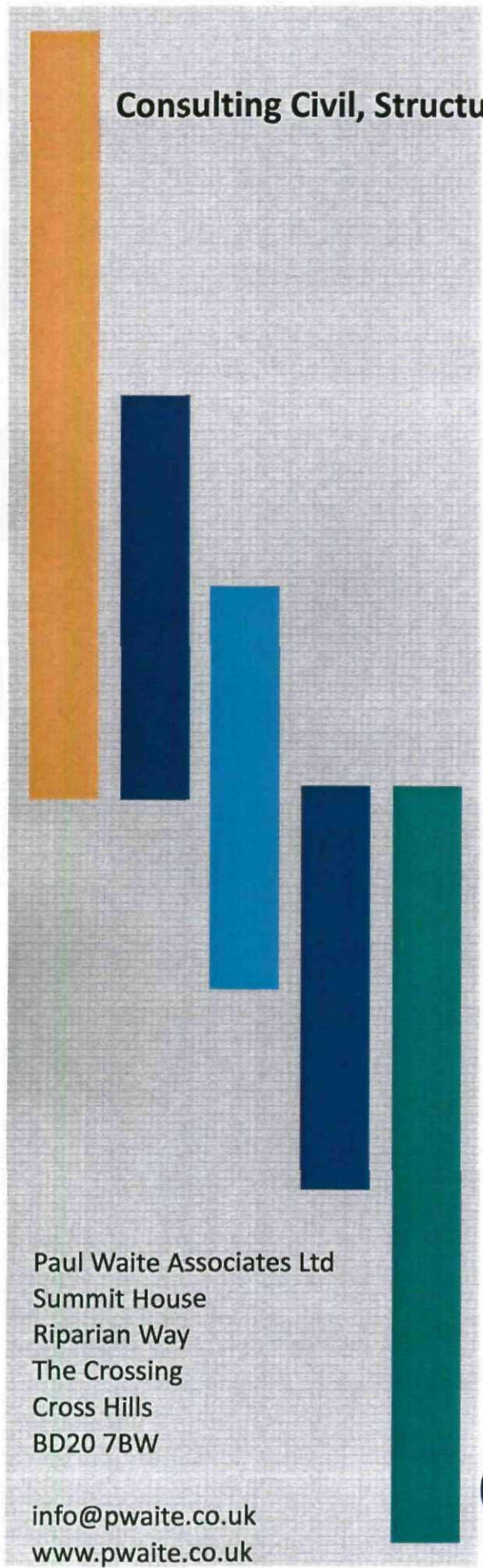




Consulting Civil, Structural & Geo-Environmental Engineers

Flood Risk Assessment

Site Address:
Redevelopment at
Ward Green
Primary School,
Barnsley

Paul Waite Associates Ltd
Summit House
Riparian Way
The Crossing
Cross Hills
BD20 7BW

info@pwaite.co.uk
www.pwaite.co.uk

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Flood Risk and Drainage Impact Assessment

REPORT REF NO:	10225/I/01	
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Paul Waite Associates were instructed by Harron Homes to produce a Flood Risk Assessment to support a planning application for redevelopment of Ward Green Primary School in Barnsley, to provide residential properties.

Clients Details

Harron Homes
Carlton House
Temple Point
Bullerthorpe Lane
Swillington
Leeds
LS15 9JL

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Contents

Executive Summary	1
1.0 Introduction	4
2.0 Approach to the Flood Risk Assessment	5
2.1 Approach	5
2.2 Application of the Sequential and Exceptions Test	5
3.0 Site Details	7
3.1 Location	7
3.2 Current/Formal Use	8
3.3 Proposals	9
3.4 Boundaries	9
3.5 Topography	9
3.6 Drainage	10
3.6.1 Public Sewer System	10
3.6.2 On-Site Drainage	10
3.7 History of Flooding	11
4.0 Flooding Mechanisms	12
4.1 Worsbrough Reservoir; the Dearne & Dove Canal; and the River Dove	12
4.2 Snape Ske	13
4.2 Surface Water Runoff	14
4.2.1 Existing Site	14
4.2.2 Proposed Site	14
4.2.3 Estimation of Existing Surface Water Runoff	17
4.2.4 Proposed Surface Water Drainage System and Attenuation Requirements	18
4.3 Domestic Foul Flows	20
4.3 Groundwater	20
5.0 Material Consideration In Respect of PPS25	22
5.1 Climatic Change	22

5.2	Environment Agency Flood Maps	22
5.3	Proposed Finished Floor Levels	23
5.4	Emergency Access and Egress during Times of Flood	23
5.5	Surface Water	24
5.6	Sustainable Urban Drainage (SUDS)	24
6.0	Conclusions and Recommendations	28

Tables

Table 1	Flood Risk Vulnerability and Flood Zone 'Compatibility' Table
Table 2	Sources of Flooding
Table 3	Existing Surface Water Runoff Calculations
Table 4	Indicative Volumes for Attenuation – Outfall to Combined Sewer
Table 5	Indicative Volumes for Attenuation – Outfall to Surface Water Sewer
Table 6	SUDS Techniques and Suitability of Use

Figures

Figure 1	Location Plan – Ward Green Primary School
Figure 2	Ward Green Primary School Viewed Northwards from High Ridge
Figure 3	Aerial Photograph Illustrating the Open Channel Length of Snape Ske
Figure 4	Aerial Photograph of the Existing Site
Figure 5	Hydrogeological and Drift Deposits Map
Figure 6	Environment Agency Flood Map

Appendices

Appendix A	Existing Site
Appendix B	Proposed Development Plans
Appendix C	Yorkshire Water Correspondence and Sewer Records
Appendix D	Modified Rational Method: Existing Surface Water Runoff
Appendix E	Modified Rational Method: Indicative Attenuation Volumes
Appendix F	SUDS Suitability Matrix
Appendix G	Proposed Drainage Strategy

Executive Summary

Paul Waite Associates has been commissioned to undertake a Flood Risk and Drainage Impact Assessment in accordance with PPS25 to support a planning application involving the redevelopment of the former Ward Green Primary School in the Worsbrough area to the south of Barnsley, to provide residential development.

Proposals for the development involve the construction of 19 No residential units.

The site is approximately 0.71 Hectares in size and previously comprised a school and a residential property.

The development site 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 at Ward Green has been identified as surface water flooding. Therefore it is imperative that a suitable strategy for managing surface water emanating from the new development is developed in order to minimise the risk of flooding at the site; and reduce the impact of the proposed development on existing property downstream of the site.

A minor watercourse known Snake Ske flows is situated 115 metres to the north east of the site and flows in a south easterly direction towards its confluence with the River Dove. Much of the watercourse is culverted and is considered to be in riparian ownership.

Owing to the topography of the area, it is considered that the watercourse presents a low risk of flooding to the proposed development.

The hierarchy for the disposal of surface water from new development is outlined within the Building Regulations Approved Document H, which identifies the use of infiltration methods as the preferred disposal option, followed by discharge to watercourse and then connection to a sewer.

Based on information obtained from the Phase 1 Site Investigation, it is understood that site conditions exclude the use of infiltration drainage, such as soakaways within the drainage strategy for the proposed development.

Owing to the characteristics of the minor watercourse, the difficulty for identifying a suitable route for connection; and the possibility that exacerbation of water levels within the watercourse may increase the flood risk to residential properties located along the route of both the open channel and culverted sections of the watercourse, it was considered that discharging surface water from the development into the watercourse is not feasible.

The sewer record plans obtained from Yorkshire Water along with a survey of the existing drainage indicate that former development was positively drained, with the foul and some surface water flows being directed via 2No. outfalls into the public sewer network surrounding the site.

From the topographical survey of the site, it is determined that a total of 0.25 Hectares (100% impermeable), is served by this positive drainage system.

Undertaking an assessment of surface water flows from the existing site, it was determined that the flow rate to the public combined sewer which traverses the site is 12.1l/s, with 15.4l/s discharged to an existing 225mm diameter surface water sewer located to the south of the development.

In order to provide a betterment with regard to flows discharged into the public sewer to accommodate future climate change, Yorkshire Water and Barnsley MBC requires that existing flow discharged to the public sewer system are reduced by 30%. Therefore surface water discharge from the redeveloped site will need to be restricted to a maximum flow rate of 8.5l/s to the combined sewer; and 11l/s to the surface water sewer, for storms up to and including the 1 in 30 year plus 30% climate change event.

Using the Modified Rational Method, a summary table indicating the storage volumes for the 1 in 2 year, 30 year, 100 year and 100 year plus 30% climate change events at both outfalls is provided overleaf:

Summary Table: Indicative Balance Volumes

Return Period	Outfall 1 – 225mm diameter combined sewer (m ³)	Outfall 2 – 225mm diameter surface water sewer (m ³)
1 in 2 year	8	0
1 in 30 year	48	15
1 in 100 year	75	25
1 in 100 year + 30% climate change	131	36

Yorkshire Water and Barnsley MBC usually requires that surface water runoff is controlled as near to its source as possible, through a sustainable drainage approach to surface water management (SUDS).

Undertaking an assessment using the SUDS suitability matrix adapted from CIRIA Report C697, it is highlighted that the following methods are suitable for inclusion within the drainage strategy:

- Sub-surface storage
- Green roof technology
- Rainwater Harvesting
- Permeable Pavements

Upon further analysis with regard to additional factors such as maintenance; community acceptance; cost; and suitability for runoff volume reduction and flow control it is recommended that the adoptable drainage strategy for the site incorporates attenuation in the form of large diameter pipework; and shallow geocellular storage units.

Flows into the existing public sewers from both outfalls are to be controlled via an orifice plate; Hydrobrake unit or similar flow control device.

It is concluded that there is a low risk of flooding at the Ward Green Primary School site and implementation of mitigation measures as described within this report will ensure that any risk of flooding at the proposed development sites may be reduced to an acceptable level.

1.0 Introduction

Paul Waite Associates has been commissioned to undertake a Flood Risk Assessment in accordance with PPS25 to support a planning application involving the redevelopment of Ward Green Primary School in the Worsbrough area of Barnsley to provide residential property.

The proposed development covers an area approximating 0.71 Hectares.

Proposals for the site involve the provision of 19 No new residential dwellings.

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 source of flood risk to the proposed development site has been identified to be from surface water runoff from the development, however other sources of flooding have been considered within this assessment.

The existing development currently accommodates a primary school development, and comprises a single storey school building within the north central part of the development; and a residential property located within the south corner of the site. The area surrounding the building is comprised a mixture of grassed areas; along with hardstanding car parking and playground areas.

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.

2.0 Approach to the Flood Risk Assessment

2.1 Approach

A topographical survey of the site was undertaken by Haycock and Todd on behalf of Harron Homes during November 2010. The survey is calibrated to Ordnance Datum using one point localisation at station S1. As such, 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 development is classified as 'more vulnerable'.

Utilising the Flood Risk Vulnerability Table as shown overleaf, 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 347 043.

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

Figure 1: Location Plan – Ward Green Primary School

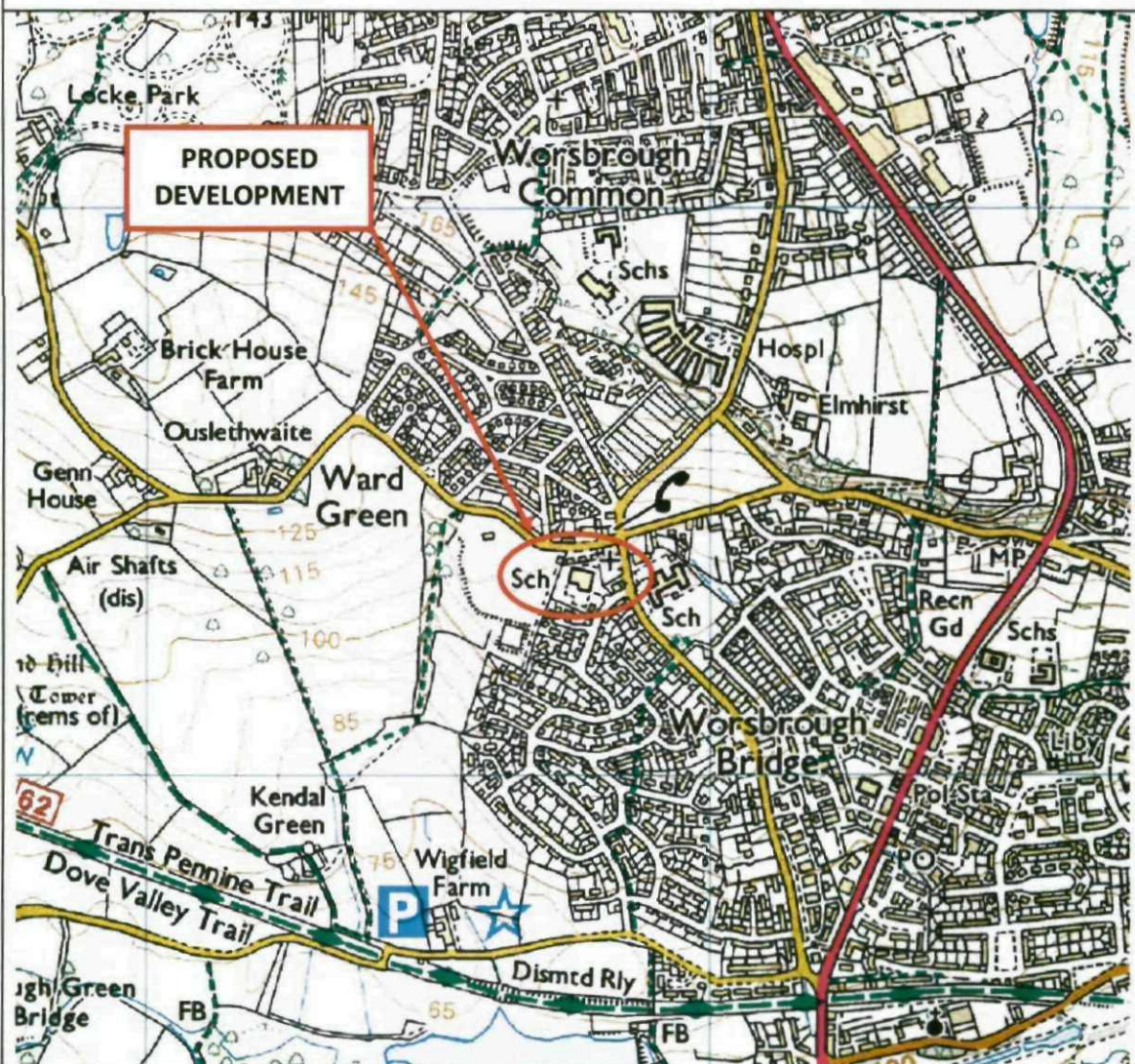


Image produced from the Ordnance Survey Get-a-map service.

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

3.2 Current/Former Use

The site currently accommodates an existing primary school, with a single residential property located within the south corner of the site.

The site was historically occupied by a farm from the 19th Century until the 1960's.

A school was constructed at the site during the early 1970's and was in use until November 2010.

Figure 2: Ward Green Primary School Viewed Northwards from High Ridge.



Image produced from Google Earth

3.3 Proposals

Proposals for the site involve the provision of residential development comprising 19No new residential units.

The proposed layout produced provided by Harron Homes is presented within Appendix B of this report.

3.4 Boundaries

The development is located within a suburb known as Worsbrough, near to the southern fringe of Barnsley.

The site is situated within an area comprising predominantly of existing residential development and is located approximately 2 kilometres to the south of Barnsley town centre.

The area of Worsbrough includes Worsbrough Bridge, Worsbrough Common, Worsbrough Dale, Worsbrough Village and Ward Green.

The River Dove flows east to west through Worsbrough and the reservoir before joining the River Dearne and the area is built on its valley.

The A61 traverses this large valley, south of Barnsley, before passing through Birdwell to junction 36 of the M1. A railway line passed along the valley as well, which is now the Trans-Pennine Trail.

The proposed development is accessed directly off High Ridge.

3.5 Topography

The development site is irregular in shape and exhibits a slope from north to south across the site.

Ground levels extracted from the topographical survey indicate that there is a natural high point 115.85mAOD at the north west corner of the site. The lowest level within the site is shown to be 109.9mAOD and is positioned at the south corner of the site.

The footprint of the existing school is situated on a plateau within the grounds of the school; with the ground floor of the building is set at a level of approximately 114.060mAOD.

The ground floor level of the residential property located within the south corner of the development is set at 110.90mAOD.

3.6 Drainage

3.6.1 Public Sewer System

Details from Yorkshire Water indicate that there is a 225mm diameter public combined sewer traversing the northern part of the existing site. The sewer is shown to be located partially beneath the existing school building. The combined sewer connects to a 300mm diameter combined sewer within Vernon Road, and flows are believed to be directed in a south easterly direction towards the Worsbrough Bridge Sewage Treatment works located approximately 2 kilometres to the south west of the development.

