4.0 Flooding Mechanisms

Table 3: Sources of Flooding

Source/Pathway	Significant?	Comment/Reason
Fluvial	Yes	River Don; Scout Dike
Tidal/Coastal	No	
Canal	No	
Pluvial (urban drainage)	Yes	Surface Water Runoff
Groundwater	No	
Overland flow	Yes	Due to topography of the area – there is potential for flooding via this mechanism
Blockage	Yes	Existing road bridges
Infrastructure failure	Yes	Existing road bridges; reservoirs
Rainfall Ponding	Yes	Low points within development areas

4.1 Fluvial: River Don

4.1.1 General

The River Don rises in the Pennines and flows for 70 miles generally in an easterly direction, through the Don Valley, via Penistone, Sheffield, Rotherham, Mexborough, Conisbrough, Doncaster and Stainforth.

It originally joined the River Trent, but was re-engineered by Vermuyden in the 1620's, and now joins the River Ouse at Goole in the East Riding of Yorkshire.

The upper reaches of the River Don, and those of several of its tributaries, are defined by dams built to provide a public water supply. The middle section of the river contains many weirs, which were built to supply mills, foundries and cutlers' wheels with water power, while the lower section of the watercourse contains weirs and locks, designed to maintain water levels for navigation.

The River Don's major tributaries are the Loxley, the Rivelin, the Sheaf, the Rother and the Dearne.

The river channel near to the proposed developments at Nether Mill Farm in Penistone is predominantly open channel, with road crossings located at Penistone Bridge, upstream of the site and at Water Hall Bridge, immediately downstream from Development Area B.

Furthermore there are no formal flood defences along the river banks within the immediate vicinity of the proposed development.

As such the impact of flooding caused by overtopping of the natural river banks and through blockage/infrastructure failure at Water Hall bridge needs to be investigated in further detail within this report.

Figure 6: River Don Viewed Downstream at Water Hall Bridge



Image courtesy of JBA Modelling Data

4.1.2 Environment Agency Flood Level Data

The Environment Agency has provided modelled flood levels for a range of probabilities at a number of locations along the River Don.

In order to assess the impact of flooding within the River Don on the development areas within Nether Mill Farm, 3No modelled nodes have been selected due to their proximity in in relation to the site.

Table 4: Modelled Flood Levels (River Don)

Return Period	Water Level Node Ref 27870 (mAOD)	Water Level Node Ref 27718 (mAOD)	Water Level Node Ref 27678 (mAOD)
1 in 5 years	193.582	193.046	192.912
1 in 10 years	193.709	193.223	193.067
1 in 25 years	193.856	193.440	193.292
1 in 50 years	193.959	193.576	193.442
1 in 75 years	194.019	193.635	193.492
1 in 100 years	194.054	193.666	193.511
1 in 200 years	194.152	193.743	193.538
1 in 1000 years	194.457	194.112	193.952

4.1.3 Overtopping: 1 in 100 year Flood Event

Area A

Surveyed ground levels within this development area range from 193.10mAOD to 197.61mAOD.

It is noted that due to the elevation of Barnsley Road, direct inundation within Development Areas A1 and A2 during a 1 in 100 year flood event within the River Don is considered unlikely. As such there is a low probability of flooding within these development areas.

This is also true with regard to Development Area A3. However, a conveyance route beneath Barnsley Road is provided by Scout Dike, and as such it is considered that flood water from the River Don will be able to 'back up' the channel of the tributary, overtopping the river bank upstream of Barnsley Road, causing inundation within this area.

The 1 in 100 year flood level within this part of the site is estimated to be 193.758mAOD; which compares well to the flood level observed within this part of the site during the flood event of July 2012.

The ground floor level of the existing farm buildings likely to be affected i.e. the tractor shed and barn are 193.26mAOD and 193.6 – 194.000mAOD respectively, and as such it is considered that flood water will be able to ingress into the buildings.

Area B

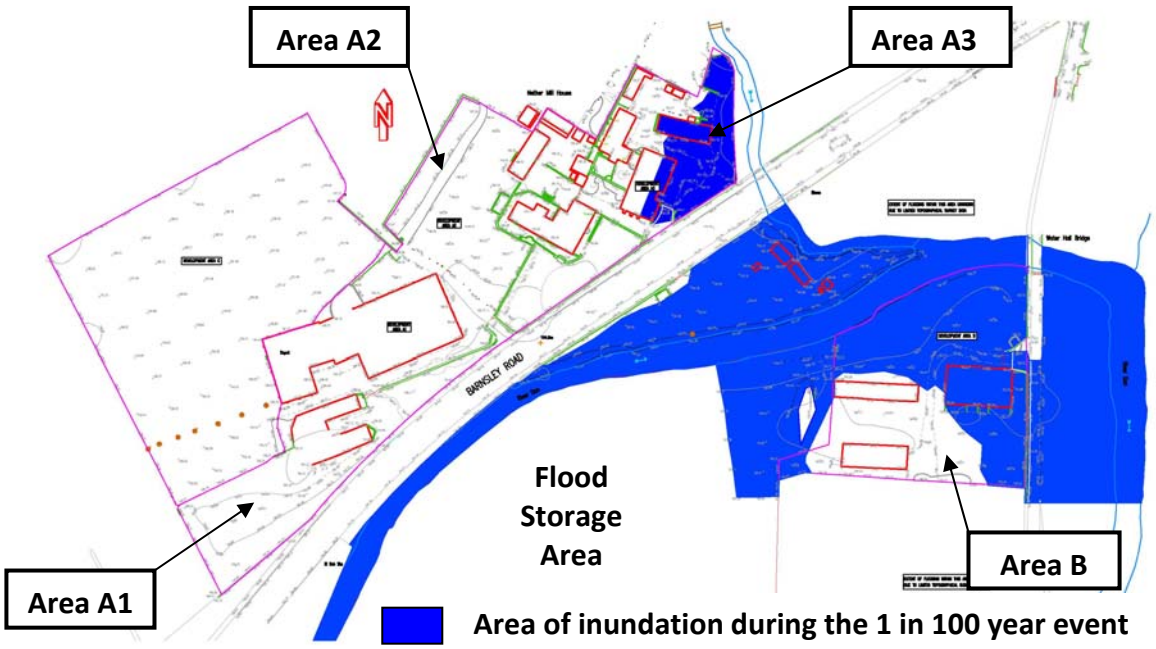
Through interpolation of modelled flood levels between the above nodes the 1 in 100 year flood level at the upstream extent of the site is estimated as 193.807mAOD.