The sewer record plans also indicate the location of a 150mm diameter public foul sewer, which is shown to traverse the rear gardens of No's 1-3 Dorchester Place to the immediate south of the proposed development.

A 225mm diameter public surface water sewer is situated within the rear garden of No 8 High Ridge, and directs flow generally in a southwards direction.

Yorkshire Water requires that a 3 metre easement either side of the public sewer is to be incorporated into the redevelopment plan. Alternatively the 225mm diameter combined sewer may be diverted to accommodate the redevelopment plan under a Section 185 agreement with the water authority.

The sewer record plans and associated correspondence received from Yorkshire Water are provided within Appendix C of the report.

3.6.2 On-Site Drainage

The site currently comprises a primary school and existing residential property. Details of the existing layout indicate that the site comprised 1 No single storey building, situated on a plateau within the north central part of the site; with the residential property located within the south portion of the site.

Roof and paved areas cover an area approximating to 0.25 Hectares, hence 35% of the total site area.

The on-site drainage identified during the topographical survey, indicates that the existing site is positively drained via a series of gullies and rainwater pipes.

In general the existing drainage system directs flow from the lower part of the site in a southerly direction. It is therefore considered that foul flows from the primary school and residential property connect into the 150mm diameter foul public sewer located adjacent to the south boundary of the site. It is also considered that surface water flows from the roof and paved areas in the south part of the site are connected to the existing 225mm diameter surface water sewer

It is believed that foul and surface water flows from the area within the north part of the site are directed to the 225mm diameter combined public sewer which traverses through the site.

Following completion of the redevelopment works, it is considered that both surface water and foul flows from the site will be increased.

Therefore, consideration of changes to surface water runoff; the requirement of surface water attenuation; and incorporation of sustainable drainage techniques within the proposed drainage strategy has been investigated further within this report.

3.7 History of Flooding

A search on the British Hydrological Society Chronology of British Hydrological Events website (<http://www.dundee.ac.uk/geography/cbhe>) indicates numerous incidents of historical flooding within the Barnsley area. However, no records relating to flooding within the immediate vicinity of the proposed development at Ward Green Primary School in Worsbrough was highlighted.

Undertaking an internet based search for flooding indicated that Barnsley was seriously affected by the floods of 2007, when homes in Darton, Hoyland, Thurnscoe, Bolton, Grimethorpe, Worsbrough, Burton Grange and Silkstone were inundate by flood water.

Although flooding in the Worsbrough area has previously been identified, no evidence regarding historical flooding within the immediate vicinity of the bproposed development was found.

4.0 Flooding Mechanisms

Table 2: Sources of Flooding

Source/Pathway	Significant?	Comment/Reason
Fluvial	No	Worsbrough Reservoir; River Dove; Snape Ske
Tidal/Coastal	No	
Canal	No	Dearne & Dove Canal
Pluvial (urban drainage)	Yes	Existing site is positively drained.
Groundwater	No	Minor Aquifer
Overland flow	No	Elevated ground situated to the north of the site.
Blockage	No	
Infrastructure failure	No	
Rainfall Ponding	No	

4.1 Worsbrough Reservoir; the Dearne & Dove Canal; and the River Dove

Worsbrough Reservoir was constructed as one of a series of header lakes to supply water to the Dearne and Dove Canal.

The canal was opened in part in 1799 and was in full use by 1804. The Worsbrough section of the canal was closed to traffic in 1906, with the reservoir and stream being retained as a feeder. Whilst there is very little left of the Dearne & Dove Canal, the reservoir was retained and is now used predominantly for leisure activities such as fishing and bird watching.

The Dearne & Dove Canal ran for almost ten miles through South Yorkshire, England from Swinton to Barnsley. The canal also had two short branches, the Worsbrough branch and the Elsecar branch, both about two miles long with reservoirs at the head of each. The canal was created mainly to carry cargo from the extensive coal mining industry in the area.

After leaving Stairfoot the Worsbrough branch of the Dearne & Dove Canal passes through Swaithe and then passes under the Penistone Line. After this it ran alongside the River Dove until reaching Worsbrough Basin.

The upper reaches of the River Dove are classified as ordinary watercourse, as it flows through the Worsbrough area of Barnsley. The river extends eastwards through the Low Valley area, and becomes a main river to the north of Wombwell, joining the River Dearne at Wombwell Ings.

The reservoir; canal and river are located approximately 1 kilometre to the south of the proposed development; and the Environment Agency Flood Map indicates that the development is situated outside of the flood envelope attributed to each.

As such it is considered that Worsbrough Reservoir; the Dearne & Dove Canal and the River Dove present a low risk of flooding to the proposed residential development.

4.2 Snape Ske

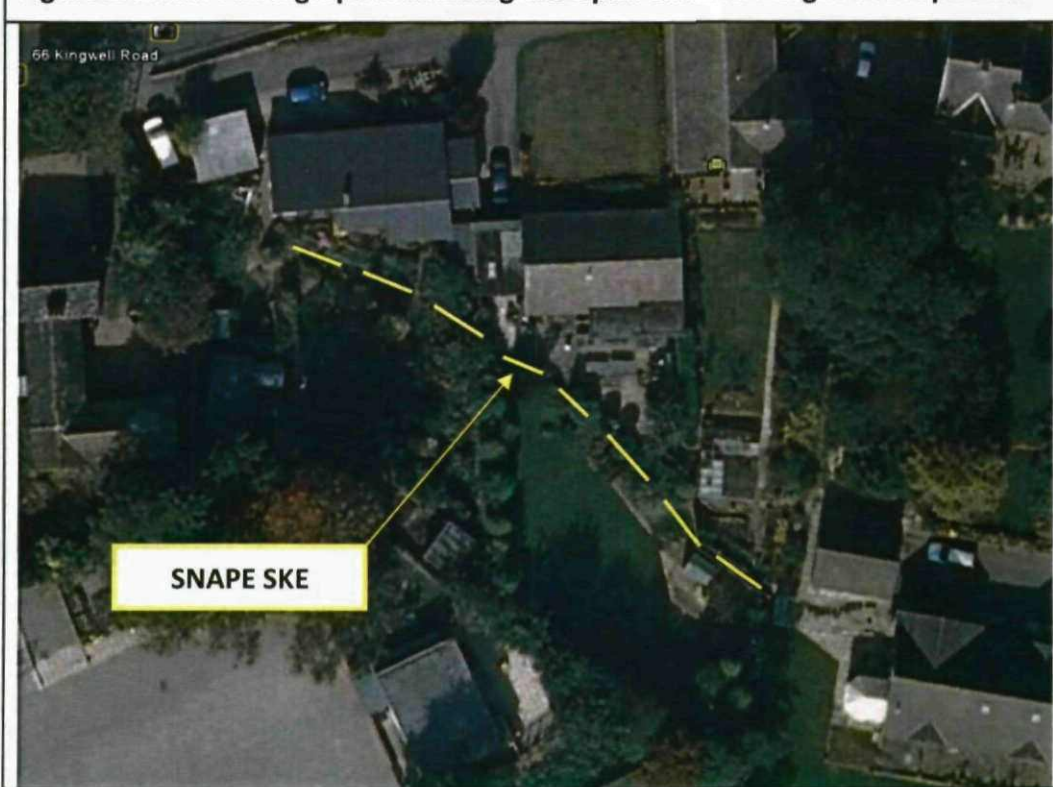
Snape Ske is a minor watercourse situated 115 metres to the north east of the development.

The watercourse is a small tributary of the River Dove, and flows in a south easterly direction to its confluence to the south of Worsbrough Bridge.

Due to the extent of development along the route of the watercourse, it is understood that a large proportion of Snape Ske is culverted.

The watercourse is shown to issue within the rear garden of No72 Kingwell Road and traverse a short length in a south easterly direction within private garden areas of properties along Kingwell Road. The watercourse is then shown to be culverted beneath existing residential property; and is considered to be riparian owned along its length.

Figure 3: Aerial Photograph Illustrating the Open Channel Length of Snape Ske.



Photograph obtained from Google Maps.

There are no records or anecdotal evidence available with regard to flooding of this watercourse, and therefore for the purposes of the report it has been assumed that Snape Ske presents a low flood risk to the development.

4.2 Surface Water Runoff

4.2.1 Existing Site

The existing site covers an area approximating 0.71 Hectares. A survey of the existing drainage network within the site has been undertaken and provides evidence of a positive drainage system.

The survey indicates the arrangement of existing gullies and inspection chambers serving the development. A copy of this survey is available within Appendix A of the report.

Figure 4: Aerial Photograph of the Existing Site.



Photograph obtained from Google Maps.

4.2.2 Proposed Site

Within the Building Regulations Approved Document H, the hierarchy for disposal of surface water must be applied in order to demonstrate a more sustainable approach to drainage from proposed development.

The hierarchy identifies infiltration on site as the preferred disposal option, followed by discharge to watercourse and then connection to a sewer.

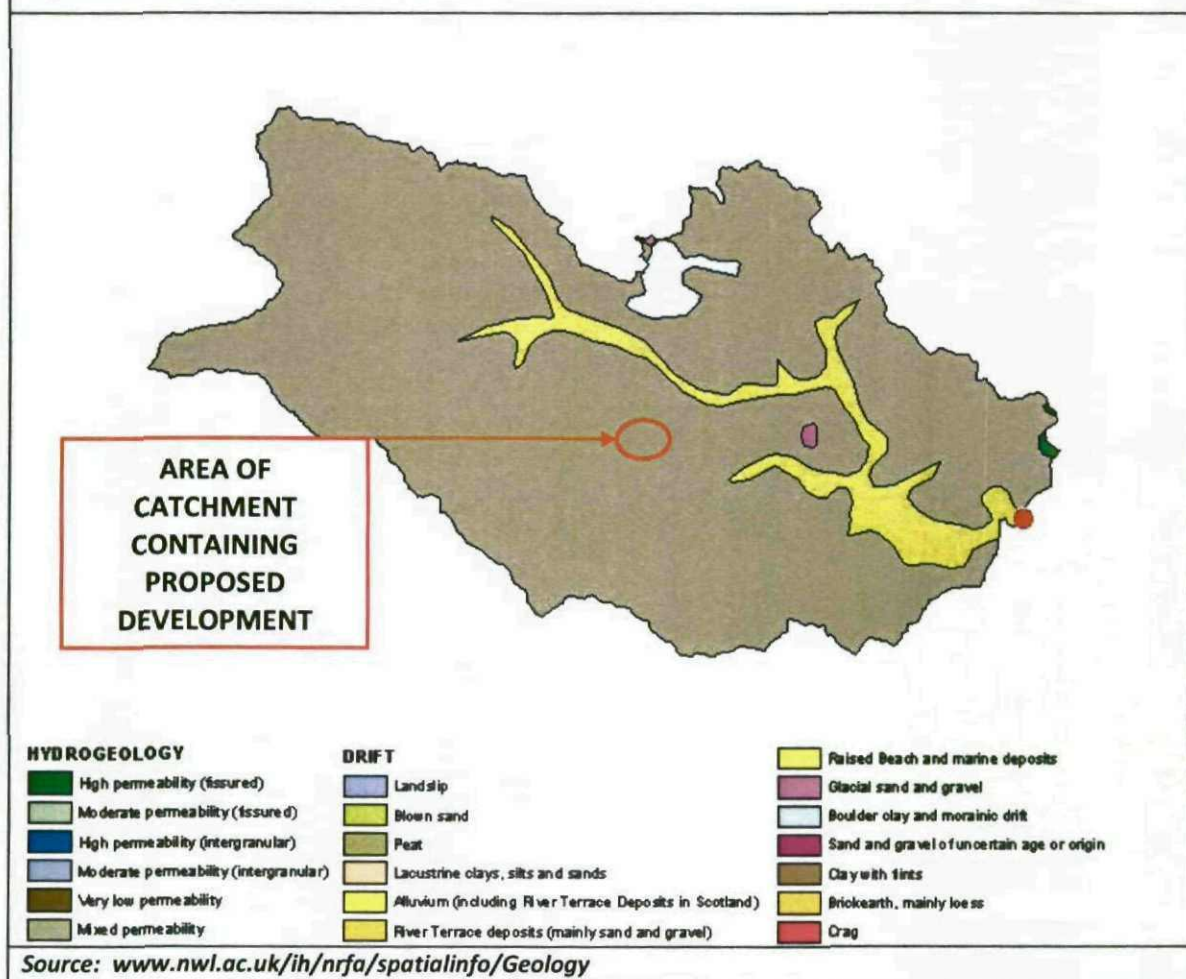
Infiltration

In order to determine the suitability for the inclusion of infiltration methods within the proposed drainage strategy for the site, a number of evidentiary sources have been investigated.

The first source involves the extraction of both drift and hydrogeological data for the area containing the site, from the Centre for Ecology and Hydrology website.

The data obtained indicates that the development is located within an area exhibiting ground conditions of mixed permeability. As such this data source is considered to be inconclusive, and further information is required. A map illustrating this data is provided within Figure 5 of the report.

Figure 5: Hydrogeological and Drift Deposits Map



In order to further investigate the suitability of infiltration drainage methods, details pertaining to the hydrological catchment area have been obtained from the FEH CD-Rom (Version 3).

The catchment characteristic labelled as the SPRHOST is defined as the Standard Percentage Runoff (%) and is dependent upon the soil classification i.e. ground conditions within the catchment area.

The relationship between permeability and SPRHOST is such that the value of the SPRHOST increases with a corresponding decrease in permeability within a catchment.

The SPRHOST at the Ward Green Primary School site is 21.1%, and as such implies that the ground conditions are fairly permeable.

Reference is made to the Phase 1 Site Investigation undertaken by PWA Geo in December 2010 (Report reference 10225/G/1). The report indicates that superficial drift deposits are shown to be absent beneath the site. However, made ground is shown to be present beneath the north of the site.

The solid geology beneath the site comprises the Pennine Middle Coal Measures formation comprising mudstone, siltstone, coal and sandstone.

Potential contamination within the site, identified during the desk study will need to be investigated further. Therefore owing to the risk of transferring pollutants to the underlying minor aquifer it is concluded for the purposes of this report, that disposal of surface water from the development via infiltration methods is unsuitable for inclusion within the drainage strategy for the proposed development.

It is understood that PWA Geo are currently undertaking a Phase 2 Site Investigation and therefore more information regarding the potential for infiltration will be available following completion of this exercise.

Discharge to Watercourse

The nearest watercourse is identified to be Snape Ske, located 115 metres to the north east of the site.

Snape Ske is shown to be a riparian owned minor watercourse, which is culverted along a large proportion of its length.

The lowest part of the proposed development is at an elevation of 109.90mAOD, with the area surrounding the west bank of the watercourse situated at a level between 110.0 and 115.0mAOD, as shown on the Ordnance Survey Maps for the Worsbrough area.

Therefore in order to discharge surface water from the site to the watercourse it is likely that a pumped solution will need to be incorporated into the drainage strategy for the development.

There is also the added difficulties of obtaining consent from the riparian owners to discharge surface water from the development into the watercourse; locating a route through third part land; and due to the small nature of the channel, it is possible that any additional flow into the watercourse is likely to have a detrimental effect on water levels within the Snape Ske. Due to the proximity of existing residential accommodation along the banks of the watercourse, it is possible that exacerbation of flood levels will cause flooding of the adjacent properties.

Discharge to Public Sewer

The existing drainage survey indicates that there are existing outfalls directing both foul and surface water runoff from the existing site to the public sewer system surrounding the Ward Green Primary School site.

It is therefore considered that discharge of surface water flows from the proposed development to the existing public sewer network presents the most appropriate solution for the site.

4.2.3 Estimation of Existing Surface Water Runoff

From the topographic survey, it is estimated that roof and hard paved areas within the existing site, which are directed towards the 225mm diameter combined sewer (Outfall 1) within the site covers 0.103 Hectares, representing 14.5% of the total site area.

The remaining roof and hardstanding areas, hence 0.147 Hectares, within the site are understood to be directed to the 225mm diameter public surface water sewer (Outfall 2) located to the south of the site.

It is noted that surface water from the site currently discharges freely to the public sewer system surrounding the development.

In order to estimate the existing 1 in 2 year runoff rate from the development area, the Modified Rational Method is considered to be appropriate. This method of calculation utilised the catchment characteristics obtained from the FEH CD-ROM (Version 3.0), to determine surface water flows to each outfall from the previously developed site. The calculation results are tabulated overleaf and the calculation spreadsheet is in Appendix D of this report.

In order to meet the requirements laid out by Yorkshire Water and Barnsley MBC, all brownfield development proposals are to provide a reduction in surface water runoff of 30% to accommodate climate change over the lifetime of the proposed development.

Table 3: Existing Surface Water Runoff Calculations

Outfall	Contributing Area (Ha)	Surface Water Runoff (l/s)	Surface Water Runoff Minus 30% (l/s)
1	0.103	12.1	8.5
2	0.147	15.4	11.0
Total	0.250	27.5	19.5

Therefore, the allowable peak 1 in 2 year runoff rate for the development is estimated to be a total of 19.5l/s.

From the approved development layout it is anticipated that the roof and paved areas within the site will remain unchanged following development. As such calculations have been carried out in order to determine the requirements for on-site attenuation, prior to discharge into the existing public sewer network.

Flows in excess of 8.5l/s and 11.0l/s respectively are required to be attenuated within the site, prior to discharge.

4.2.4 Proposed Surface Water Drainage System and Attenuation Requirements

In accordance with PPS25 and the requirements of the Statutory Authorities, surface water runoff from the proposed development which is to be discharged to a local sewer network should be restricted to the existing flow incorporating a 30% reduction to accommodate climate change over the lifetime of the proposed development.

The proposed 1 in 2 year runoff should be maintained within the drainage system and the 1 in 30 year event should not be 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 is usually allowed to flood the surface but flood water will not be permitted to enter any of the buildings within the site. In addition, the 1 in 100 year plus climate change flood must be limited to the development boundary and must not be allowed to migrate to adjacent properties.

The proposed residential development will involve the construction of estate roads, footpaths and driveways to access the residential units. From the development layout it is estimated that the impermeable area contributing flows to the existing 225mm diameter public combined sewer is 0.249 Hectares, with 0.121 Hectares contributing flow to the existing 225mm diameter public surface water sewer.

The combined impermeable area within the proposed development is therefore 0.37 Hectares, and equates to 52% of the total site area.

Outfall to 225mm Diameter Public Combined Sewer

Harron Homes have produced a development layout, which indicates that the impermeable area which is to be discharged to the public combined sewer located within the site following development will be approximately 35% of the total site area, hence 0.249 Hectares.

It is proposed that this public sewer is diverted along the proposed line of the access road, in order to maximise the developable area within the north part of the site.

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 8.5l/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.

The required attenuation volumes have been tabulated below.

Table 4: Indicative Volumes for Attenuation – Outfall to Combined Sewer

Return Period	Balance Volumes: Total Development Area (m ³)
1 in 2 year	8
1 in 30 year	48
1 in 100 year	75
1 in 100 year + 30% climate change	131

Outfall to 225mm Diameter Public Surface Water Sewer

The proposed residential development will involve the construction of estate roads, footpaths and driveways to access the residential units, the total impermeable area within the site will be increased.

The development layout indicates that the impermeable area within the site, which is to be discharged via an existing outfall to the public surface water located to the south of the site, following development will be approximately 17% of the total site area, hence 0.121 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 11l/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.

The required attenuation volumes have been tabulated below.

Table 5: Indicative Volumes for Attenuation – Outfall to Surface Water Sewer

Return Period	Balance Volumes: Total Development Area (m ³)
1 in 2 year	0
1 in 30 year	15
1 in 100 year	25
1 in 100 year + 30% climate change	36

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.

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.

4.3 Domestic Foul Flows

It is proposed that foul flows from the new development are discharged to the existing 150mm diameter public foul sewer situated to the south of the proposed development, in line with the recommendations provided by Yorkshire Water.

4.3 Groundwater

The Phase 1 Site Investigation report undertaken by PWA Geo identified potential soil and groundwater contamination associated with the historical use of the site and the surrounding area. No information has been provided to indicate whether or not remedial works have been carried out on site.

It is understood that a more intrusive site investigation is being carried out, and as such further information with regard to groundwater issues at the Ward Green development will be available following this exercise.

However there is no historical evidence to suggest that groundwater flooding has been an issue within the Worsbrough area of Barnsley, and therefore it is concluded that groundwater presents a low flood risk to the proposed development.

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.

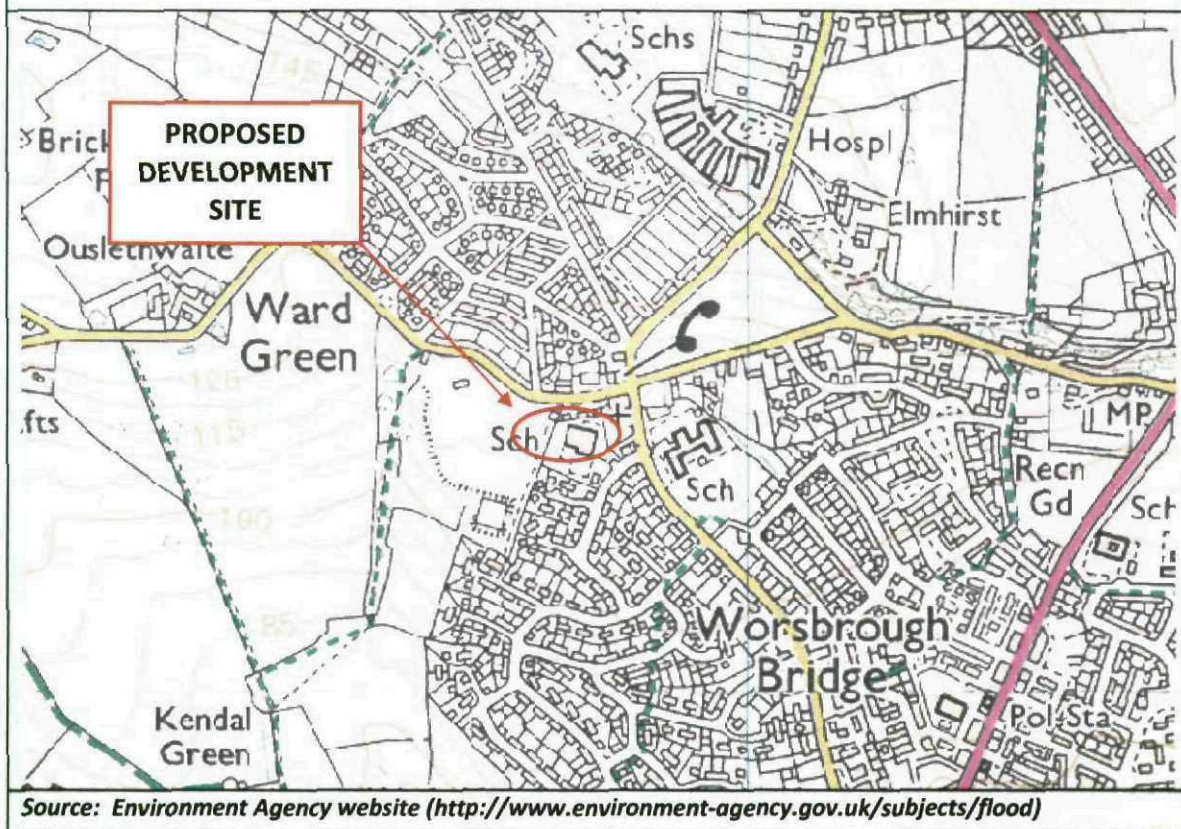
The latest identified figures in Annex B of PPS25 identifies that increases in rainfall of around 30% are anticipated for developments extending beyond the year 2050. It will be necessary, therefore, to make allowance for this increased rainfall in any positive drainage system assumed on the site.

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.

An extract of the Environment Agency flood map at the development site is provided in Figure 6 overleaf.

Figure 6: Environment Agency Flood Map



5.3 Proposed Finished Floor Levels

The proposed development located within the Worsbrough area, to the south of Barnsley.

The site is situated within Flood Zone 1 of the Environment Agency Map and as such it is considered that land raising will not be required as a direct result of flood risk.

Due to the possibility of localised flooding caused by heavy rainfall, it is also recommended that the internal ground floor level is elevated a minimum of 150mm above the adjacent external finished ground levels.

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

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; discharge to watercourse; or groundwater recharge via infiltration methods.

It is proposed that the drainage strategy for the development will incorporate a number of different methods in order to reduce the volume of surface water leaving the site. The suitability of such methods is investigated further in Section 5.6 below.

5.6 Sustainable Urban Drainage (SUDS)

The impermeable area within the site is shown to be increased following development. The existing site is developed and is drained via a positive system to 2No outfalls into the public sewer system. One outfall directs flow to the 225mm diameter combined public sewer which traverses the site, with the second outfall allowing discharge to an existing 225mm diameter surface water sewer located adjacent to the south boundary of the site.

Surface water outflow from the existing development to the existing combined sewer is estimated to be 12.1l/s. Incorporating a 30% reduction to existing surface water flows in accordance with the requirements of Yorkshire Water and Barnsley MBC, surface water discharge from the new development to this outfall should be restricted to a maximum of 8.5l/s.

In addition surface water flows discharging to the existing surface water sewer should be restricted to a maximum discharge rate of 11.5l/s.

Flows generated by the proposed development, which are in excess of the estimated discharge rates should be attenuated within the site.

To reduce the impact of surface water runoff from the development in accordance with the requirements of PPS25; Yorkshire Water and Barnsley MBC, 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 provides an indication of the 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.

Yorkshire Water and Barnsley MBC recommend the use of source control techniques within the drainage strategy for any development. 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 within Table 6. The precise combination of methods used will be dependent upon the site constraints identified at the final design stage.

A Phase 1 Site Investigation has been undertaken by PWA Geo. The underlying geology within the site has been identified as:

- Made ground across the site associated with school and former farm buildings.
- Geological plans indicate that superficial drift deposits are absent beneath the site.
- Solid geology beneath the site comprises Pennine Middle Coal Measures, comprising mudstone, siltstone, coal and sandstone.

Whilst the presence of sandstone may imply that the site is suitable for infiltration, the presence of mudstone provides the opposite result, due to its impervious nature. The extent and distribution of sandstone and mudstone within the site is currently unknown.

The preliminary risk assessment also identified potential soil and groundwater contamination associated with the historical use of the site and the surrounding area.

Until further site investigation works are completed, it has therefore been assumed that disposing of surface water via infiltration methods is unsuitable for inclusion within the proposed drainage strategy.

Utilising a suitability matrix derived from CIRIA Report C697 (see Appendix G) it is indicated that

Table 6: SUDS Techniques and Suitability of Use

Method	Description	Potential for use at site
FILTRATION: Filter drains & trenches	Drainage trench filled with gravel and provided with a perforated pipe.	Unsuitable in terms of the SUDS matrix (Appendix G), due to the topographical characteristics of the site. The average gradient of the site is considered to be in excess of 5%. Therefore this method has not been included within the drainage strategy.
OPEN CHANNEL: Swales	Shallow grass ditch	Due to the lack of available space and topographical characteristics of the site, conveyance swales have not been utilised within the proposed drainage strategy.
SOURCE CONTROL: 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 car park and hard paved areas within the development, in order to reduce the volume needed for on-line attenuation. However, Yorkshire Water has advised that shallow storage such as Hydro-International's Stormcell arrangement within the adoptable drainage system is unacceptable.
DETENTION/RETENTION AND WETLAND: 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	A pocket wetland appears to be suited to the site conditions within the development, however the current development proposals do not provide enough space for such a structure and owing to public safety concerns associated with open water; accompanied with a lack of open space within the site this method of attenuation is considered unsuitable for this development.

SOURCE CONTROL: Green roofs	Roof system that is vegetated with plants (note sedum plants rather than grass so no mowing is required)	Suitable in terms of the matrix (Appendix G); however, owing to the limited area per roof and the maintenance issues involved, this method is considered more suited to buildings with larger roof areas, such as educational establishments and commercial buildings.
INFILTRATION: Infiltration devices	Methods that allow rainwater to soak into the ground, e.g. soakaways	Current information obtained from the Phase 1 site investigation for the site indicates that the development may have some contamination issues. Therefore until further investigation works are undertaken, it has been taken that ground conditions within the site are not suited for soakaways.
RETENTION: Storage tanks	Underground tanks that temporarily store water in the drainage system	Online attenuation in the form of oversized sewer sections, is considered to be the most suitable method for inclusion within the proposed drainage strategy. Similarly shallow storage may be considered suitable for the attenuation of small surface water volumes.

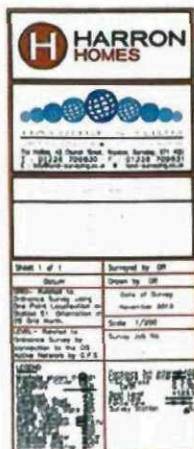
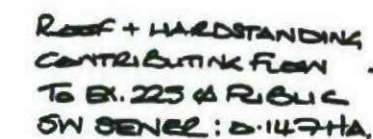
6.0 Conclusions and Recommendations

- 6.1 The development known as Ward Green Primary School, in the Worsbrough area of Barnsley is located within Flood Zone 1 of the Environment Agency's Flood Map.
- 6.2 Surface water runoff has been identified as the primary flood risk to the development area.
- 6.3 Proposal for the development incorporates the construction of 19No residential properties.
- 6.4 Following development the impermeable area within the site will be increased from 0.25 Hectares to 0.37 Hectares and hence the volume of surface water emanating from the site will be increased as a result of the development.
- 6.5 Details obtained from the Phase 1 Site Investigation report, has revealed that the ground conditions within the development are likely to discount the suitability for the use of infiltration methods within the proposed drainage strategy for the development.
- 6.6 Owing to the difficulties arising from the discharge of surface water from the development to Snape Ske, as outlined within the report, it is considered that this is not a viable solution for disposal of surface water from the proposed development.
- 6.7 Yorkshire Water and Barnsley MBC requires that allowable surface water discharge rates from development proposals on Brownfield sites, are to be restricted to existing rates with an additional 30% reduction to accommodate climate change over the lifetime of the development.
- 6.8 The existing site is positively drained with surface water being discharged to 2No outfalls; a combined sewer within the site; and surface water sewer adjacent to the south boundary of the development.
- 6.9 It is calculated that discharge to the surface water sewer should be restricted to a maximum rate of 11l/s; with a maximum of 8.5l/s allowed to discharge to the existing combined sewer.
- 6.10 The existing 225mm diameter public combined sewer which is known to traverse the site will be diverted along the route of the proposed access road, in order to maximise the developable area within the north portion of the site.
- 6.11 It is estimated that the volume of attenuation required for the 1 in 30 year event for the area of development discharging to the surface water sewer site is approximately 15m³.

- 6.12 The volume of attenuation required for the development area discharging surface water to the combined sewer during the 1 in 30 year event is estimated to be 48m³.
- 6.13 The drainage strategy involves the conveyance of surface water runoff via a piped network to an oversized pipe situated within the estate road. This will then discharge into the 225mm diameter combined sewer within the site boundary.
- 6.14 It is proposed that surface water from the residential plots located within the south part of the site, will discharge via an existing connection to the existing 225 mm diameter surface water sewer. Attenuation is to be provided by shallow geocellular storage units such as Hydro-International's Stormcell.
- 6.15 It is proposed that surface water discharge rates from both the oversized pipes and Stormcell storage units will be controlled using an orifice plate; hydrobrake or similar arrangement.