Similarly the 1 in 100 year flood level along the west boundary, within the centre of the site and along the east boundary are estimated to be 193.758mAOD; 193.666mAOD and 193.511mAOD.

Surveyed ground levels along the natural river bank, although limited, indicate that the north boundary of Area B lies at approximately 192.37mAOD to 192.76mAOD.

Consequently, during the 1 in 100 year flood event it is noted that the river bank will become overtopped, and the site is likely to become inundated.

Figure 7: 1 in 100 year Flood Outline Attributed to the River Don



4.1.4 Overtopping: Climate Change

In accordance with the requirements of the NPPF (2012), the impact of climate change over the lifetime of the development must be evaluated.

Unfortunately the modelled flood levels available for the River Don do not make a provision for climate change.

From Table 5 of the 'Technical Guidance for the NPPF' an increase of 20% to peak river flows is deemed appropriate to assess the impact of climate change.

Therefore through interpolation of modelled flows and flood levels, the estimated flood level within the River Don, during the 1 in 100 year plus 20% climate change for each node has been estimated and is tabulated below.

Table 5: Estimated 1 in 100 year plus 20% Climate Change Flood Levels (River Don)

Return Period	Water Level Node Ref 27870 (mAOD)	Water Level Node Ref 27718 (mAOD)	Water Level Node Ref 27678 (mAOD)
1 in 100 year + 20%	194.162	193.762	193.569

Area A

Surveyed ground levels within this development area range from 193.10mAOD to 197.61mAOD.

It is noted that the application of climate change is unlikely affect Development Areas A1 and A2, which are considered to have a low probability of flooding during the 1 in 100 year plus 20% climate change flood event within the River Don.

At Development Area A3, the flood envelope attributed to the 1 in 100 year flood event within the River Don is marginally expanded with the application of climate change, as illustrated within Figure 8 overleaf. The estimated 1 in 100 year plus climate change flood level within this part of the site is estimated at 193.857mAOD.

Area B

Through interpolation the 1 in 100 year plus 20% climate change flood level at the upstream extent of the site is estimated as 193.916mAOD.

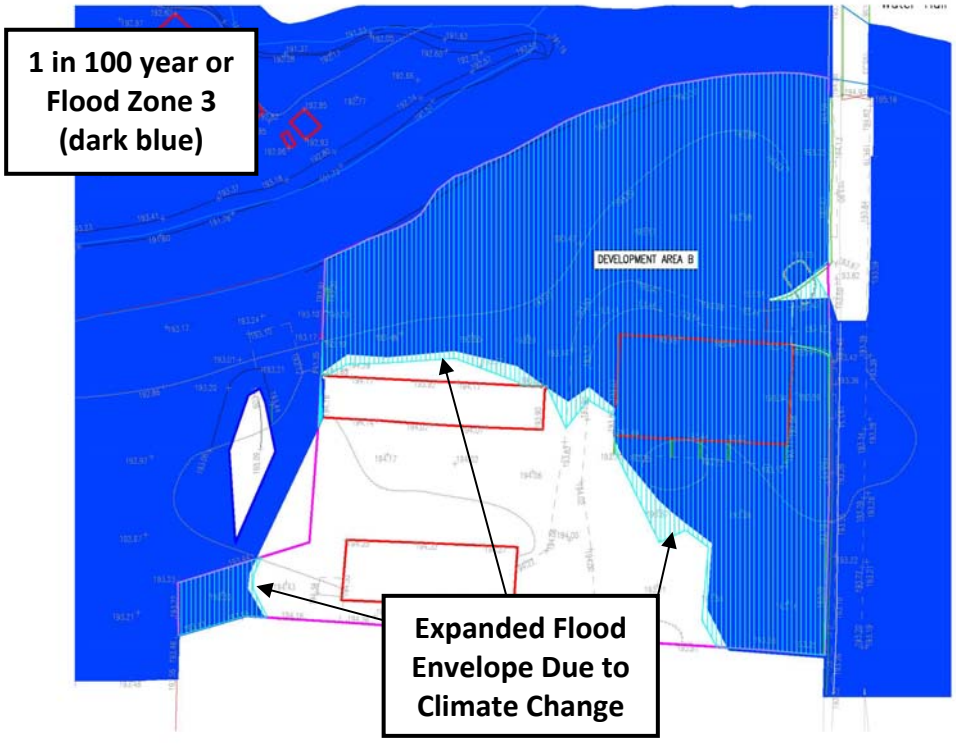
Similarly the 1 in 100 year flood level along the west boundary, within the centre of the site and along the east boundary are estimated to be 193.867mAOD; 193.762mAOD and 193.569mAOD respectively.

The extent of flooding within Development Area B is considered to marginally expand as a result of future climate change, with the predicted outline illustrated within Figure 9.

Figure 8: 1 in 100 year Plus 20% Climate Change Flood Outline – Area A3



Figure 9: 1 in 100 year Plus 20% Climate Change Flood Outline – Area B



4.1.5 Overtopping: Extreme 1 in 1000 year Event

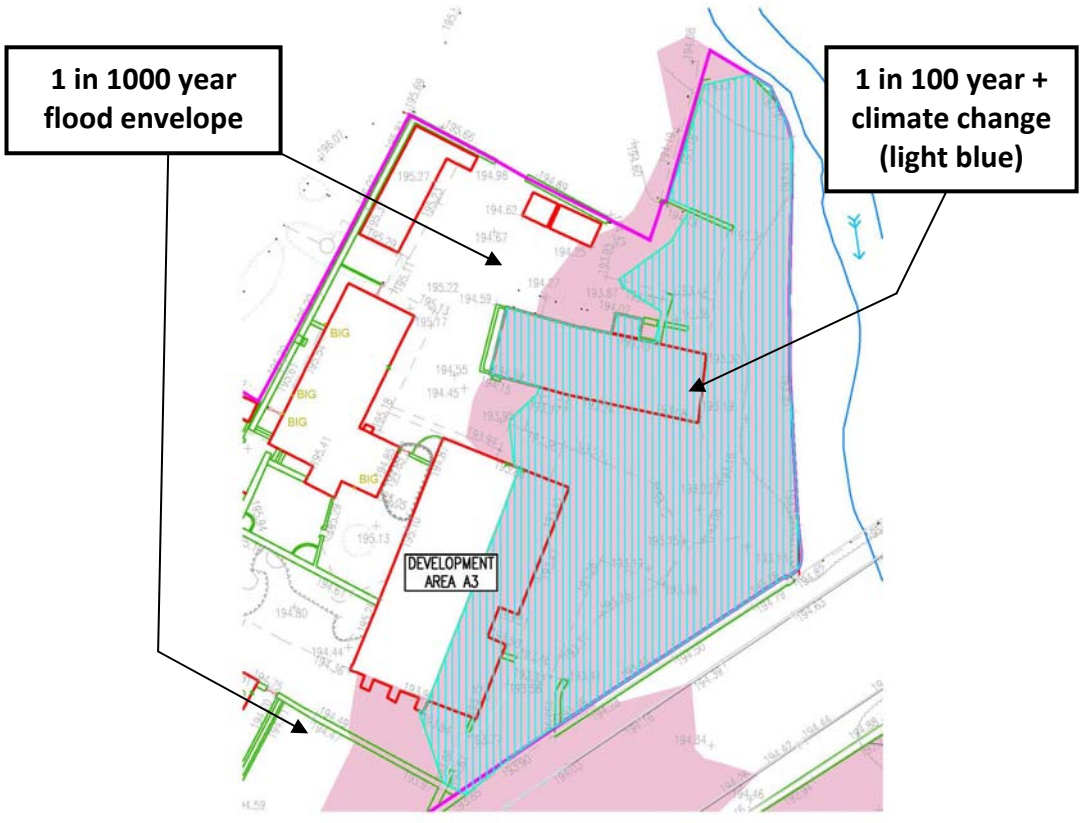
Area A

Surveyed ground levels within this development area range from 193.10mAOD to 197.61mAOD.

Superimposing modelled flood levels for the River Don during the extreme event onto the topographical survey indicates that, whilst Barnsley Road will become inundated, Development Areas A1 and A2 retain a low probability of flooding during the 1 in 1000 year event.

At Development Area A3, the flood envelope attributed to the 1 in 100 year flood event within the River Don is further expanded in comparison to the 1 in 100 year plus climate change flood envelope.

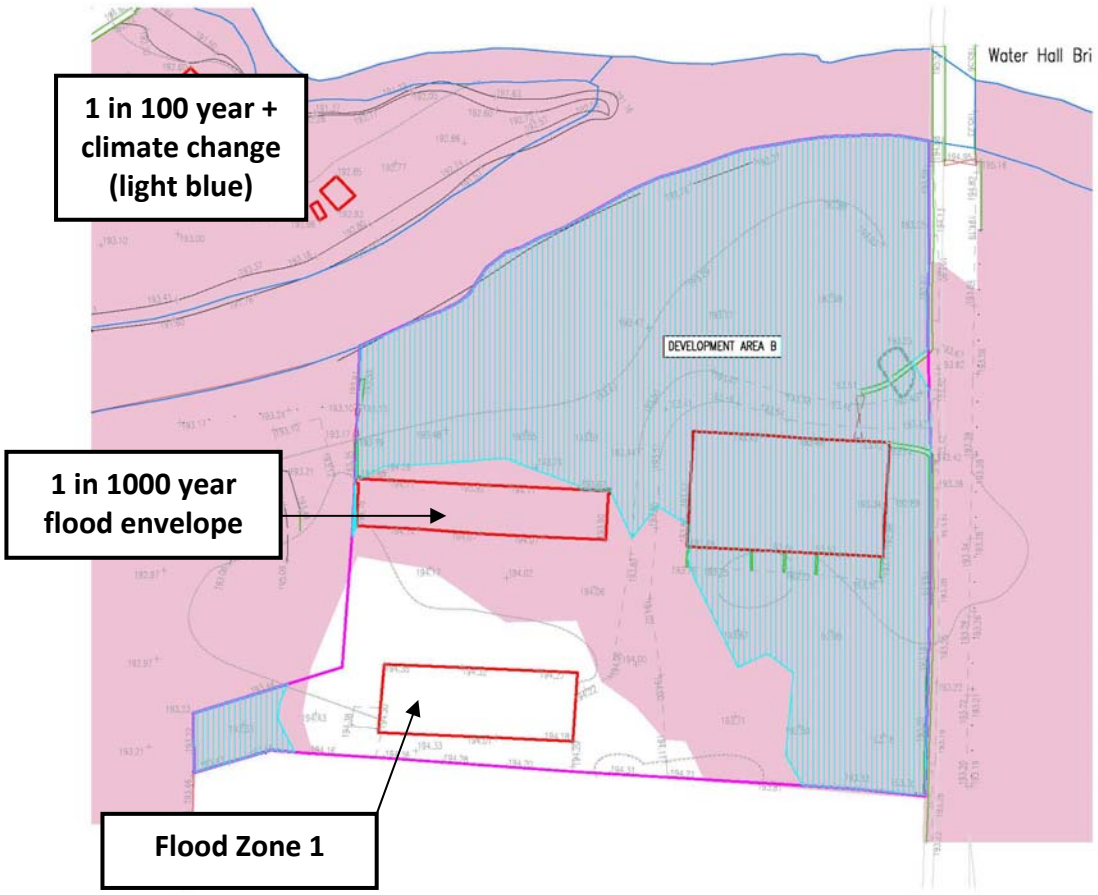
Figure 10: 1 in 1000 year Flood Outline – Area A3



Area B

Application of the 1 in 1000 year modelled flood levels to surveyed ground levels within Development Area B indicates that a small area along the south boundary of the site is located outside of the River Don's floodplain i.e. within Flood Zone 1.

Figure 11: 1 in 1000 year Flood Outline – Area B



4.1.6 Infrastructure Failure: Blockage or Collapse at Water Hall Bridge

During flood conditions there is the potential for debris to enter open channel sections of the watercourse, and be washed downstream.

An accumulation of debris such as uprooted vegetation or silt at bridged and/or culverted sections of the watercourse, may lead to blockages within structures located along the channel, causing flood water to backup.

Similarly, should the bridge spanning the River Don at Water Hall Lane fail, the capacity of the culverted section of watercourse is likely to be greatly reduced, which again is likely to cause flood water to backup within the channel upstream from the bridge crossing.