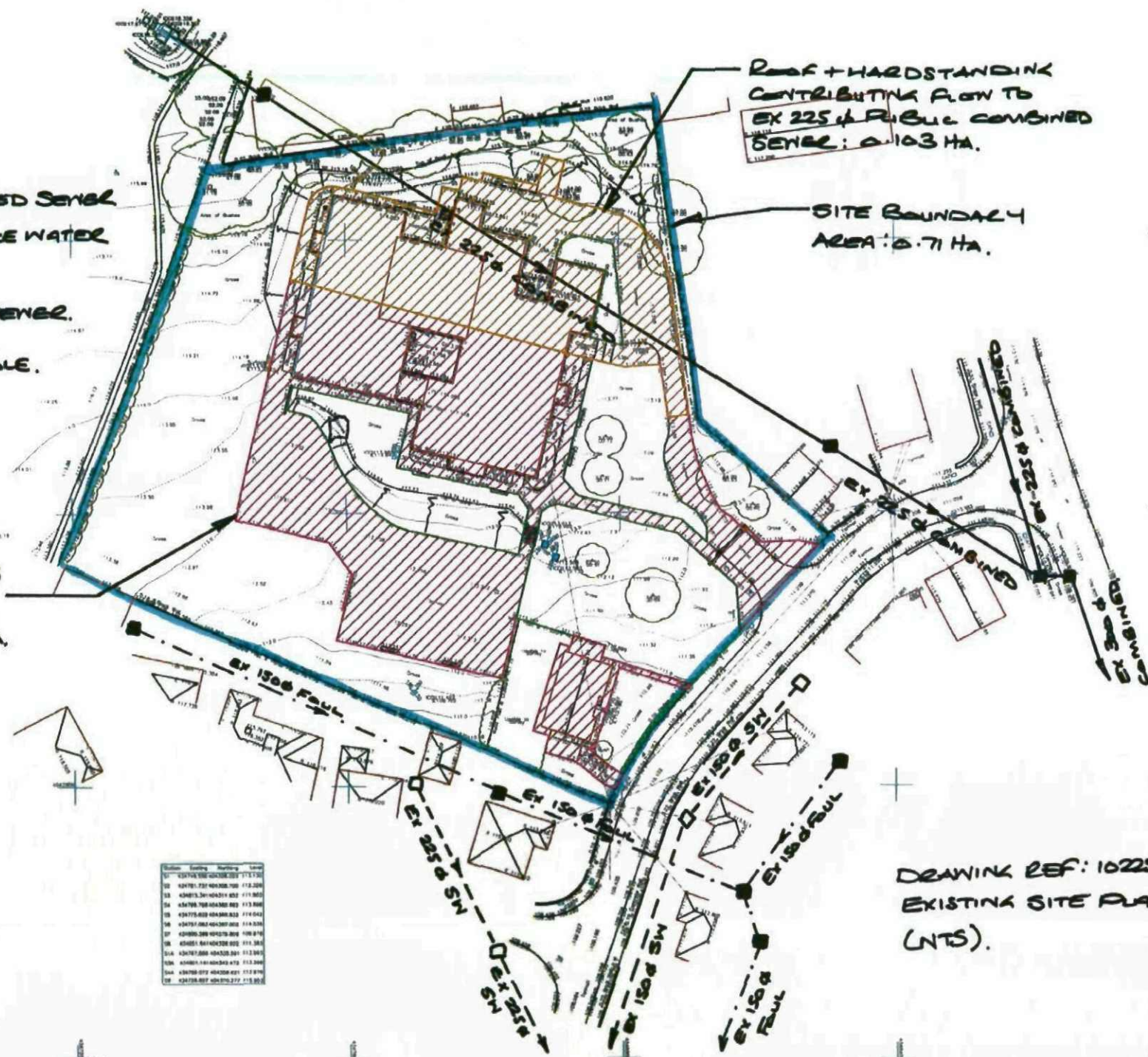
APPENDIX A

EXISTING SITE



Station	Easting	Northing	Altitude
51	434794.000	4063308.000	171.520
52	434781.737	4063308.700	172.200
53	434813.341	4063311.452	171.800
54	434798.798	4063308.800	173.800
55	434775.610	4063308.313	174.042
56	434797.082	4063307.000	174.838
57	434800.588	4063312.781	176.100
58	434815.541	4063328.010	177.100
51A	434787.888	4063328.241	173.200
52A	434801.541	4063342.472	173.200
53A	434780.177	4063358.471	172.878
54A	434758.897	4063372.272	171.900

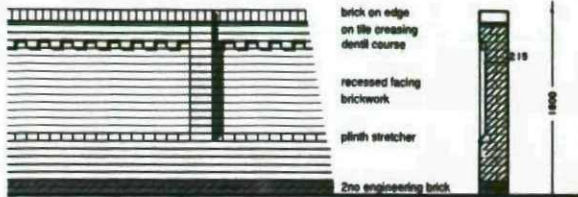
DRAWING REF: 10225/SK/C/01
EXISTING SITE PLAN
(NTS).



APPENDIX B

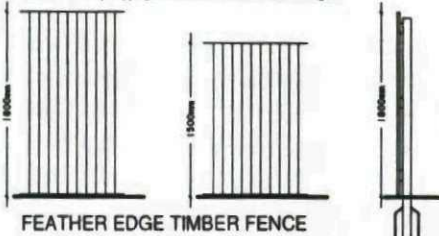
PROPOSED DEVELOPMENT PLANS

Boundary Details

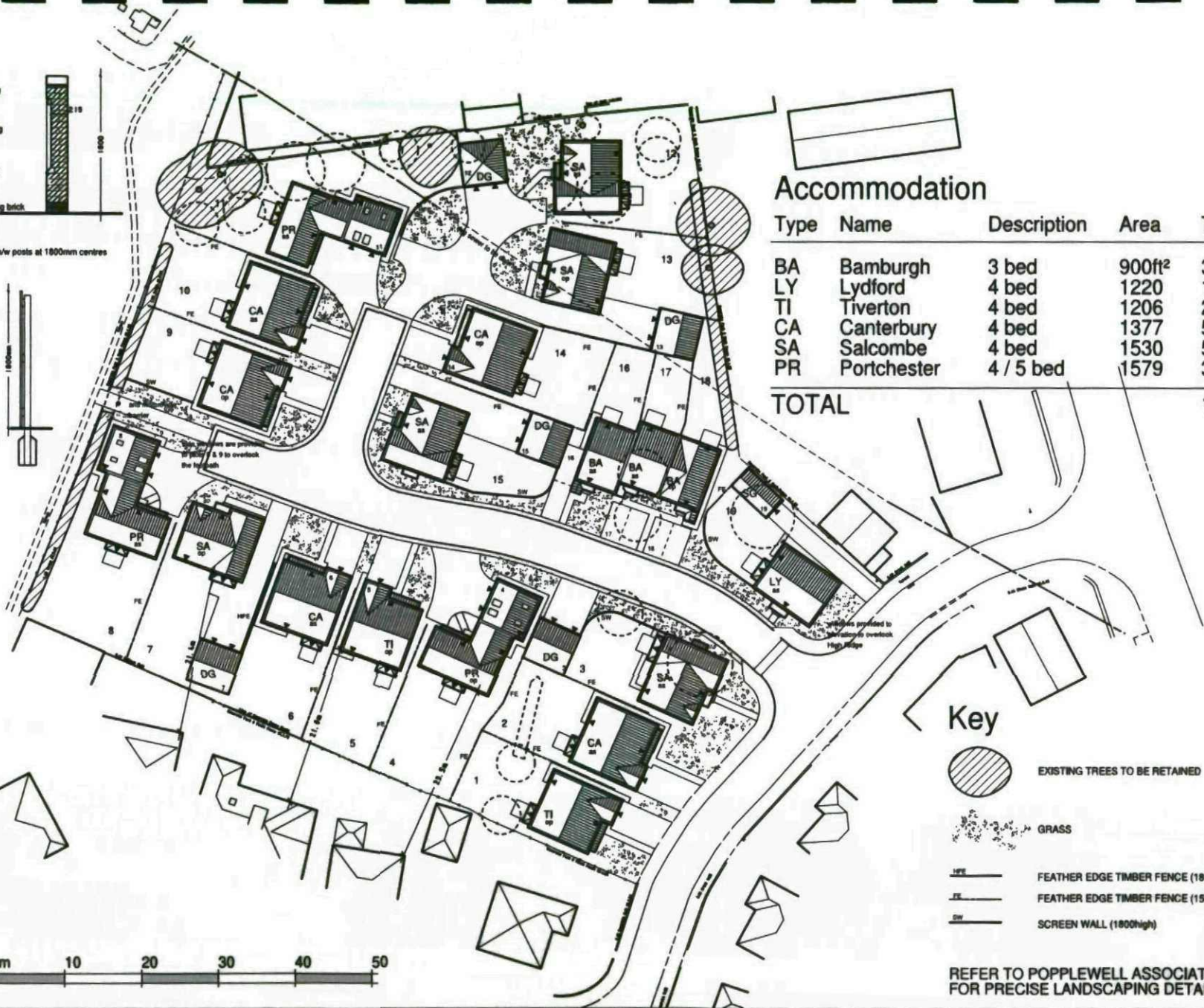


SCREEN WALL

100x25to12.5mm boards lapped on 100x35mm s/r rails on 75x75mm s/r posts at 1800mm centres
(all timbers to be tarred in Dark Brown)
Fit 75x22mm top capping to fences visible from road frontages.



FEATHER EDGE TIMBER FENCE



Accommodation

Type	Name	Description	Area	Total
BA	Bamburgh	3 bed	900ft ²	3no
LY	Lydford	4 bed	1220	1no
TI	Tiverton	4 bed	1206	2no
CA	Canterbury	4 bed	1377	5no
SA	Salcombe	4 bed	1530	5no
PR	Portchester	4 / 5 bed	1579	3no
TOTAL				19no

Key

- EXISTING TREES TO BE RETAINED
- GRASS
- FEATHER EDGE TIMBER FENCE (1800high)
- FEATHER EDGE TIMBER FENCE (1500high)
- SCREEN WALL (1800high)

REFER TO POPPLEWELL ASSOCIATES DRG FOR PRECISE LANDSCAPING DETAILS



REV	DATE	AMENDMENT
C	17/02/11	WALLS TO PL. 3, 15, 19 ADJUSTED, PL. 16-18 GARDENS INCREASED, WINDOW NOTES ADDRESS
B	01/02/11	AMENDED TO ADDRESS LPA COMMENTS IN LETTER DATED 26/01/10
A	26/01/11	PL. 3 & 18 SWAPPED

01845 524758
01845 524278
diparchitects@btconnect.com
www.diparchitects.co.uk
CHARTERED ARCHITECTS
Midland Chambers, 77 Market Place,
Thirsk, North Yorkshire YO7 1BY

downes
illingsworth
partnership ltd

HARRON
HOMES

PROJECT:
DEVELOPMENT AT WARD GREEN, WORSBOROUGH
DRAWING TITLE:
PROPOSED SITE LAYOUT PLAN

SCALE: 1 : 500 @ A3	DATE: DECEMBER 2010
DRAWN: JW	CHECKED: -
DWG NO. 3481/10	REV. C

APPENDIX C

YORKSHIRE WATER CORRESPONDENCE & SEWER RECORDS



YorkshireWater

Harron Homes (Yorkshire) Ltd
Colton House
Temple Point
Bullerthorpe Lane
LEEDS
LS15 9JL

For the attention of Mr K Lerums

Your Ref:
Our Ref: L005635

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

For telephone enquiries ring:

Kashif Khan on (0845)120 8482

25th August 2010

Dear Sir,

Ward Green, Worsborough - Pre-Planning Sewerage Enquiry - Residential

Thank you for your enquiry received 13th August 2010. Our charge of £60.00 (plus VAT) will be added to your account with us, reference HAH044. 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:

There is a 225 mm diameter public combined sewer recorded crossing the site. No buildings are to be erected within 3 (three) metres, nor trees planted within 5 (five) metres of this public sewer. It may not be acceptable to raise or lower ground levels over the sewer, nor to restrict access to the manholes on the sewer. If you wish to have this sewer diverted under Section 185 of the Water Industry Act 1991 an application should be made in writing. To discuss this matter, please telephone 0845 120 84 82.

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 150 mm diameter public foul sewer recorded to the south of the site, at a point adjacent to the site. You may re-utilise the existing connection.

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 additional 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.

Alternatively, curtilage surface water discharges to the public sewer will be restricted to the level of run-off - i.e. same rate of discharge - to that from the existing use of the site. To maintain the "status quo" in the public sewer network, any discharge of surface water from the site should take place with similar rates of flow and/or measured areas discharging to similar points of connection to that of the existing use of the site. You will need to demonstrate positive drainage to the public sewer to Yorkshire Water by means of investigation and calculation carried out at your expense. Discharges to the public sewer must take into account a 30% reduction in existing discharge and climate change.

To do this, Yorkshire Water requires to see existing and proposed drainage layouts with pipe sizes, gradients and connection points, measured impermeable areas of the present and proposed use of the site, along with the calculations that show the existing and proposed discharge rate from the site to the public sewer.

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.

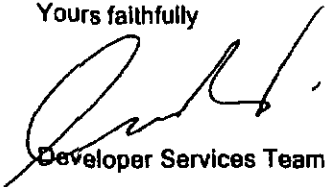
The public sewer network is for domestic sewage purposes. This generally means foul water for domestic purposes and, where a suitable surface water or combined sewer is available, surface water from the roofs of buildings together with surface water from paved areas of land appurtenant to those buildings. Land and highway drainage have no right of connection to the public sewer network. 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, the developer will be required to enter into a formal agreement with Yorkshire Water Services under Section 115 Water Industry Act 1991 to discharge non-domestic flows into the public sewer network.

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



434580 : 404204

Map Name : SE3404SE

Title



YorkshireWater

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

Notes

NR = No recorded depth.

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Partial Key

Fed 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 : 25/08/2010, 12:28:44

Date Gen : 25/08/2010, 12:28:48

Source : Sewer Network Enquiry

UPN: Undefined

Originator: K KHAN, New Development - Waste Water,

APPENDIX D

MODIFIED RATIONAL METHOD: EXISTING SURFACE WATER RUNOFF

Modified Rational Method

Length (m)	21	m
Area (ha)	0.103	Ha
Max Height	114.0	mAOD
Min Height	112.5	mAOD
DeltaH	1.5	
Slope (%)	7.14	
Te (mins)	6.51	mins
ARF	0.999	
SAAR	673.000	mm
UCWI	67	mm
PIMP	100.0	%
SOIL	0.21	
Percentage Runoff PR	72.68	
DEEPSTOR	0.28	
Cv	0.72676	
Cr	1.3	

Peak 1 in 2 yr runoff	12.1	l/s
-----------------------	------	-----

Return Period flood 2 years
Post Development Rainfall 2 years

OUTFALL 1

Rainfall Duration (hours)	Rainfall Duration (days)	Rainfall Depth (mm)	Effective Depth (mm)	Rainfall Intensity (mm/hr)	FLOW (l/s)	FLOW (l/s/ha)
0.11	0.005	4.9	4.6	44.5	12.1	117.0
0.25	0.010	6.76	6.4	27.0	7.3	71.0
0.50	0.021	8.83	8.3	17.7	4.8	46.4
0.75	0.031	10.31	9.7	13.7	3.7	36.1
1.00	0.042	11.5	10.9	11.5	3.1	30.2
1.25	0.052	12.51	11.8	10.0	2.7	26.3
1.50	0.063	13.41	12.7	8.9	2.4	23.5
1.75	0.073	14.21	13.4	8.1	2.2	21.3
2.00	0.083	14.94	14.1	7.5	2.0	19.6
2.25	0.094	15.62	14.8	6.9	1.9	18.2
2.50	0.104	16.25	15.4	6.5	1.8	17.1
2.75	0.115	16.84	15.9	6.1	1.7	16.1
3.00	0.125	17.4	16.4	5.8	1.6	15.2

Modified Rational Method

Length (m)	37	m
Area (ha)	0.147	Ha
Max Height	111.0	mAOD
Min Height	109.1	mAOD
DeltaH	1.9	
Slope (%)	5.09	
Te (mins)	7.70	mins
ARF	0.998	
SAAR	673.000	mm
UCWI	67	mm
PIMP	100.0	%
SOIL	0.21	
Percentage Runoff PR	72.68	
DEEPSTOR	0.33	
Cv	0.72676	
Cr	1.3	

Peak 1 in 2 yr runoff	15.4	l/s
-----------------------	------	-----

Return Period		flood	2	years	OUTFALL 2		
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)	
0.13	0.005	5.2	4.9	40.0	15.4	105.1	
0.25	0.010	6.76	6.4	27.0	10.4	71.0	
0.50	0.021	8.83	8.3	17.7	6.8	46.4	
0.75	0.031	10.31	9.7	13.7	5.3	36.1	
1.00	0.042	11.5	10.9	11.5	4.4	30.2	
1.25	0.052	12.51	11.8	10.0	3.9	26.3	
1.50	0.063	13.41	12.7	8.9	3.5	23.5	
1.75	0.073	14.21	13.4	8.1	3.1	21.3	
2.00	0.083	14.94	14.1	7.5	2.9	19.6	
2.25	0.094	15.62	14.8	6.9	2.7	18.2	
2.50	0.104	16.25	15.4	6.5	2.5	17.1	
2.75	0.115	16.84	15.9	6.1	2.4	16.1	
3.00	0.125	17.4	16.4	5.8	2.2	15.2	

APPENDIX E

MODIFIED RATIONAL METHOD: INDICATIVE ATTENUATION VOLUMES

Modified Rational Method

Length (m)	100	m
Area (ha)	0.249	Ha
Max Height	114.0	mAOD
Min Height	112.0	mAOD
DeltaH	2.0	
Slope (%)	2.00	
Te (mins)	11.35	mins
ARF	0.998	
SAAR	673.000	mm
UCWI	67	mm
PIMP	100.0	%
SOIL	0.21	
Percentage Runoff PR	72.68	
DEEPSTOR	0.51	

Cv	0.72676	
Cr	1.3	
allowable outflow		
2 year return period	0.0085	m/s
		m3
Storage	RT years	Storage
	2	8

Post Development	Return Period	flood Rainfall	2 2	years years	OUTFALL 1					
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	6.76	6.4	27.0	17.7	71.0	16	16	7.65	8
0.5	0.021	8.83	8.3	17.7	11.5	46.4	21	21	15.30	5
0.75	0.031	10.31	9.7	13.7	9.0	36.1	24	24	22.95	1
1	0.042	11.5	10.9	11.5	7.5	30.2	27	27	30.60	-4
1.25	0.052	12.51	11.8	10.0	6.5	26.3	29	29	38.25	-9
1.5	0.063	13.41	12.7	8.9	5.8	23.5	32	32	45.90	-14
1.75	0.073	14.21	13.4	8.1	5.3	21.3	33	33	53.55	-20
2	0.083	14.94	14.1	7.5	4.9	19.6	35	35	61.20	-26
2.25	0.094	15.62	14.8	6.9	4.5	18.2	37	37	68.85	-32
2.5	0.104	16.25	15.4	6.5	4.3	17.1	38	38	76.50	-38
2.75	0.115	16.84	15.9	6.1	4.0	16.1	40	40	84.15	-45
3	0.125	17.4	16.4	5.8	3.8	15.2	41	41	91.80	-51
3.25	0.135	17.94	16.9	5.5	3.6	14.5	42	42	99.45	-57
3.5	0.146	18.44	17.4	5.3	3.4	13.8	43	43	107.10	-64
3.75	0.156	18.92	17.9	5.0	3.3	13.3	45	45	114.75	-70
4	0.167	19.39	18.3	4.8	3.2	12.7	46	46	122.40	-77
4.25	0.177	19.83	18.7	4.7	3.1	12.3	47	47	130.05	-83
4.5	0.188	20.26	19.1	4.5	2.9	11.8	48	48	137.70	-90
4.75	0.198	20.68	19.5	4.4	2.8	11.4	49	49	145.35	-97
5	0.208	21.08	19.9	4.2	2.8	11.1	50	50	153.00	-103
5.25	0.219	21.47	20.3	4.1	2.7	10.7	51	51	160.65	-110
5.5	0.229	21.84	20.6	4.0	2.6	10.4	51	51	168.30	-117
5.75	0.240	22.21	21.0	3.9	2.5	10.1	52	52	175.95	-124
6	0.250	22.57	21.3	3.8	2.5	9.9	53	53	183.60	-131
6.25	0.260	22.91	21.6	3.7	2.4	9.6	54	54	191.25	-137
6.5	0.271	23.25	22.0	3.6	2.3	9.4	55	55	198.90	-144
6.75	0.281	23.58	22.3	3.5	2.3	9.2	56	55	206.55	-151
7	0.292	23.9	22.6	3.4	2.2	9.0	56	56	214.20	-158
7.25	0.302	24.22	22.9	3.3	2.2	8.8	57	57	221.85	-165
7.5	0.313	24.53	23.2	3.3	2.1	8.6	58	58	229.50	-172
7.75	0.323	24.83	23.5	3.2	2.1	8.4	58	58	237.15	-179
8	0.333	25.12	23.7	3.1	2.1	8.2	59	59	244.80	-186
8.25	0.344	25.41	24.0	3.1	2.0	8.1	60	60	252.45	-193
8.5	0.354	25.7	24.3	3.0	2.0	7.9	61	60	260.10	-200
8.75	0.365	25.98	24.5	3.0	1.9	7.8	61	61	267.75	-207
9	0.375	26.25	24.8	2.9	1.9	7.7	62	62	275.40	-214
9.25	0.385	26.52	25.1	2.9	1.9	7.5	62	62	283.05	-221
9.5	0.396	26.79	25.3	2.8	1.8	7.4	63	63	290.70	-228
9.75	0.406	27.05	25.6	2.8	1.8	7.3	64	64	298.35	-235
10	0.417	27.31	25.8	2.7	1.8	7.2	64	64	306.00	-242
10.25	0.427	27.56	26.0	2.7	1.8	7.1	65	65	313.65	-249
10.5	0.438	27.81	26.3	2.6	1.7	7.0	65	65	321.30	-256
10.75	0.448	28.05	26.5	2.6	1.7	6.9	66	66	328.95	-263
11	0.458	28.29	26.7	2.6	1.7	6.8	67	67	336.60	-270
11.25	0.469	28.53	27.0	2.5	1.7	6.7	67	67	344.25	-277
11.5	0.479	28.77	27.2	2.5	1.6	6.6	68	68	351.90	-284
11.75	0.490	29	27.4	2.5	1.6	6.5	68	68	359.55	-291
12	0.500	29.22	27.6	2.4	1.6	6.4	69	69	367.20	-298

Modified Rational Method

Length (m)	60	m
Area (ha)	0.121	Ha
Max Height	113.5	mAOD
Min Height	111.5	mAOD
DeltaH	2.0	
Slope (%)	3.33	
Te (mins)	9.22	mins
ARF	0.999	
SAAR	673.000	mm
UCWI	67	mm
PIMP	100.0	%
SOIL	0.21	
Percentage Runoff PR	72.68	
DEEPSTOR	0.40	

Cv	0.72676	
Cr	1.3	
allowable outflow		
2 year	0.011	m/s
		m3
Storage	RT years	Storage
	2	-2

Return Period		flood	2	years	OUTFALL 2					
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 (m³)	Difference (m³)
							FLOW (m³)	RAIN (m³)		
0.25	0.010	6.76	6.4	27.0	8.6	71.0	8	8	9.90	-2
0.5	0.021	8.83	8.3	17.7	5.6	46.4	10	10	19.80	-10
0.75	0.031	10.31	9.7	13.7	4.4	36.1	12	12	29.70	-18
1	0.042	11.5	10.9	11.5	3.7	30.2	13	13	39.60	-26
1.25	0.052	12.51	11.8	10.0	3.2	26.3	14	14	49.50	-35
1.5	0.063	13.41	12.7	8.9	2.8	23.5	15	15	59.40	-44
1.75	0.073	14.21	13.4	8.1	2.6	21.3	16	16	69.30	-53
2	0.083	14.94	14.1	7.5	2.4	19.6	17	17	79.20	-62
2.25	0.094	15.62	14.8	6.9	2.2	18.2	18	18	89.10	-71
2.5	0.104	16.25	15.4	6.5	2.1	17.1	19	19	99.00	-80
2.75	0.115	16.84	15.9	6.1	1.9	16.1	19	19	108.90	-90
3	0.125	17.4	16.4	5.8	1.8	15.2	20	20	118.80	-99
3.25	0.135	17.94	16.9	5.5	1.8	14.5	21	21	128.70	-108
3.5	0.146	18.44	17.4	5.3	1.7	13.8	21	21	138.60	-118
3.75	0.156	18.92	17.9	5.0	1.6	13.3	22	22	148.50	-127
4	0.167	19.39	18.3	4.8	1.5	12.7	22	22	158.40	-136
4.25	0.177	19.83	18.7	4.7	1.5	12.3	23	23	168.30	-146
4.5	0.188	20.26	19.1	4.5	1.4	11.8	23	23	178.20	-155
4.75	0.198	20.68	19.5	4.4	1.4	11.4	24	24	188.10	-164
5	0.208	21.08	19.9	4.2	1.3	11.1	24	24	198.00	-174
5.25	0.219	21.47	20.3	4.1	1.3	10.7	25	25	207.90	-183
5.5	0.229	21.84	20.6	4.0	1.3	10.4	25	25	217.80	-193
5.75	0.240	22.21	21.0	3.9	1.2	10.1	25	25	227.70	-202
6	0.250	22.57	21.3	3.8	1.2	9.9	26	26	237.60	-212
6.25	0.260	22.91	21.6	3.7	1.2	9.6	26	26	247.50	-221
6.5	0.271	23.25	22.0	3.6	1.1	9.4	27	27	257.40	-231
6.75	0.281	23.58	22.3	3.5	1.1	9.2	27	27	267.30	-240
7	0.292	23.9	22.6	3.4	1.1	9.0	27	27	277.20	-250
7.25	0.302	24.22	22.9	3.3	1.1	8.8	28	28	287.10	-259
7.5	0.313	24.53	23.2	3.3	1.0	8.6	28	28	297.00	-269
7.75	0.323	24.83	23.5	3.2	1.0	8.4	28	28	306.90	-279
8	0.333	25.12	23.7	3.1	1.0	8.2	29	29	316.80	-288
8.25	0.344	25.41	24.0	3.1	1.0	8.1	29	29	326.70	-298
8.5	0.354	25.7	24.3	3.0	1.0	7.9	29	29	336.60	-307
8.75	0.365	25.98	24.5	3.0	0.9	7.8	30	30	346.50	-317
9	0.375	26.25	24.8	2.9	0.9	7.7	30	30	356.40	-326
9.25	0.385	26.52	25.1	2.9	0.9	7.5	30	30	366.30	-336
9.5	0.396	26.79	25.3	2.8	0.9	7.4	31	31	376.20	-346
9.75	0.406	27.05	25.6	2.8	0.9	7.3	31	31	386.10	-355
10	0.417	27.31	25.8	2.7	0.9	7.2	31	31	396.00	-365
10.25	0.427	27.56	26.0	2.7	0.9	7.1	32	32	405.90	-374
10.5	0.438	27.81	26.3	2.6	0.8	7.0	32	32	415.80	-384
10.75	0.448	28.05	26.5	2.6	0.8	6.9	32	32	425.70	-394
11	0.458	28.29	26.7	2.6	0.8	6.8	32	32	435.60	-403
11.25	0.469	28.53	27.0	2.5	0.8	6.7	33	33	445.50	-413
11.5	0.479	28.77	27.2	2.5	0.8	6.6	33	33	455.40	-423
11.75	0.490	29	27.4	2.5	0.8	6.5	33	33	465.30	-432
12	0.500	29.22	27.6	2.4	0.8	6.4	33	33	475.20	-442

Modified Rational Method

Length (m)	100	m
Area (ha)	0.249	Ha
Max Height	114.0	mAOD
Min Height	112.0	mAOD
DeltaH	2.0	
Slope (%)	2.00	
Te (mins)	11.35	mins
ARF	0.998	
SAAR	673.000	mm
UCWI	67	mm
PIMP	100.0	%
SOIL	0.21	
Percentage Runoff PR	72.66	
DEEPSTOR	0.51	

Cv	0.72676	
Cr	1.3	
allowable outflow		
30 year	0.0085	m/s
		m3
Storage	RT years	Storage
	30	48

Return Period		flood	30	years	OUTFALL 1						
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	20.6	87.4	57.1	229.5	51	51	7.65	44	
0.5	0.021	26.82	25.3	53.6	35.1	140.9	63	63	15.30	48	
0.75	0.031	30.21	28.5	40.3	26.3	105.8	71	71	22.95	48	
1	0.042	32.86	31.0	32.9	21.5	86.3	77	77	30.60	47	
1.25	0.052	35.06	33.1	28.0	18.3	73.7	83	82	38.25	44	
1.5	0.063	36.96	34.9	24.6	16.1	64.7	87	87	45.90	41	
1.75	0.073	38.65	36.5	22.1	14.4	58.0	91	91	53.55	37	
2	0.083	40.16	37.9	20.1	13.1	52.7	95	94	61.20	33	
2.25	0.094	41.55	39.3	18.5	12.1	48.5	98	98	68.85	29	
2.5	0.104	42.83	40.5	17.1	11.2	45.0	101	101	76.50	24	
2.75	0.115	44.02	41.6	16.0	10.5	42.0	104	104	84.15	19	
3	0.125	45.14	42.6	15.0	9.8	39.5	106	106	91.80	14	
3.25	0.135	46.18	43.6	14.2	9.3	37.3	109	109	99.45	9	
3.5	0.146	47.18	44.6	13.5	8.8	35.4	111	111	107.10	4	
3.75	0.156	48.12	45.5	12.8	8.4	33.7	113	113	114.75	-2	
4	0.167	49.02	46.3	12.3	8.0	32.2	115	115	122.40	-7	
4.25	0.177	49.88	47.1	11.7	7.7	30.8	117	117	130.05	-13	
4.5	0.188	50.7	47.9	11.3	7.4	29.6	119	119	137.70	-18	
4.75	0.198	51.49	48.6	10.8	7.1	28.5	121	121	145.35	-24	
5	0.208	52.25	49.4	10.5	6.8	27.4	123	123	153.00	-30	
5.25	0.219	52.98	50.1	10.1	6.6	26.5	125	125	160.65	-36	
5.5	0.229	53.69	50.7	9.8	6.4	25.6	126	126	168.30	-42	
5.75	0.240	54.38	51.4	9.5	6.2	24.8	128	128	175.95	-48	
6	0.250	55.04	52.0	9.2	6.0	24.1	130	129	183.60	-54	
6.25	0.260	55.69	52.6	8.9	5.8	23.4	131	131	191.25	-60	
6.5	0.271	56.31	53.2	8.7	5.7	22.8	133	132	198.90	-66	
6.75	0.281	56.92	53.8	8.4	5.5	22.1	134	134	206.55	-73	
7	0.292	57.52	54.3	8.2	5.4	21.6	135	135	214.20	-79	
7.25	0.302	58.09	54.9	8.0	5.2	21.0	137	137	221.85	-85	
7.5	0.313	58.66	55.4	7.8	5.1	20.5	138	138	229.50	-92	
7.75	0.323	59.21	55.9	7.6	5.0	20.1	139	139	237.15	-98	
8	0.333	59.75	56.5	7.5	4.9	19.6	141	141	244.80	-104	
8.25	0.344	60.27	56.9	7.3	4.8	19.2	142	142	252.45	-111	
8.5	0.354	60.79	57.4	7.2	4.7	18.8	143	143	260.10	-117	
8.75	0.365	61.29	57.9	7.0	4.6	18.4	144	144	267.75	-124	
9	0.375	61.78	58.4	6.9	4.5	18.0	145	145	275.40	-130	
9.25	0.385	62.27	58.8	6.7	4.4	17.7	147	146	283.05	-137	
9.5	0.396	62.74	59.3	6.6	4.3	17.3	148	148	290.70	-143	
9.75	0.406	63.21	59.7	6.5	4.2	17.0	149	149	298.35	-150	
10	0.417	63.66	60.1	6.4	4.2	16.7	150	150	306.00	-156	
10.25	0.427	64.11	60.6	6.3	4.1	16.4	151	151	313.65	-163	
10.5	0.438	64.55	61.0	6.1	4.0	16.1	152	152	321.30	-169	
10.75	0.448	64.99	61.4	6.0	4.0	15.9	153	153	328.95	-176	
11	0.458	65.41	61.8	5.9	3.9	15.6	154	154	336.60	-183	
11.25	0.469	65.83	62.2	5.9	3.8	15.4	155	155	344.25	-189	
11.5	0.479	66.24	62.6	5.8	3.8	15.1	156	156	351.90	-196	
11.75	0.490	66.65	63.0	5.7	3.7	14.9	157	157	359.55	-203	
12	0.500	67.05	63.3	5.6	3.7	14.7	158	158	367.20	-209	

Modified Rational Method

Length (m)	60	m
Area (ha)	0.121	Ha
Max Height	113.5	mAOD
Min Height	111.5	mAOD
DeltaH	2.0	
Slope (%)	3.33	
Te (mins)	9.22	mins
ARF	0.999	
SAAR	673.000	mm
UCWI	67	mm
PIMP	100.0	%
SOIL	0.21	
Percentage Runoff PR	72.66	
DEEPSTOR	0.40	

Cv	0.72676	
Cr	1.3	
Allowable outflow		
50 year	0.011	m/s
		m3
Storage	RT years	Storage
	30	15