It is considered likely therefore that the extent of flooding will be exacerbated in the event of severe blockage or structural collapse of the nearby bridge structure.

It is noted that the River Don is designated as 'Main River' within the vicinity of Nether Hall farm and therefore the Environment Agency are responsible for managing flood risk along the watercourse.

The Environment Agency undertakes an annual programme of maintenance, which generally includes the following activities:

- Maintaining flood barriers & pumping stations
- Clearing grills and removing obstructions from rivers
- Controlling aquatic weeds within rivers
- Managing grass, trees and bushes on flood embankments
- Inspection and repair of flood defence structures

An extract from the Environment Agency's routine maintenance programme for 2012-13 at Penistone includes the following:

'Weed cut by machine. Weed is removed from the channel where it is required to maintain flows within the channel and reduce flood risk. This is undertaken by the use of large excavators or by specialist boat equipment where necessary.'

As such, blockage or structural collapse at Water Hall Bridge is therefore considered to have a relatively low probability.

4.1.7 Conclusion

The resulting flood pattern identified within the Nether Mill Farm site was found to compare well with the extent of flooding depicted by the Environment Agency Flood Map of the area.

Under normal flood conditions it is concluded that the River Don presents a flood risk to Development Areas A3 and B.

Furthermore, the watercourse is considered to present a low flood risk to Development Areas A1 and A2.

4.2 Fluvial: Scout Dike

4.2.1 General

Scout Dike is a tributary of the River Don. The watercourse begins as a number of small streams on moorland located to the north west of Penistone.

The watercourse serves a number of reservoirs, including Broadstone; Ingbirchworth; Royd Moor and Scout Dike, emerging from this final reservoir as Scout Dike.

The channel flows generally in a southerly direction along the east boundary of Nether Mill Farm, beneath Barnsley Road, joining with the River Don to the north side of Development Area B.

There are no raised flood defences evident along the banks of the watercourse.

The flood mechanisms in respect of the watercourse are similar to those identified for the River Don i.e. overtopping of the river bank, along with blockage and/or infrastructure failure of the existing road bridge.

The watercourse is classified as 'Ordinary Watercourse' and as such the responsibility for managing activity on or alongside the watercourse lies with the Local Lead Flood Authority i.e. Barnsley Council. The responsibility for maintenance of the watercourse however lies with the riparian owner.

Unfortunately the Environment Agency has been unable to provide modelled water levels for Scout Dike.

4.2.2 Overtopping

It is considered that flood levels within the lower reaches of the watercourse are dominated by water levels within the River Don.

As such inundation at the Nether Mill Farm site attributed to this mechanism has been investigated previously within Section 4.1 of this report.

The flood envelopes produced by the 1 in 100 year and 1 in 1000 year River Don flood levels was found to compare well with Flood Zones 2 and 3, as illustrated on the Environment Agency's Flood Map for the Penistone area.

This also corresponds to the pattern of flooding witnessed by the Client during the July 2012 flood, where Development Area A3 was subject to inundation via overtopping of the river bank; with seepage of flood water into the site through an existing dry-stone wall.

The estimated depth of flooding at the existing tractor shed within Development Area A3 was given as 500mm. The threshold level of the building is at 193.2mAOD; consequently the historic flood level has been taken as 193.7mAOD for the purposes of this assessment.

It is noted that this historic flood level compares well to the 1 in 100 year River Don Flood level at Development Area A3, estimated using the modelled flood level data supplied by the Environment Agency.

Flow into the upper reaches of the watercourse is largely controlled via Scout Dike reservoir. However historic flood maps provided by the Environment Agency indicate that out of bank flooding occurred immediately upstream of Nether Mill Farm during 2007.

The historic flood outline indicates that the open field bordering Development Areas A2 and A3 was inundated over a large area. Reference is made to the Environment Agency Maps provided within Appendix D of this report.

4.2.3 Infrastructure Failure: Blockage or Collapse at Barnsley Road Bridge

The bridge which provides a conveyance route under Barnsley Road is considered to be a highway asset, and therefore from a structural perspective is the responsibility of the Highways and Transportation Department at Barnsley Council.

As such, it is considered that the bridge structure undergoes a regular schedule of inspection, with the Highways Authority undertaking maintenance as required.

It is therefore considered that the road bridge has a low probability of structural failure.

In contrast, due to the semi-wooded nature of the river banks, it is considered possible that during high water levels within Scout Dike, vegetation such as tree branches may become washed into the watercourse; resulting in blockage at the road crossing.

The watercourse is under riparian ownership and therefore the land owner at Nether Mill has responsibility with regard to ensuring that the bridge opening is regularly cleared of debris to minimise large blockages from occurring.

In the event that the bridge opening becomes blocked, water levels upstream of the bridge are likely to become elevated, and overtopping of the river bank, particularly within the lower reaches, just upstream from the bridge are likely to occur.

The resulting impact on the extent of inundation within the Nether Mill Farm site is difficult to ascertain during such an event; however due to its proximity to Scout Dike, it is likely that Development Area A3 will be worst affected.

4.2.4 Conclusion

It is concluded that Scout Dike presents a flood risk to proposed Development Area A3.

4.3 Pluvial: Surface Water Runoff

4.3.1 Barnsley MBC Level 1 SFRA – Surface Water Flooding

In regard to the potential for surface water flooding within the Penistone area, the following details have been extracted from the Level 1 SFRA document.

'*Surface water flooding occurs where high rainfall events exceed the drainage capacity in an area and these events can lead to serious flooding of property and possessions as demonstrated by the summer 2007 floods. In addition, large amounts of surface water runoff can lead to water quality problems and potential health risks to people*.'