Return Period		flood	30	years	OUTFALL 2						
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	20.6	87.4	27.8	229.5	25	25	9.90	15	
0.5	0.021	26.82	25.3	53.6	17.0	140.9	31	31	19.80	11	
0.75	0.031	30.21	28.5	40.3	12.8	105.8	35	35	29.70	5	
1	0.042	32.86	31.0	32.9	10.4	86.3	38	38	39.60	-2	
1.25	0.052	35.06	33.1	28.0	8.9	73.7	40	40	49.50	-9	
1.5	0.063	36.96	34.9	24.6	7.8	64.7	42	42	59.40	-17	
1.75	0.073	38.65	36.5	22.1	7.0	58.0	44	44	69.30	-25	
2	0.083	40.16	37.9	20.1	6.4	52.7	46	46	79.20	-33	
2.25	0.094	41.55	39.3	18.5	5.9	48.5	48	47	89.10	-42	
2.5	0.104	42.83	40.5	17.1	5.4	45.0	49	49	99.00	-50	
2.75	0.115	44.02	41.6	16.0	5.1	42.0	50	50	108.90	-59	
3	0.125	45.14	42.6	15.0	4.8	39.5	52	52	118.80	-67	
3.25	0.135	46.18	43.6	14.2	4.5	37.3	53	53	128.70	-76	
3.5	0.146	47.18	44.6	13.5	4.3	35.4	54	54	138.60	-85	
3.75	0.156	48.12	45.5	12.8	4.1	33.7	55	55	148.50	-93	
4	0.167	49.02	46.3	12.3	3.9	32.2	56	56	158.40	-102	
4.25	0.177	49.88	47.1	11.7	3.7	30.8	57	57	168.30	-111	
4.5	0.188	50.7	47.9	11.3	3.6	29.6	58	58	178.20	-120	
4.75	0.198	51.49	48.6	10.8	3.4	28.5	59	59	188.10	-129	
5	0.208	52.25	49.4	10.5	3.3	27.4	60	60	198.00	-138	
5.25	0.219	52.98	50.1	10.1	3.2	26.5	61	61	207.90	-147	
5.5	0.229	53.69	50.7	9.8	3.1	25.6	61	61	217.80	-156	
5.75	0.240	54.38	51.4	9.5	3.0	24.8	62	62	227.70	-166	
6	0.250	55.04	52.0	9.2	2.9	24.1	63	63	237.60	-175	
6.25	0.260	55.69	52.6	8.9	2.8	23.4	64	64	247.50	-184	
6.5	0.271	56.31	53.2	8.7	2.8	22.8	64	64	257.40	-193	
6.75	0.281	56.92	53.8	8.4	2.7	22.1	65	65	267.30	-202	
7	0.292	57.52	54.3	8.2	2.6	21.6	66	66	277.20	-211	
7.25	0.302	58.09	54.9	8.0	2.5	21.0	66	66	287.10	-221	
7.5	0.313	58.66	55.4	7.8	2.5	20.5	67	67	297.00	-230	
7.75	0.323	59.21	55.9	7.6	2.4	20.1	68	68	306.90	-239	
8	0.333	59.75	56.5	7.5	2.4	19.6	68	68	316.80	-248	
8.25	0.344	60.27	56.9	7.3	2.3	19.2	69	69	326.70	-258	
8.5	0.354	60.79	57.4	7.2	2.3	18.8	70	69	336.60	-267	
8.75	0.365	61.29	57.9	7.0	2.2	18.4	70	70	346.50	-276	
9	0.375	61.78	58.4	6.9	2.2	18.0	71	71	356.40	-286	
9.25	0.385	62.27	58.8	6.7	2.1	17.7	71	71	366.30	-295	
9.5	0.396	62.74	59.3	6.6	2.1	17.3	72	72	376.20	-304	
9.75	0.406	63.21	59.7	6.5	2.1	17.0	72	72	386.10	-314	
10	0.417	63.66	60.1	6.4	2.0	16.7	73	73	396.00	-323	
10.25	0.427	64.11	60.6	6.3	2.0	16.4	73	73	405.90	-333	
10.5	0.438	64.55	61.0	6.1	2.0	16.1	74	74	415.80	-342	
10.75	0.448	64.99	61.4	6.0	1.9	15.9	74	74	425.70	-351	
11	0.458	65.41	61.8	5.9	1.9	15.6	75	75	435.60	-361	
11.25	0.469	65.83	62.2	5.9	1.9	15.4	75	75	445.50	-370	
11.5	0.479	66.24	62.6	5.8	1.8	15.1	76	76	455.40	-380	
11.75	0.490	66.65	63.0	5.7	1.8	14.9	76	76	465.30	-389	
12	0.500	67.05	63.3	5.6	1.8	14.7	77	77	475.20	-399	

Modified Rational Method

Length (m)	100	m
Area (ha)	0.249	Ha
Max Height	114.0	mAOD
Min Height	112.0	mAOD
DeltaH	2.0	
Slope (%)	2.00	
Te (mins)	11.35	mins
ARF	0.998	
SAAR	673.000	mm
UCWI	67	mm
PIMP	100.0	%
SOIL	0.21	
Percentage Runoff PR	72.68	
DEEPSTOR	0.51	

Cv	0.72676	
Cr	1.3	
Allowable outflow		
100 year	0.0085	m/s
		m3
Storage	RT years	Storage
	100	75

Post Development		Return Period	flood	100	years	OUTFALL 1					
		Rainfall		140	years						
Rainfall Duration (hours)	Rainfall Duration (days)	Rainfall Depth (mm)	Effective Depth (mm)	Rainfall Intensity (mm/hr)	FLOW (l/s)	FLOW (Va/ha)	RUN-OFF		Allowable Outflow (m³)	Difference (m³)	
							FLOW (m³)	RAIN (m³)			
0.25	0.010	30.79	29.1	123.2	80.5	323.5	72	72	7.65	65	
0.5	0.021	37.15	35.1	74.3	48.6	195.1	87	87	15.30	72	
0.75	0.031	41.41	39.1	55.2	36.1	145.0	97	97	22.95	74	
1	0.042	44.7	42.2	44.7	29.2	117.4	105	105	30.60	75	
1.25	0.052	47.42	44.8	37.9	24.8	99.6	112	112	38.25	73	
1.5	0.063	49.75	47.0	33.2	21.7	87.1	117	117	45.90	71	
1.75	0.073	51.82	49.0	29.6	19.4	77.8	122	122	53.55	68	
2	0.083	53.67	50.7	26.8	17.6	70.5	126	126	61.20	65	
2.25	0.094	55.35	52.3	24.6	16.1	64.6	130	130	68.85	61	
2.5	0.104	56.9	53.8	22.8	14.9	59.8	134	134	76.50	57	
2.75	0.115	58.34	55.1	21.2	13.9	55.7	137	137	84.15	53	
3	0.125	59.68	56.4	19.9	13.0	52.3	141	140	91.80	49	
3.25	0.135	60.94	57.6	18.8	12.3	49.2	143	143	99.45	44	
3.5	0.146	62.13	58.7	17.8	11.6	46.6	146	146	107.10	39	
3.75	0.156	63.26	59.8	16.9	11.0	44.3	149	149	114.75	34	
4	0.167	64.33	60.8	16.1	10.5	42.2	151	151	122.40	29	
4.25	0.177	65.35	61.7	15.4	10.1	40.4	154	154	130.05	24	
4.5	0.188	66.33	62.7	14.7	9.6	38.7	156	156	137.70	18	
4.75	0.198	67.27	63.6	14.2	9.3	37.2	158	158	145.35	13	
5	0.208	68.17	64.4	13.6	8.9	35.8	160	160	153.00	7	
5.25	0.219	69.04	65.2	13.2	8.6	34.5	163	162	160.65	2	
5.5	0.229	69.88	66.0	12.7	8.3	33.4	165	164	168.30	-4	
5.75	0.240	70.7	66.8	12.3	8.0	32.3	166	166	175.95	-10	
6	0.250	71.48	67.5	11.9	7.8	31.3	168	168	183.60	-15	
6.25	0.260	72.24	68.3	11.6	7.6	30	170	170	191.25	-21	
6.5	0.271	72.98	69.0	11.2	7.3	29	172	172	198.90	-27	
6.75	0.281	73.7	69.6	10.9	7.1	29	174	173	206.55	-33	
7	0.292	74.4	70.3	10.6	7.0	28	175	175	214.20	-39	
7.25	0.302	75.08	70.9	10.4	6.8	27	177	177	221.85	-45	
7.5	0.313	75.74	71.6	10.1	6.6	27	178	178	229.50	-51	
7.75	0.323	76.38	72.2	9.9	6.4	26	180	180	237.15	-57	
8	0.333	77.01	72.8	9.6	6.3	25	181	181	244.80	-64	
8.25	0.344	77.63	73.3	9.4	6.2	25	183	183	252.45	-70	
8.5	0.354	78.23	73.9	9.2	6.0	24	184	184	260.10	-76	
8.75	0.365	78.82	74.5	9.0	5.9	24	186	185	267.75	-82	
9	0.375	79.4	75.0	8.8	5.8	23	187	187	275.40	-89	
9.25	0.385	79.96	75.5	8.6	5.7	23	188	188	283.05	-95	
9.5	0.396	80.52	76.1	8.5	5.5	22	190	189	290.70	-101	
9.75	0.406	81.06	76.6	8.3	5.4	22	191	191	298.35	-108	
10	0.417	81.59	77.1	8.2	5.3	21	192	192	306.00	-114	
10.25	0.427	82.11	77.6	8.0	5.2	21	193	193	313.65	-120	
10.5	0.438	82.63	78.1	7.9	5.1	21	195	194	321.30	-127	
10.75	0.448	83.13	78.5	7.7	5.1	20	196	196	328.95	-133	
11	0.458	83.63	79.0	7.6	5.0	20	197	197	336.60	-140	
11.25	0.469	84.11	79.5	7.5	4.9	20	198	198	344.25	-146	
11.5	0.479	84.59	79.9	7.4	4.8	19	199	199	351.90	-153	
11.75	0.490	85.06	80.4	7.2	4.7	19	200	200	359.55	-159	
12	0.500	85.53	80.8	7.1	4.7	19	201	201	367.20	-166	

Modified Rational Method

Length (m)	60	m
Area (ha)	0.121	Ha
Max Height	113.5	mAOD
Min Height	111.5	mAOD
DeltaH	2.0	
Slope (%)	3.33	
Te (mins)	9.22	mins
ARF	0.999	
SAAR	673.000	mm
UCWI	67	mm
PIMP	100.0	%
SOIL	0.21	
Percentage Runoff PR	72.68	
DEEPSTOR	0.40	

Cv	0.72676	
Cr	1.3	
Return Period	100 year	m s
Storage	RT years	Storage
	100	25

Post Development		Return Period	flood	100	years	OUTFALL 2				
		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	30.79	29.1	123.2	39.1	323.5	35	35	9.90	25
0.5	0.021	37.15	35.1	74.3	23.6	195.1	43	42	19.80	23
0.75	0.031	41.41	39.1	55.2	17.5	145.0	47	47	29.70	18
1	0.042	44.7	42.2	44.7	14.2	117.4	51	51	39.60	12
1.25	0.052	47.42	44.8	37.9	12.1	99.6	54	54	49.50	5
1.5	0.063	49.75	47.0	33.2	10.5	87.1	57	57	59.40	-3
1.75	0.073	51.82	49.0	29.6	9.4	77.8	59	59	69.30	-10
2	0.083	53.67	50.7	26.8	8.5	70.5	61	61	79.20	-18
2.25	0.094	55.35	52.3	24.6	7.8	64.6	63	63	89.10	-26
2.5	0.104	56.9	53.8	22.8	7.2	59.8	65	65	99.00	-34
2.75	0.115	58.34	55.1	21.2	6.7	55.7	67	67	108.90	-42
3	0.125	59.68	56.4	19.9	6.3	52.3	68	68	118.80	-51
3.25	0.135	60.94	57.6	18.8	6.0	49.2	70	70	128.70	-59
3.5	0.146	62.13	58.7	17.8	5.6	46.6	71	71	138.60	-68
3.75	0.156	63.26	59.8	16.9	5.4	44.3	72	72	148.50	-76
4	0.167	64.33	60.8	16.1	5.1	42.2	74	74	158.40	-85
4.25	0.177	65.35	61.7	15.4	4.9	40.4	75	75	168.30	-94
4.5	0.188	66.33	62.7	14.7	4.7	38.7	76	76	178.20	-102
4.75	0.198	67.27	63.6	14.2	4.5	37.2	77	77	188.10	-111
5	0.208	68.17	64.4	13.6	4.3	35.8	78	78	198.00	-120
5.25	0.219	69.04	65.2	13.2	4.2	34.5	79	79	207.90	-129
5.5	0.229	69.88	66.0	12.7	4.0	33.4	80	80	217.80	-138
5.75	0.240	70.7	66.8	12.3	3.9	32.3	81	81	227.70	-147
6	0.250	71.48	67.5	11.9	3.8	31.3	82	82	237.60	-156
6.25	0.260	72.24	68.3	11.6	3.7	30	83	83	247.50	-165
6.5	0.271	72.98	69.0	11.2	3.6	29	83	83	257.40	-174
6.75	0.281	73.7	69.6	10.9	3.5	29	84	84	267.30	-183
7	0.292	74.4	70.3	10.6	3.4	28	85	85	277.20	-192
7.25	0.302	75.08	70.9	10.4	3.3	27	86	86	287.10	-201
7.5	0.313	75.74	71.6	10.1	3.2	27	87	87	297.00	-210
7.75	0.323	76.38	72.2	9.9	3.1	26	87	87	306.90	-220
8	0.333	77.01	72.8	9.6	3.1	25	88	88	316.80	-229
8.25	0.344	77.63	73.3	9.4	3.0	25	89	89	326.70	-238
8.5	0.354	78.23	73.9	9.2	2.9	24	90	89	336.60	-247
8.75	0.365	78.82	74.5	9.0	2.9	24	90	90	346.50	-256
9	0.375	79.4	75.0	8.8	2.8	23	91	91	356.40	-266
9.25	0.385	79.96	75.5	8.6	2.7	23	91	91	366.30	-275
9.5	0.396	80.52	76.1	8.5	2.7	22	92	92	376.20	-284
9.75	0.406	81.06	76.6	8.3	2.6	22	93	93	386.10	-293
10	0.417	81.59	77.1	8.2	2.6	21	93	93	396.00	-303
10.25	0.427	82.11	77.6	8.0	2.5	21	94	94	405.90	-312
10.5	0.438	82.63	78.1	7.9	2.5	21	95	94	415.80	-321
10.75	0.448	83.13	78.5	7.7	2.5	20	95	95	425.70	-331
11	0.458	83.63	79.0	7.6	2.4	20	96	96	435.60	-340
11.25	0.469	84.11	79.5	7.5	2.4	20	96	96	445.50	-349
11.5	0.479	84.59	79.9	7.4	2.3	19	97	97	455.40	-359
11.75	0.490	85.06	80.4	7.2	2.3	19	97	97	465.30	-368
12	0.500	85.53	80.8	7.1	2.3	19	98	98	475.20	-377

Modified Rational Method

Length (m)	100	m
Area (ha)	0.249	Ha
Max Height	114.0	mAOD
Min Height	112.0	mAOD
DeltaH	2.0	
Slope (%)	2.00	
Te (mins)	11.35	mins
ARF	0.998	
SAAR	1219.000	mm
UCWI	129	mm
PIMP	100.0	%
SOIL	0.48	
Percentage Runoff PR	84.36	
DEEPSTOR	0.51	

Cv	0.84362	
Cr	1.3	
Allowable outflow		
100 year	0.0085	m/s
		m3
Storage	RT years	Storage
	100+CC	131

Post Development		Return Period	Flood Rainfall	100+30%cc 140 years	OUTFALL 1						
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	30.79	40.027	43.9	123.2	93.5	375.5	84	109	7.65	102
0.5	0.021	37.15	48.295	53.0	74.3	56.4	226.5	102	132	15.30	117
0.75	0.031	41.41	53.833	59.0	55.2	41.9	168.3	113	147	22.95	124
1	0.042	44.7	58.11	63.7	44.7	33.9	136.3	122	159	30.60	128
1.25	0.052	47.42	61.646	67.6	37.9	28.8	115.7	130	168	38.25	130
1.5	0.063	49.75	64.675	70.9	33.2	25.2	101.1	136	177	45.90	131
1.75	0.073	51.82	67.366	73.9	29.6	22.5	90.3	142	184	53.55	130
2	0.083	53.67	69.771	76.5	26.8	20.4	81.8	147	191	61.20	129
2.25	0.094	55.35	71.955	78.9	24.6	18.7	75.0	151	196	68.85	128
2.5	0.104	56.9	73.97	81.1	22.8	17.3	69.4	156	202	76.50	125
2.75	0.115	58.34	75.842	83.2	21.2	16.1	64.7	159	207	84.15	123
3	0.125	59.68	77.584	85.1	19.9	15.1	60.7	163	212	91.80	120
3.25	0.135	60.94	79.222	86.9	18.8	14.2	57.2	167	216	99.45	117
3.5	0.146	62.13	80.769	88.6	17.8	13.5	54.1	170	221	107.10	113
3.75	0.156	63.26	82.238	90.2	16.9	12.8	51.4	173	225	114.75	110
4	0.167	64.33	83.629	91.7	16.1	12.2	49.0	176	228	122.40	106
4.25	0.177	65.35	84.955	93.2	15.4	11.7	46.9	179	232	130.05	102
4.5	0.188	66.33	86.229	94.6	14.7	11.2	44.9	181	235	137.70	98
4.75	0.198	67.27	87.451	95.9	14.2	10.8	43.2	184	239	145.35	93
5	0.208	68.17	88.621	97.2	13.6	10.4	41.6	186	242	153.00	89
5.25	0.219	69.04	89.752	98.4	13.2	10.0	40.1	189	245	160.65	84
5.5	0.229	69.88	90.844	99.6	12.7	9.6	38.7	191	248	168.30	80
5.75	0.240	70.7	91.91	100.8	12.3	9.3	37.5	193	251	175.95	75
6	0.250	71.48	92.924	101.9	11.9	9.0	36.3	195	254	183.60	70
6.25	0.260	72.24	93.912	103.0	11.6	8.8	35.2	197	256	191.25	65
6.5	0.271	72.98	94.874	104.0	11.2	8.5	34.2	199	259	198.90	60
6.75	0.281	73.7	95.81	105.1	10.9	8.3	33.3	201	262	206.55	55
7	0.292	74.4	96.72	106.1	10.6	8.1	32.4	203	264	214.20	50
7.25	0.302	75.08	97.604	107.0	10.4	7.9	31.6	205	267	221.85	45
7.5	0.313	75.74	98.462	108.0	10.1	7.7	30.8	207	269	229.50	39
7.75	0.323	76.38	99.294	108.9	9.9	7.5	30.0	209	271	237.15	34
8	0.333	77.01	100.113	109.8	9.6	7.3	29.3	210	273	244.80	29
8.25	0.344	77.63	100.919	110.7	9.4	7.1	28.7	212	276	252.45	23
8.5	0.354	78.23	101.699	111.5	9.2	7.0	28.1	214	278	260.10	18
8.75	0.365	78.82	102.466	112.4	9.0	6.8	27.5	215	280	267.75	12
9	0.375	79.4	103.22	113.2	8.8	6.7	26.9	217	282	275.40	6
9.25	0.385	79.96	103.948	114.0	8.6	6.6	26.4	219	284	283.05	1
9.5	0.396	80.52	104.676	114.8	8.5	6.4	25.8	220	286	290.70	-5
9.75	0.406	81.06	105.378	115.6	8.3	6.3	25.3	222	288	298.35	-11
10	0.417	81.59	106.067	116.3	8.2	6.2	24.9	223	290	306.00	-16
10.25	0.427	82.11	106.743	117.1	8.0	6.1	24.4	224	291	313.65	-22
10.5	0.438	82.63	107.419	117.8	7.9	6.0	24.0	226	293	321.30	-28
10.75	0.448	83.13	108.069	118.5	7.7	5.9	23.6	227	295	328.95	-34
11	0.458	83.63	108.719	119.2	7.6	5.8	23.2	229	297	336.60	-40
11.25	0.469	84.11	109.343	119.9	7.5	5.7	22.8	230	299	344.25	-46
11.5	0.479	84.59	109.967	120.6	7.4	5.6	22.4	231	300	351.90	-52
11.75	0.490	85.06	110.578	121.3	7.2	5.5	22.1	232	302	359.55	-58
12	0.500	85.53	111.189	121.9	7.1	5.4	21.7	234	304	367.20	-64