Figure 12: Extract from SFRA Map C - Surface Water Flooding

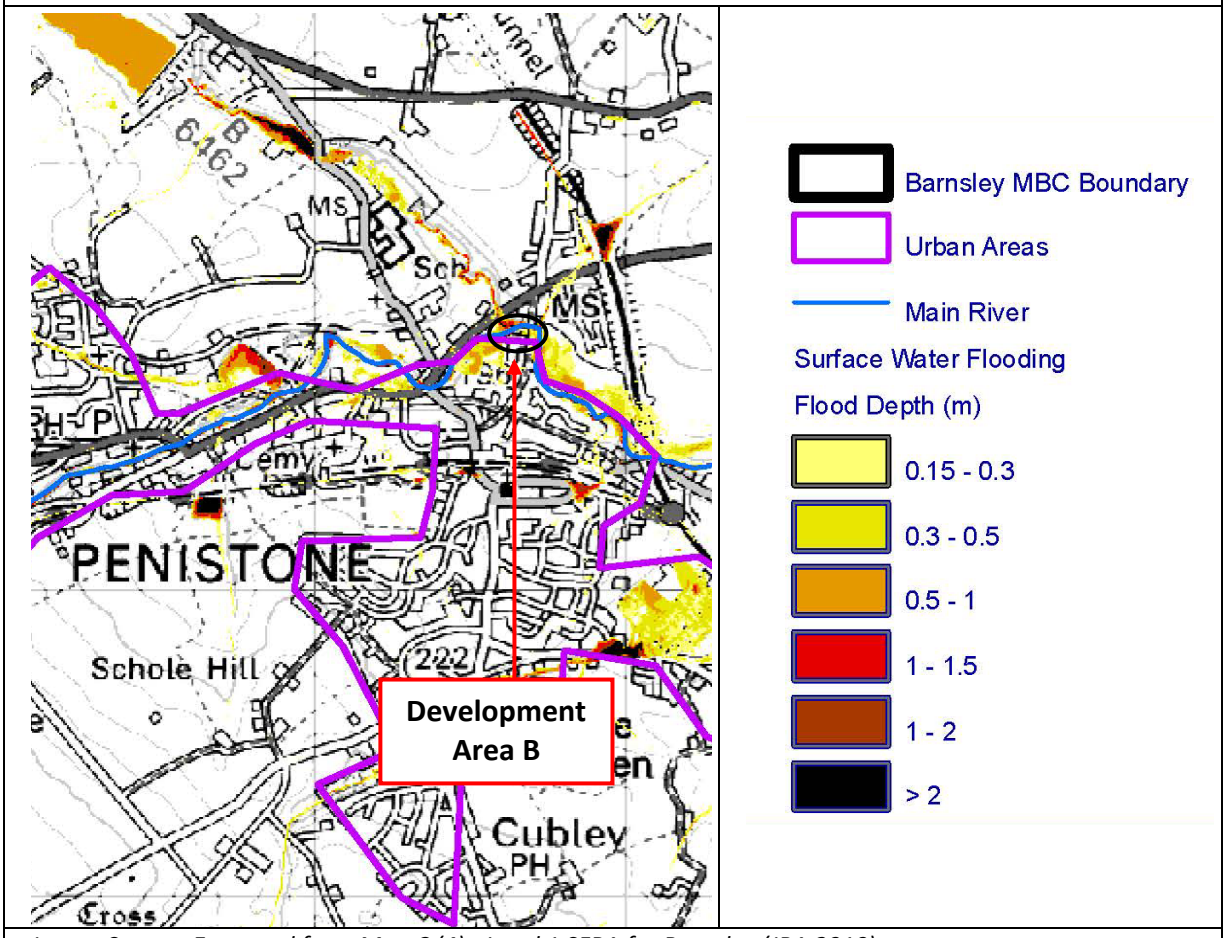


Image Source: Extracted from Map C (4) - Level 1 SFRA for Barnsley (JBA 2010)

'*The topography of the Barnsley MBC area, especially in and around a number of the built-up areas makes them potentially prone to flooding caused by direct rainfall due to the amount of impermeable surfaces and the lack of sufficient sewer capacity. Some modelling of the possible surface water flooding within the urban areas as a result of the 100 year rainfall event has been undertaken in order to provide an indication of areas where surface water (derived from rainfall only) will naturally flow towards and possibly pond.*'

'Areas where surface ponding may generate flood depths in excess of 0.5m (which could also be further exacerbated by flooding from local watercourses), are distributed across the Barnsley MBC urban areas with particular concentrations in:

- *The railway area just east of Market Hall in Barnsley town centre*
- *South western parts of Thurnscoe*
- *North western parts of Bolton-on-Dearne*
- *Eastern parts of Penistone'*

A review of Map C illustrates that there is no surface water flooding predicted for Development Areas A1; A2; A3; and C. However it is predicted that pluvial flooding caused by the 1 in 100 year rainfall event will result in flooding within Development Area B to depths approximating 0.15m – 0.3m.

4.3.2 Increased Runoff Due to Development: General

The total development area within the Nether Mill Farm site approximates 2.48 Hectares and is composed of the following:

- Development Area A (A1; A2; and A3) – 1.18 Hectares
- Development Area B – 0.47 Hectares

Proposals involve provision of residential accommodation via redevelopment of existing farm buildings or new build properties over 3No phases.

Due to the placement of each phase within the overall development, the surface water management issues with regard to each development area have been dealt with within this report on an individual basis.

4.3.3 Evaluation of Existing Contributing Areas – A1

Area A comprises the smaller development areas identified as A1; A2; and A3.

The area within the boundary associated with Area A1 is approximately 0.5 Hectares; and is comprised of:

- 2No adjoined stone built dwellings fronting Barnsley Road
  - Building 1 – single storey cottage style dwelling
  - Building 2 – two storey, derelict farmhouse/barn
- A row of open fronted, block built storage sheds to the rear of the existing dwellings. The buildings are single storey and comprise corrugated metal roofing.
- 2No large barns

Figure 13: Existing Dwellings within Development Area A1



Image Source: Google Earth

Roof water from the existing dwellings and barns are shown to be positively drained via downpipes; however the topographical survey did not highlight any manhole chambers within this area of the site. It is therefore surmised that roof water is allowed to discharge to ground surface level; where it flows overland to Barnsley Road via the site access or via the south west boundary of the development; where it is collected by road gullies; and is ultimately directed into the River Don.