Modified Rational Method

Length (m)	60	m
Area (ha)	0.121	Ha
Max Height	113.5	mAOD
Min Height	111.5	mAOD
DeltaH	2.0	
Slope (%)	3.33	
Te (mins)	9.22	mins
ARF	0.999	
SAAR	673.000	mm
UCWI	67	mm
PIMP	100.0	%
SOIL	0.21	
Percentage Runoff PR	72.68	
DEEPSTOR	0.40	

Cv	0.72676	
Cr	1.3	
allowable outflow		
100 year	0.011	m/s
Storage	RT years	Storage
	100+CC	36

Post Development		Return Period	flood	100+30%cc	years	OUTFALL 2					
			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	30.79	40.027	37.8	123.2	39.1	323.5	35	46	9.90	36
0.5	0.021	37.15	48.295	45.6	74.3	23.6	195.1	43	55	19.80	35
0.75	0.031	41.41	53.833	50.9	55.2	17.5	145.0	47	62	29.70	32
1	0.042	44.7	58.11	54.9	44.7	14.2	117.4	51	66	39.60	27
1.25	0.052	47.42	61.646	58.2	37.9	12.1	99.6	54	70	49.50	21
1.5	0.063	49.75	64.675	61.1	33.2	10.5	87.1	57	74	59.40	15
1.75	0.073	51.82	67.366	63.6	29.6	9.4	77.8	59	77	69.30	8
2	0.083	53.67	69.771	65.9	26.8	8.5	70.5	61	80	79.20	1
2.25	0.094	55.35	71.955	68.0	24.6	7.8	64.6	63	82	89.10	-7
2.5	0.104	56.9	73.97	69.9	22.8	7.2	59.8	65	85	99.00	-14
2.75	0.115	58.34	75.842	71.7	21.2	6.7	55.7	67	87	108.90	-22
3	0.125	59.68	77.584	73.3	19.9	6.3	52.3	68	89	118.80	-30
3.25	0.135	60.94	79.222	74.8	18.8	6.0	49.2	70	91	128.70	-38
3.5	0.146	62.13	80.769	76.3	17.8	5.6	46.6	71	92	138.60	-46
3.75	0.156	63.26	82.238	77.7	16.9	5.4	44.3	72	94	148.50	-54
4	0.167	64.33	83.629	79.0	16.1	5.1	42.2	74	96	158.40	-63
4.25	0.177	65.35	84.955	80.3	15.4	4.9	40.4	75	97	168.30	-71
4.5	0.188	66.33	86.229	81.5	14.7	4.7	38.7	76	99	178.20	-80
4.75	0.198	67.27	87.451	82.6	14.2	4.5	37.2	77	100	188.10	-88
5	0.208	68.17	88.621	83.7	13.6	4.3	35.8	78	101	198.00	-97
5.25	0.219	69.04	89.752	84.8	13.2	4.2	34.5	79	103	207.90	-105
5.5	0.229	69.88	90.844	85.8	12.7	4.0	33.4	80	104	217.80	-114
5.75	0.240	70.7	91.91	86.8	12.3	3.9	32.3	81	105	227.70	-123
6	0.250	71.48	92.924	87.8	11.9	3.8	31.3	82	106	237.60	-131
6.25	0.260	72.24	93.912	88.7	11.6	3.7	30.4	83	107	247.50	-140
6.5	0.271	72.96	94.874	89.6	11.2	3.6	29.5	83	108	257.40	-149
6.75	0.281	73.7	95.81	90.5	10.9	3.5	28.7	84	110	267.30	-158
7	0.292	74.4	96.72	91.4	10.6	3.4	27.9	85	111	277.20	-167
7.25	0.302	75.08	97.604	92.2	10.4	3.3	27.2	86	112	287.10	-176
7.5	0.313	75.74	98.462	93.0	10.1	3.2	26.5	87	113	297.00	-184
7.75	0.323	76.38	99.294	93.8	9.9	3.1	25.9	87	114	306.90	-193
8	0.333	77.01	100.113	94.6	9.6	3.1	25.3	88	114	316.80	-202
8.25	0.344	77.63	100.919	95.3	9.4	3.0	24.7	89	115	326.70	-211
8.5	0.354	78.23	101.699	96.1	9.2	2.9	24.2	90	116	336.60	-220
8.75	0.365	78.82	102.466	96.8	9.0	2.9	23.7	90	117	346.50	-229
9	0.375	79.4	103.22	97.5	8.8	2.8	23.2	91	118	356.40	-238
9.25	0.385	79.96	103.948	98.2	8.6	2.7	22.7	91	119	366.30	-247
9.5	0.396	80.52	104.676	98.9	8.5	2.7	22.3	92	120	376.20	-257
9.75	0.406	81.06	105.378	99.6	8.3	2.6	21.8	93	120	386.10	-266
10	0.417	81.59	106.067	100.2	8.2	2.6	21.4	93	121	396.00	-275
10.25	0.427	82.11	106.743	100.8	8.0	2.5	21.0	94	122	405.90	-284
10.5	0.438	82.63	107.419	101.5	7.9	2.5	20.7	95	123	415.80	-293
10.75	0.448	83.13	108.089	102.1	7.7	2.5	20.3	95	124	425.70	-302
11	0.458	83.63	108.719	102.7	7.6	2.4	20.0	96	124	435.60	-311
11.25	0.469	84.11	109.343	103.3	7.5	2.4	19.6	96	125	445.50	-320
11.5	0.479	84.59	109.967	103.9	7.4	2.3	19.3	97	126	455.40	-330
11.75	0.490	85.06	110.578	104.5	7.2	2.3	19.0	97	126	465.30	-339
12	0.500	85.53	111.189	105.1	7.1	2.3	18.7	98	127	475.20	-348

APPENDIX F

SUDS SUITABILITY MATRIX

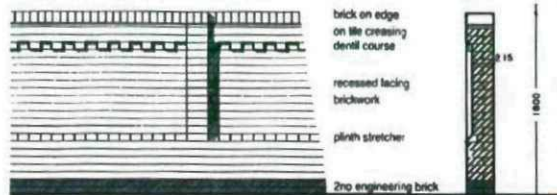
SUDS SUITABILITY MATRIX ADAPTED FROM CIRIA REPORT C697 'THE MANUAL FOR SUDS'

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)	Suitability for Flow Rate Control (probability)	0.01 (100 yr)
Retention	Retention Pond	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	M	H*	M	H	H	M	M	M	H	L	H	H	H	
	Sub-surface Storage	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	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	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	H	H*	H	H	H	M	H	M	H	L	H	M	L	
	Extended Detention Wetland	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	H	H*	H	H	H	M	H	M	H	L	H	M	L	
	Pond/ Wetland	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	H	H*	H	H	H	M	H	M	H	L	H	M	L	
	Pocket Wetland	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	H	M*	H	H	H	M	H	M	H	L	H	M	L	
	Submerged Gravel Wetland	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	M	L	H	M	H	M	H	M	H	L	H	M	L	
	Wetland Channel	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	H	H*	H	H	H	M	H	M	H	L	H	M	L	
Infiltration	Infiltration Trench	Y	Y	Y	Y	N	N	Y	Y	N	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	L	M*	L	L	H	H	H	M	H	H	H	H	L	
	Infiltration Basin	Y	Y	Y	Y	N	N	Y	Y	N	Y	Y	N	Y	Y	Y	Y	Y	N	N	Y	M	H*	L	M	H	H	H	M	H	H	H	H	L	
	Soakaway	Y	Y	Y	Y	N	N	Y	Y	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	Y	Y	N	Y	Y	Y	Y	N	Y	Y	N	N	N	Y	N	Y	Y	M	L	H	M	H	H	H	M	H	L	H	M	L	
	Sub-surface Sand Filter	N	Y	Y	Y	Y	N	Y	Y	Y	Y	N	N	Y	Y	N	N	Y	Y	Y	Y	M	L	H	L	H	H	H	M	H	L	H	M	L	
	Perimeter Sand Filter	N	N	Y	Y	Y	N	Y	Y	Y	Y	N	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	Y	Y	N	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	Y	N	Y	H	H	M	H	H	H	M	H	L	H	M	L		
	Filter Trench	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	N	N	Y	Y	N	Y	Y	Y	Y	Y	M	M	M	L	H	H	H	M	H	L	H	H	L	
Detention	Detention Basin	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	N	Y	N	Y	Y	L	H*	L	M	M	M	M	L	L	L	H	H	H	
Open Channels	Conveyance Swale	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	N	Y	Y	L	M*	L	M	H	M	M	M	H	M	H	H	H	
	Enhanced Dry Swale	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	N	Y	Y	L	M*	M	M	H	H	M	M	H	M	H	H	H	
	Enhanced Wet Swale	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	N	N	Y	Y	M	M*	M	H	H	M	M	H	H	L	H	H	H	
Source Control	Green Roof	Y	Y	N	Y	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	N	N	Y	Y	Y	Y	Y	N	Y	Y	Y	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	Y	N	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	M	M	M	L	H	H	H	H	H	H	H	L		
Y: Yes N: No										Y: Yes N: No										H: High M: Medium L: Low				* Limited Data Available n/a: not applicable H: High Potential M: Medium Potential L: Low Potential											
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 requires address at design stage															
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 both lines are diverted around SUDS component																									

APPENDIX G

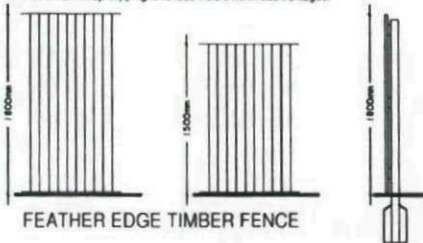
PROPOSED DRAINAGE STRATEGY

Boundary Details



SCREEN WALL

100x25x12.5mm boards lapped on 100x35mm s/w rails on 75x75mm s/w posts at 1800mm centres (all timbers to be tanalised in Dark Brown)
F4 75x22mm top capping to fences visible from road frontages.



DEVELOPMENT AREA
DIRECTED TO 225 & COMBINED
SEWER = 0.219 HA.

Accommodation

Type	Name	Description	Area	Total
BA	Bamburgh	3 bed	900ft ²	3no
LY	Lydford	4 bed	1220	1no
TI	Tiverton	4 bed	1206	2no
CA	Canterbury	4 bed	1377	5no
SA	Salcombe	4 bed	1530	5no
PR	Portchester	4 / 5 bed	1579	3no
TOTAL				19no

SITE BOUNDARY
AREA: 0.71 HA.

DEVELOPMENT AREA
DIRECTED TO 225 &
PUBLIC SURFACE WATER
SEWER = 0.121 HA.

Key

- EXISTING TREES TO BE RETAINED
- GRASS
- FEATHER EDGE TIMBER FENCE (1800high)
- FEATHER EDGE TIMBER FENCE (1500high)
- SCREEN WALL (1800high)

REFER TO POPPLEWELL ASSOCIATES DRG
FOR PRECISE LANDSCAPING DETAILS

DRAWING REF 10225/SC/C/03 Rev A.
CONTRIBUTING AREAS: PROPOSED DEVELOPMENT.
(SCALE AS SHOWN)



REV	DATE	AMENDMENT
C	17/01/11	WALLS TO PL. 3, 15, 19 ADJUSTED. PL. 16-18 GARAGES ENLARGED. WINDOW MOTIFS ADDED
B	01/02/11	AMENDED TO ADDRESS LPA COMMENTS BY LETTER DATED 26/01/10
A	20/01/11	PL. 3 & 18 SWAPPED

01845 524758
01845 524278
diparchitects@btconnect.com
www.diparchitects.co.uk
CHARTERED ARCHITECTS
Mildred Chambers, 77 Market Place,
Thirsk, North Yorkshire YO7 1EY

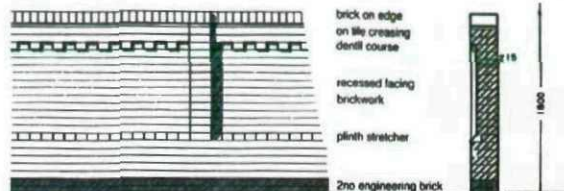


PROJECT:
DEVELOPMENT AT WARD GREEN, WORSBOROUGH
DRAWING TITLE:
PROPOSED SITE LAYOUT PLAN

SCALE:		DATE:	
1 : 500 @ A3		DECEMBER 2010	
DRAWN:	CHECKED:	DWG NO.	REV.
JW	-	3481/10	C

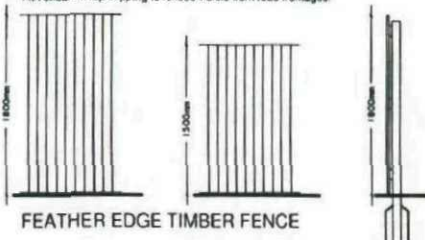
ALL DIMENSIONS TO BE CHECKED ON SITE. DISCREPANCIES, AMBIGUITIES AND/OR OMISSIONS BETWEEN THIS DRAWING AND INFORMATION GIVEN ELSEWHERE MUST BE REPORTED TO THIS OFFICE AND CLARIFICATION SOUGHT BEFORE PROCEEDING

Boundary Details



SCREEN WALL

100x25to12.5mm boards lapped on 100x35mm s/r rails on 75x75mm s/r posts at 1800mm centres (all timbers to be tanalised in Dark Brown)
Fit 75x22mm top capping to fences visible from road frontages.



KEY

- EX PUBLIC COMBINED SEWER.
- EX MANHOLE CHAMBER
- PROPOSED SW SEWER
- PROPOSED FAUL SEWER
- PROPOSED SW MANHOLE EX MH 4
CL 113.000
IL 111.000 (TBC)
- PROPOSED FAUL /
COMBINED SEWER
MANHOLE
- ** EX SEWER TO BE ABANDONED

EXISTING CONNECTION TO
SURFACE WATER SEWER TO
BE RE-UTILISED.
FLOW CONTROL CHAMBER RESTRICTS
SW FLOW TO A MAX OF 11.5L/S FOR
STORMS UP TO THE 1 IN 30 YR + 30%
CLIMATE CHANGE EVENT.



EX MH 1
CL 117.500
IL 118.200 (TBC)

SEWER BASEMENT 3M EITHER
SIDE OF EXISTING SEWER.

Accommodation

Type	Name	Description	Area	Total
BA	Bamburgh	3 bed	900ft ²	3no
LY	Lydford	4 bed	1220	1no
TI	Tiverton	4 bed	1206	2no
CA	Canterbury	4 bed	1377	5no
SA	Salcombe	4 bed	1530	5no
PR	Portchester	4 / 5 bed	1579	3no
TOTAL				19no

1. MH'S 5G & 5BA ARE FLOW
CONTROL MANHOLES.
2. COVER + INVERT LEVELS TO
BE CONFIRMED DURING THE
DETAILED DESIGN PHASE OF
THE PROJECT.

MH 5G (FLOW CONTROL)
FLOW RESTRICTED TO
8.5L/S FOR STORMS UP TO
1 IN 30 YR + 30% CLIMATE
CHANGE EVENT.

EX MH 2
CL 112.000
IL 110.910 (TBC)

EX MH 3
CL 110.960
IL 108.175 (TBC)

Key

- EXISTING TREES TO BE RETAINED
- FEATHER EDGE TIMBER FENCE (1800high)
- FEATHER EDGE TIMBER FENCE (1500high)
- SCREEN WALL (1800high)

EXISTING CONNECTION TO FAUL
SEWER TO BE RE-UTILISED.