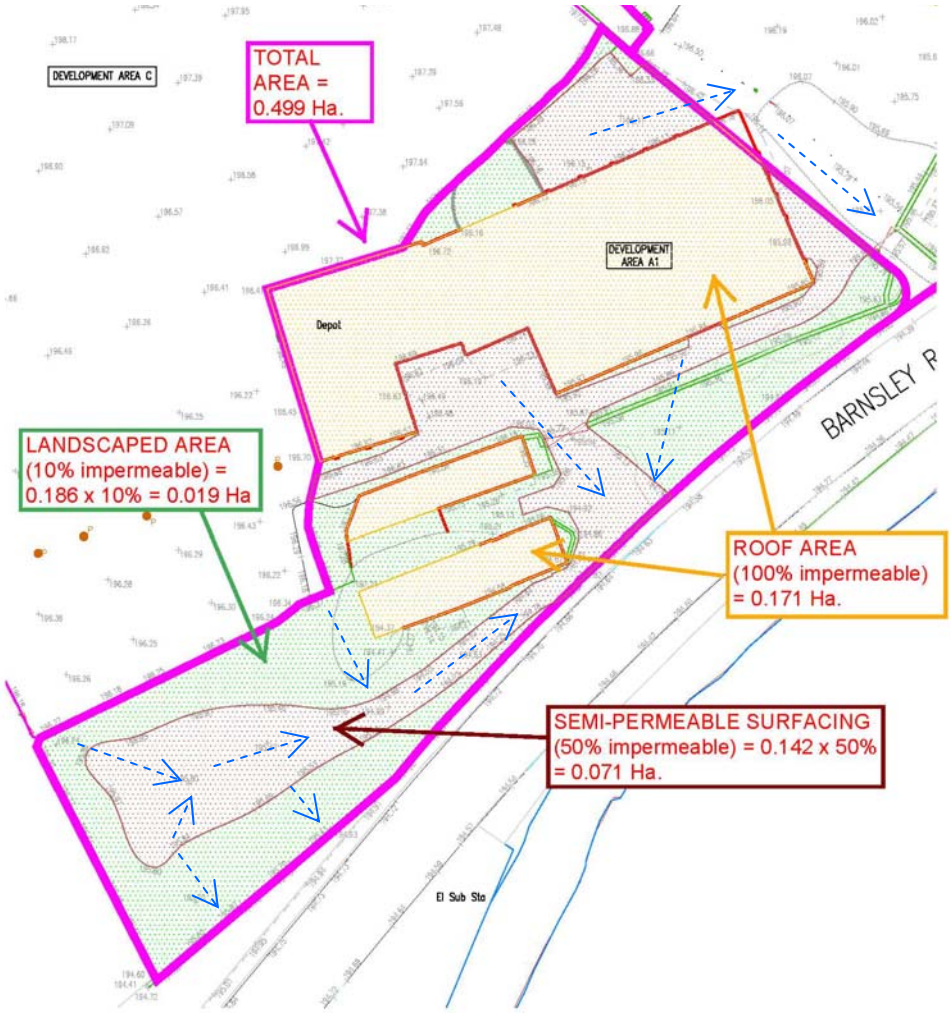
An evaluation of the roof and hardstanding areas within Development Area A1 has been undertaken, and is tabulated below. A sketch illustrating this assessment is provided within Figure 14 overleaf.

Table 6: Existing Contributing Areas – Development Area A1

Surface Type	% Impermeable	Total Area (Ha)	Contributing Area (Ha)
Roof/Building Footprint	100	0.171	0.171
Open storage & yard areas (Gravel/Chippings)	50	0.142	0.071
Concrete/Tarmacadam Hardstanding	100	0	0
Landscape	10	0.186	0.019
Total		0.499	0.261

It is estimated therefore that the site is roof and paved to approximately 52% of the total development area.

Figure 14: Existing Areas Contributing to SW Runoff (Development Area A1)



4.3.4 Estimation of Existing Peak Surface Water Runoff – A1

Utilising rainfall profiles obtained from the FEH CD-ROM (Version 3.0) and the Modified Rational Method, the peak surface water flows for a range of probabilities have been calculated and tabulated below. The full calculation spreadsheets are provided for reference within Appendix F of this report.

Table 7: Existing Surface Water Runoff – Development Area A1

Return Period	Ex. Peak Runoff Rate (l/s)	30% Reduction (l/s)
1 in 2 year	20.3	14.2
1 in 30 year	58.9	41.2
1 in 100 year	90.5	63.4

In order to accommodate future climate change and provide a betterment to the existing situation, the Environment Agency; Yorkshire Water and Barnsley Council requires the application of a 30% reduction to existing peak runoff rates generated by the existing development.

Flows in excess of this should be attenuated on-site prior to discharge into the receiving sewer or watercourse.

4.3.5 Evaluation of Existing Contributing Areas – A2 & A3

Area A comprises the smaller development areas identified as A1; A2; and A3.

The area within the boundary associated with Areas A2 & A3 is approximately 0.675 Hectares; and is comprised of 11No existing buildings made up of residential and farm outbuildings principally of stone construction.

Figure 15: Existing Tractor Shed within Development Area A3



Image Source: PWA Associates

Similar to Development Area A1, roof water from some of the existing buildings is shown to be positively drained via downpipes; however it is again believed that roof water is allowed to discharge to ground surface level; where it flows overland to Barnsley Road and is collected by road gullies; and ultimately into the River Don.

An evaluation of the roof and hardstanding areas within Development Areas A2 & A3 has been undertaken, and is tabulated below. A sketch illustrating this assessment is provided within Figure 16 overleaf.

Table 8: Existing Contributing Areas – Development Areas A2 & A3

Surface Type	% Impermeable	Total Area (Ha)	Contributing Area (Ha)
Roof/Building Footprint	100	0.116	0.116
Semi-permeable (Gravel/Chippings)	50	0.040	0.020
Concrete/Tarmacadam Hardstanding	100	0.157	0.157
Landscape	10	0.362	0.036
Total		0.675	0.329

It is estimated therefore that the site is roof and paved to approximately 49% of the total development area.

4.3.6 Estimation of Existing Peak Surface Water Runoff – A2 & A3

Utilising rainfall profiles obtained from the FEH CD-ROM (Version 3.0) and the Modified Rational Method, the peak surface water flows for a range of probabilities have been calculated and tabulated below. The full calculation spreadsheets are provided for reference within Appendix F of this report.