REFER TO POPPLEWELL ASSOCIATES DRG
FOR PRECISE LANDSCAPING DETAILS

REV	DATE	AMENDMENT
C	13/02/11	WALLS TO PL. 1.15.14 ADJUSTED. PL. 16.18 GARDENS FOR RELEASED WINDOW NOTES ABOVE
B	04/02/11	AMENDED TO ADDRESS LPA COMMENTS IN LATER DATED SKETCH
A	20/01/11	PL. 3 & 18 SWAPPED

01845 524758
01845 524278
diparchitects@btconnect.com
www.diparchitects.co.uk

CHARTERED ARCHITECTS
Midland Chambers, 77 Mark Lane,
Thirsk, North Yorkshire YO1 1BY

downes
illingsworth
partnership ltd

HARRON HOMES

PROJECT
DEVELOPMENT AT WARD GREEN, WORSBOROUGH

DRAWING TITLE
PROPOSED SITE LAYOUT PLAN

SCALE:		DATE:	
1 : 500 @ A3		DECEMBER 2010	
DRAWN:	CHECKED:	DWG NO.	REV.
JW	-	3481/10	C

DRAWING REF 102516/C/C/CL PRELIMINARY DRAINAGE STRATEGY. (SCALE AS SHOWN)

ALL DIMENSIONS TO BE CHECKED ON SITE. DISCREPANCIES, AMBIGUITIES AND/OR OMISSIONS BETWEEN THIS DRAWING AND INFORMATION GIVEN ELSEWHERE MUST BE REPORTED TO THIS OFFICE AND CLARIFICATION SOUGHT BEFORE PROCEEDING.

Paul Waite Associates		Page 1
Summit House	PLOTS 9-18 TO	
Riparian Way	OUTFALL 1	
Keighley BD20 7BW	(DIVERTED 225 COMB)	
Date 23 DECEMBER 2010	Designed By DM	
File OUTFALL 1 STORAGE.SRC	Checked By	
Infrasoft	Source Control W.11.4	

Summary of Results for 30 year Return Period (+30%)

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	110.8392	0.4392	35.9	O K
30 Summer	7.9	7.9	110.9212	0.5212	44.2	O K
60 Summer	8.1	8.1	110.9638	0.5637	48.4	O K
120 Summer	8.1	8.1	110.9642	0.5642	48.5	O K
180 Summer	8.0	8.0	110.9408	0.5407	46.1	O K
240 Summer	7.9	7.9	110.9112	0.5112	43.1	O K
360 Summer	7.8	7.8	110.8503	0.4502	37.0	O K
480 Summer	7.8	7.8	110.7933	0.3932	31.3	O K
600 Summer	7.8	7.8	110.7412	0.3412	26.1	O K
720 Summer	7.7	7.7	110.6982	0.2982	21.7	O K
960 Summer	7.5	7.5	110.6353	0.2352	15.4	O K
1440 Summer	6.5	6.5	110.5742	0.1742	9.3	O K
2160 Summer	5.2	5.2	110.5308	0.1308	5.2	O K
2880 Summer	4.3	4.3	110.5033	0.1033	3.3	O K
4320 Summer	3.2	3.2	110.4762	0.0763	1.8	O K
5760 Summer	2.6	2.6	110.4613	0.0613	1.2	O K
7200 Summer	2.2	2.2	110.4518	0.0517	0.8	O K
8640 Summer	1.9	1.9	110.4447	0.0447	0.6	O K
10080 Summer	1.7	1.7	110.4398	0.0397	0.5	O K
15 Winter	7.8	7.8	110.8882	0.4882	40.9	O K
30 Winter	8.2	8.2	110.9857	0.5857	50.7	O K
60 Winter	8.5	8.5	111.0468	0.6468	56.1	O K
120 Winter	8.4	8.4	111.0408	0.6408	55.7	O K
180 Winter	8.2	8.2	110.9987	0.5988	52.0	O K

Storm Duration (mins)	Rain (mm/hr)	Time-Peak (mins)
15 Summer	90.09	17
30 Summer	59.78	31
60 Summer	38.01	52
120 Summer	23.47	86
180 Summer	17.50	120
240 Summer	14.15	156
360 Summer	10.45	222
480 Summer	8.43	286
600 Summer	7.13	346
720 Summer	6.21	404
960 Summer	5.00	520
1440 Summer	3.67	750
2160 Summer	2.70	1104
2880 Summer	2.16	1468
4320 Summer	1.58	2196
5760 Summer	1.27	2888
7200 Summer	1.07	3616
8640 Summer	0.93	4296
10080 Summer	0.82	5032
15 Winter	90.09	17
30 Winter	59.78	31
60 Winter	38.01	58
120 Winter	23.47	92
180 Winter	17.50	130

Paul Waite Associates		Page 2
Summit House Riparian Way Keighley BD20 7BW	PLOTS 9-18 TO OUTFALL 1 (DIVERTED 225 COMB)	
Date 23 DECEMBER 2010	Designed By DM	
File OUTFALL 1 STORAGE.SRC	Checked By	
Infrasoft	Source Control W.11.4	

Summary of Results for 30 year Return Period (+30%)

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	8.0	8.0	110.9522	0.5522	47.3	O K
360 Winter	7.8	7.8	110.8567	0.4567	37.7	O K
480 Winter	7.8	7.8	110.7682	0.3682	28.8	O K
600 Winter	7.7	7.7	110.6947	0.2947	21.4	O K
720 Winter	7.5	7.5	110.6407	0.2407	16.0	O K
960 Winter	6.8	6.8	110.5833	0.1832	10.2	O K
1440 Winter	5.3	5.3	110.5328	0.1328	5.4	O K
2160 Winter	3.9	3.9	110.4933	0.0933	2.7	O K
2880 Winter	3.2	3.2	110.4753	0.0753	1.8	O K
4320 Winter	2.3	2.3	110.4553	0.0552	1.0	O K
5760 Winter	1.9	1.9	110.4443	0.0442	0.6	O K
7200 Winter	1.6	1.6	110.4372	0.0372	0.5	O K
8640 Winter	1.4	1.4	110.4323	0.0322	0.3	O K
10080 Winter	1.2	1.2	110.4287	0.0287	0.3	O K

Storm Duration (mins)	Rain (mm/hr)	Time-Peak (mins)
240 Winter	14.15	168
360 Winter	10.45	238
480 Winter	8.43	302
600 Winter	7.13	360
720 Winter	6.21	414
960 Winter	5.00	520
1440 Winter	3.67	752
2160 Winter	2.70	1100
2880 Winter	2.16	1468
4320 Winter	1.58	2200
5760 Winter	1.27	2928
7200 Winter	1.07	3648
8640 Winter	0.93	4288
10080 Winter	0.82	5064

Paul Waite Associates		Page 3
Summit House Riparian Way Keighley BD20 7BW	PLOTS 9-18 TO OUTFALL 1 (DIVERTED 225 COMB)	
Date 23 DECEMBER 2010	Designed By DM	
File OUTFALL 1 STORAGE.SRC	Checked By	
Infrasoft	Source Control W.11.4	

Rainfall Details

Region	ENG+WAL	Shortest Storm (mins)	15
Return Period (years)	30	Longest Storm (mins)	10080
M5-60 (mm)	19.000	Summer Storms	Yes
Ratio-R	0.357	Winter Storms	Yes
Cv (Summer)	0.750	Climate Change %	+30
Cv (Winter)	0.840		

Time / Area Diagram

Total Area (ha) = 0.249

Time	(mins)	Area
from:	to:	(ha)
0	4	0.249

Summit House
Riparian Way
Keighley BD20 7BW

PLOTS 9-18 TO
OUTFALL 1
(DIVERTED 225 COMB)

Date 23 DECEMBER 2010
File OUTFALL 1 STORAGE.SRC

Designed By DM
Checked By

Infrasoft

Source Control W.11.4



Box Culvert Details

Height (m) 0.600 Width (m) 1.200 Invert Level (m) 110.400
Length (m) 83.000 Slope (1:x) 500.0 Cover Level (m) 111.200

Hydro-Brake Outflow Control

Design Head (m) 0.650 Diameter (mm) 131
Design Flow (l/s) 8.5 Invert Level (m) 110.400
Hydro-Brake Type MD5

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	4.2	0.80	9.3	2.00	14.6	4.00	20.6	7.00	27.2
0.20	7.3	1.00	10.3	2.20	15.3	4.50	21.8	7.50	28.2
0.30	7.8	1.20	11.3	2.40	16.0	5.00	23.0	8.00	29.1
0.40	7.7	1.40	12.2	2.60	16.6	5.50	24.1	8.50	30.0
0.50	7.8	1.60	13.0	3.00	17.8	6.00	25.2	9.00	30.9
0.60	8.2	1.80	13.8	3.50	19.3	6.50	26.2	9.50	31.7

Paul Waite Associates		Page 1
Summit House Riparian Way Keighley BD20 7BW	PLOTS 1-8 TO OUTFALL 2 (EX 225 SW SEWER)	Micro Drainage.
Date 23 DECEMBER 2010	Designed By DM	
File	Checked By	
Infrasoft	Source Control W.11.4	

Summary of Results for 30 year Return Period (+30%)

Half Drain Time : 21 minutes

Storm Duration (mins)	Maximum Control (l/s)	Maximum Filtration (l/s)	Maximum Outflow (l/s)	Maximum Water Level (m OD)	Maximum Depth (m)	Maximum Volume (m ³)	Status
15 Summer	9.6	0.0	9.6	109.3942	0.3942	15.5	O K
30 Summer	10.3	0.0	10.3	109.4537	0.4537	17.8	O K
60 Summer	10.5	0.0	10.5	109.4687	0.4687	18.4	O K
120 Summer	10.0	0.0	10.0	109.4232	0.4232	16.6	O K
180 Summer	9.2	0.0	9.2	109.3697	0.3697	14.5	O K
240 Summer	8.6	0.0	8.6	109.3242	0.3242	12.7	O K
360 Summer	7.5	0.0	7.5	109.2568	0.2567	10.1	O K
480 Summer	6.6	0.0	6.6	109.2117	0.2117	8.3	O K
600 Summer	6.0	0.0	6.0	109.1803	0.1802	7.1	O K
720 Summer	5.5	0.0	5.5	109.1578	0.1578	6.2	O K
960 Summer	4.7	0.0	4.7	109.1288	0.1288	5.0	O K
1440 Summer	3.6	0.0	3.6	109.1048	0.1048	4.1	O K
2160 Summer	2.7	0.0	2.7	109.0868	0.0868	3.4	O K
2880 Summer	2.1	0.0	2.1	109.0758	0.0757	3.0	O K
4320 Summer	1.6	0.0	1.6	109.0618	0.0617	2.4	O K
5760 Summer	1.3	0.0	1.3	109.0533	0.0532	2.1	O K
7200 Summer	1.1	0.0	1.1	109.0488	0.0487	1.9	O K
8640 Summer	0.9	0.0	0.9	109.0458	0.0457	1.8	O K
10080 Summer	0.8	0.0	0.8	109.0437	0.0437	1.7	O K
15 Winter	10.2	0.0	10.2	109.4457	0.4457	17.5	O K
30 Winter	11.0	0.0	11.0	109.5067	0.5067	19.9	O K
60 Winter	11.0	0.0	11.0	109.5062	0.5062	19.9	O K
120 Winter	10.0	0.0	10.0	109.4267	0.4267	16.7	O K

Storm Duration (mins)	Rain (mm/hr)	Time-Peak (mins)
15 Summer	90.09	15
30 Summer	59.78	23
60 Summer	38.01	40
120 Summer	23.47	74
180 Summer	17.50	106
240 Summer	14.15	136
360 Summer	10.45	198
480 Summer	8.43	256
600 Summer	7.13	316
720 Summer	6.21	376
960 Summer	5.00	492
1440 Summer	3.67	736
2160 Summer	2.70	1100
2880 Summer	2.16	1468
4320 Summer	1.58	2200
5760 Summer	1.27	2896
7200 Summer	1.07	3584
8640 Summer	0.93	4344
10080 Summer	0.82	5120
15 Winter	90.09	15
30 Winter	59.78	25
60 Winter	38.01	44
120 Winter	23.47	78

Paul Waite Associates		Page 2
Summit House	PLOTS 1-8 TO	
Riparian Way	OUTFALL 2	
Keighley BD20 7BW	(EX 225 SW SEWER)	
Date 23 DECEMBER 2010	Designed By DM	
File	Checked By	
Infrasoft	Source Control W.11.4	

Summary of Results for 30 year Return Period (+30%)

Storm Duration (mins)	Maximum Control (l/s)	Maximum Filtration (l/s)	Maximum Outflow (l/s)	Maximum Water Level (m OD)	Maximum Depth (m)	Maximum Volume (m³)	Status
180 Winter	8.9	0.0	8.9	109.3503	0.3502	13.7	O K
240 Winter	8.0	0.0	8.0	109.2902	0.2902	11.4	O K
360 Winter	6.6	0.0	6.6	109.2117	0.2117	8.3	O K
480 Winter	5.6	0.0	5.6	109.1653	0.1652	6.5	O K
600 Winter	4.9	0.0	4.9	109.1363	0.1363	5.3	O K
720 Winter	4.4	0.0	4.4	109.1208	0.1208	4.7	O K
960 Winter	3.5	0.0	3.5	109.1042	0.1043	4.1	O K
1440 Winter	2.6	0.0	2.6	109.0858	0.0858	3.4	O K
2160 Winter	1.9	0.0	1.9	109.0717	0.0718	2.8	O K
2880 Winter	1.5	0.0	1.5	109.0612	0.0612	2.4	O K
4320 Winter	1.1	0.0	1.1	109.0502	0.0502	2.0	O K
5760 Winter	0.9	0.0	0.9	109.0452	0.0452	1.8	O K
7200 Winter	0.8	0.0	0.8	109.0423	0.0422	1.7	O K
8640 Winter	0.7	0.0	0.7	109.0397	0.0397	1.6	O K
10080 Winter	0.6	0.0	0.6	109.0372	0.0372	1.5	O K

Storm Duration (mins)	Rain (mm/hr)	Time-Peak (mins)
180 Winter	17.50	110
240 Winter	14.15	142
360 Winter	10.45	202
480 Winter	8.43	260
600 Winter	7.13	318
720 Winter	6.21	374
960 Winter	5.00	492
1440 Winter	3.67	736
2160 Winter	2.70	1092
2880 Winter	2.16	1468
4320 Winter	1.58	2168
5760 Winter	1.27	2936
7200 Winter	1.07	3576
8640 Winter	0.93	4392
10080 Winter	0.82	5136

Summit House

Riparian Way

Keighley BD20 7BW

Date 23 DECEMBER 2010

File

PLOTS 1-8 TO

OUTFALL 2

(EX 225 SW SEWER)

Designed By DM

Checked By



Infrasoft

Source Control W.11.4

Rainfall Details

Region	ENG+WAL	Shortest Storm (mins)	15
Return Period (years)	30	Longest Storm (mins)	10080
M5-60 (mm)	19.000	Summer Storms	Yes
Ratio-R	0.357	Winter Storms	Yes
Cv (Summer)	0.750	Climate Change %	+30
Cv (Winter)	0.840		

Time / Area Diagram

Total Area (ha) = 0.121

Time	(mins)	Area
from:	to:	(ha)
0	4	0.121

Paul Waite Associates		Page 4
Summit House	PLOTS 1-8 TO	
Riparian Way	OUTFALL 2	
Keighley BD20 7BW	(EX 225 SW SEWER)	
Date 23 DECEMBER 2010	Designed By DM	
File	Checked By	
Infrasoft	Source Control W.11.4	

Cellular Storage Details

Infil Coef - Base (m/hr) 0.000000 Porosity 0.95
 Infil Coef - Sides (m/hr) 0.000000 Invert Level (m) 109.000
 Safety Factor 2.0 Ground Level (m) 111.000

Depth (m)	Area (m ²)	Infil. Area (m ²)	Depth (m)	Area (m ²)	Infil. Area (m ²)	Depth (m)	Area (m ²)	Infil. Area (m ²)
0.00	41.3	41.3	0.90	0.0	55.4	1.80	0.0	55.4
0.10	41.3	43.9	1.00	0.0	55.4	1.90	0.0	55.4
0.20	41.3	46.4	1.10	0.0	55.4	2.00	0.0	55.4
0.30	41.3	49.0	1.20	0.0	55.4	2.10	0.0	55.4
0.40	41.3	51.6	1.30	0.0	55.4	2.20	0.0	55.4
0.50	41.3	54.2	1.40	0.0	55.4	2.30	0.0	55.4
0.60	0.0	55.4	1.50	0.0	55.4	2.40	0.0	55.4
0.70	0.0	55.4	1.60	0.0	55.4	2.50	0.0	55.4
0.80	0.0	55.4	1.70	0.0	55.4			

Orifice Outflow Control

Diameter (m) 0.088 Invert Level (m) 109.000
 Discharge Coefficient 0.600