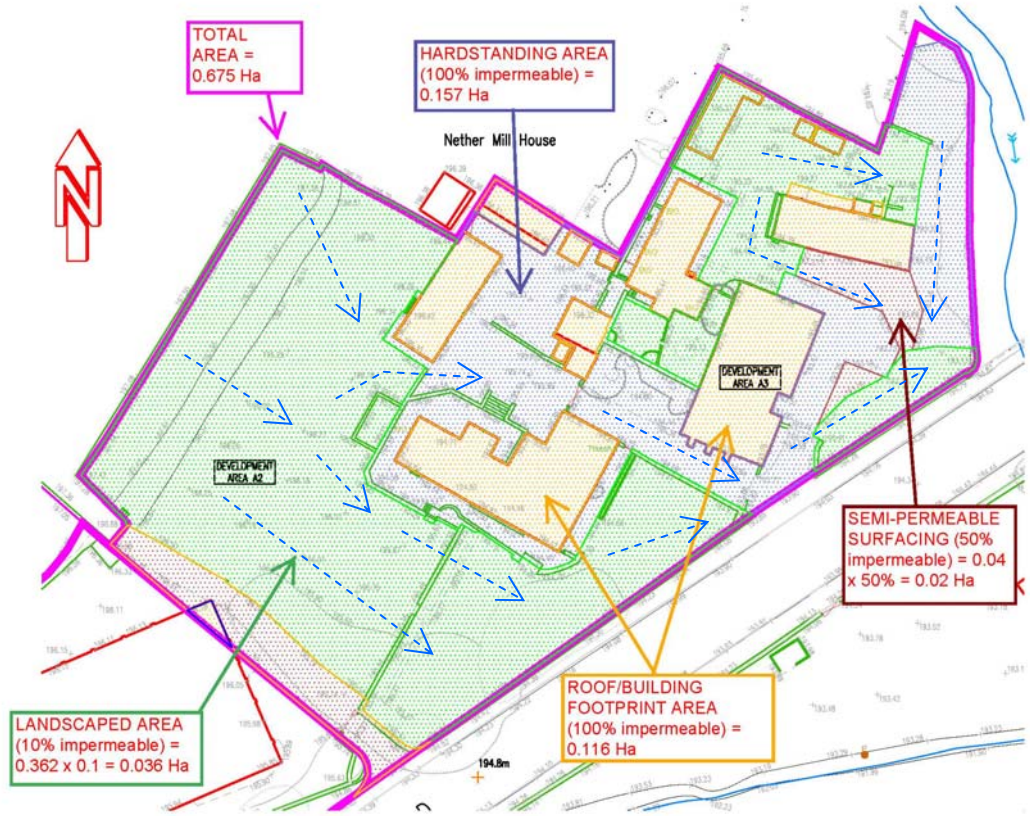
Table 9: Existing Surface Water Runoff – Development Areas A2 & A3

Return Period	Ex. Peak Runoff Rate (l/s)	30% Reduction (l/s)
1 in 2 year	27.2	19.0
1 in 30 year	79.5	55.7
1 in 100 year	122.5	85.8

In order to accommodate future climate change and provide a betterment to the existing situation, the Environment Agency; Yorkshire Water and Barnsley Council requires the application of a 30% reduction to existing peak runoff rates generated by the existing development.

Flows in excess of this should be attenuated on-site prior to discharge into the receiving sewer or watercourse.

Figure 16: Existing Areas Contributing to SW Runoff (Development Areas A2 & A3)



4.3.7 Evaluation of Existing Contributing Areas – B

The area within the boundary associated with Development Area B is approximately 0.47 Hectares; and is comprised of 3No barns. One barn, which is located near to the south boundary within the site, is open sided; whilst the other 2No buildings are stone construction.

Surface water runoff from the site is not currently drained via a positive drainage system. Roof water is allowed to discharge to ground surface level; where it flows overland towards the Don.

An evaluation of the roof and hardstanding areas within Development Area B has been undertaken, and is tabulated below. A sketch illustrating this assessment is provided within Figure 18.

Figure 17: Existing Barns within Development Area B Viewed South



Image Source: PWA Associates

Table 10: Existing Contributing Areas – Development Area B

Surface Type	% Impermeable	Total Area (Ha)	Contributing Area (Ha)
Roof/Building Footprint	100	0.066	0.066
Semi-permeable (Gravel/Chippings)	50	0.006	0.003
Concrete/Tarmacadam Hardstanding	100	0	0
Landscape	10	0.396	0.040
Total		0.468	0.109

It is estimated therefore that the site is roof and paved to approximately 23% of the total development area.

4.3.8 Estimation of Existing Peak Surface Water Runoff – B

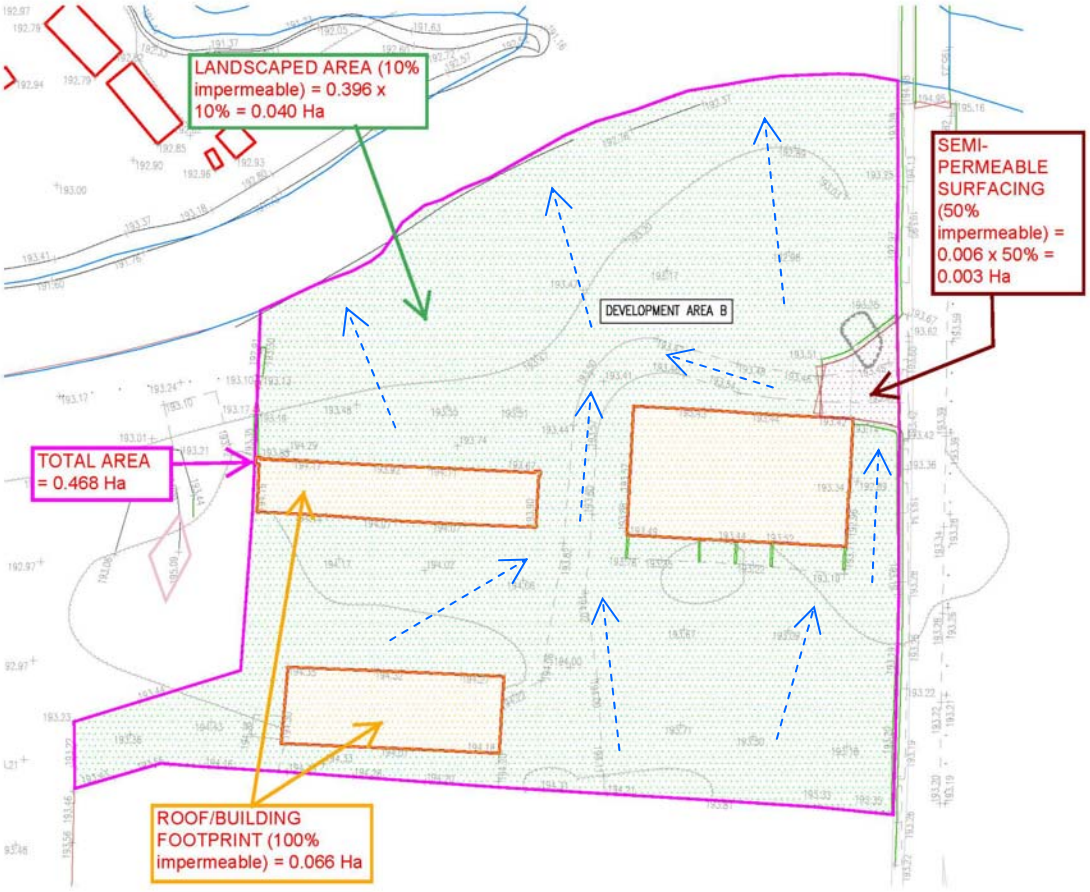
Utilising rainfall profiles obtained from the FEH CD-ROM (Version 3.0) and the Modified Rational Method, the peak surface water flows for a range of probabilities have been calculated and tabulated below. The full calculation spreadsheets are provided for reference within Appendix F of this report.

Table 11: Existing Surface Water Runoff – Development Area B

Return Period	Ex. Peak Runoff Rate (l/s)	30% Reduction (l/s)
1 in 2 year	8.4	5.9
1 in 30 year	24.5	17.2
1 in 100 year	37.6	26.3

In order to accommodate future climate change and provide a betterment to the existing situation, the Environment Agency; Yorkshire Water and Barnsley Council requires the application of a 30% reduction to existing peak runoff rates generated by the existing development.

Figure 18: Existing Areas Contributing to SW Runoff (Development Area B)



Flows in excess of this should be attenuated on-site prior to discharge into the receiving sewer or watercourse.

4.3.10 Post Development Contributing Areas

From the latest Architect Masterplan, the areas contributing to surface water runoff from each development area has been evaluated and tabulated below.

Table 12: Post-Development Contributing Areas

Surface Type	% Impermeable	Total Area (Ha)	Contributing Area (Ha)
Area A1			
Roof & Hardstanding	100	0.268	0.268
Landscape	10	0.231	0.023
Total		0.499	0.291
Comments: Existing area of roof/building footprint = 0.171Ha. Following development this is increased significantly in comparison; however the overall increase in impermeable area within the site only slightly rises from 0.261Ha to 0.291Ha i.e. 58% of the total area available within Development Area A1.			
Areas A2 & A3			
Roof & Hardstanding	100	0.363	0.363
Landscape	10	0.312	0.031
Total		0.675	0.394
Comments: Existing area of roof/hardstanding 0.273Ha. Following development this is increased significantly in comparison; as is the overall increase in impermeable area within the site, which rises from 0.329Ha to 0.394Ha i.e. 58% of the total area available within Development Areas A2 & A3.			
Area B			
Roof & Hardstanding	100	0.187	0.187
Landscape	10	0.281	0.028
Total		0.468	0.215
Comments: Existing area of roof/hardstanding 0.066Ha. Following development this is increased significantly in comparison; as is the overall increase in impermeable area within the site, which rises from 0.109Ha to 0.215Ha i.e. 46% of the total area available within Development Area B.			

It is advised that the contributing areas provided above should be re-evaluated during the detailed design phase to accommodate any changes made to the proposed development plan for each phase.

4.3.11 Attenuation Requirements

Due to the general increase in impermeable area within each phase of the proposed development at Nether Mill Farm, surface water runoff rates will be increased; and consequently will need to be attenuated prior to discharge from the site.

In accordance with Table 5 from the Technical Guidance for the National Planning Policy Framework (2012); peak rainfall intensities should be increased by 30% to accommodate climate change over the lifetime of the development i.e. 100 years for residential development.

The Environment Agency and Local Authority will insist that the proposed 1 in 2 year runoff can be maintained and also insist that the 1 in 30 year event is not allowed to flood the surface; hence the water must remain within the pipes, manholes, and storage systems.

The resulting runoff from the 1 in 100 year event, is allowed to flood the surface, however flood water must not be allowed to enter any of the buildings; or migrate to adjoining development outside of the site boundary.

Using the Wallingford Procedure Modified Rational Method storage volumes for each development area, for the 1 in 2 year, 30 year, 100 year plus climate change events have been calculated and tabulated below. The allowable discharge rates from the proposed development have been set to existing rates for the matching probabilities; or 5l/s whichever is the highest.

Areas A1; A2 and A3

Due to the proposed layout it is suggested that that 3No outfalls would be sufficient to serve the proposed development for areas A1; A2; A3 and C.

Outfall 1: Discharge from Areas A1

The area contributing to Outfall 1 from Development Area A1 is estimated to be 0.102 Hectares i.e. 35% of the overall area calculated for A1 (0.291 Hectares).

Pro-rating the allowable surface water discharge rates calculated within Section 4.3.4 of this report gives 5.0l/s; 14.4l/s; and 22.2l/s respectively for the 1 in 2 year; 1 in 30 year; and 1 in 100 year plus climate change storm events.

Table 13: Indicative Volume of Attenuation: Outfall 1 - Area A1 (0.102 Hectares)

Return Period	Storage Volume (m^3)
1 in 2 year + 30% climate change	3
1 in 30 year + 30% climate change	9
1 in 100 year + 30% climate change	14

Outfall 2: Discharge from Area A1

The area contributing to Outfall 2 from Development Area A1 is estimated to be 0.120 Hectares i.e. 41% of the overall area calculated for A1 (0.291 Hectares).

Pro-rating the allowable surface water discharge rates calculated within Section 4.3.4 of this report gives 8.4l/s; 24.3l/s; and 37.3l/s respectively for the 1 in 2 year; 1 in 30 year; and 1 in 100 year plus climate change storm events.

Table 14: Indicative Volume of Attenuation: Outfall 2 - Area A1 (0.120 Hectares)

Return Period	Storage Volume (m^3)
1 in 2 year + 30% climate change	4
1 in 30 year + 30% climate change	11
1 in 100 year + 30% climate change	16

Outfall 3: Discharge from Area A1; A2 & A3

The area contributing to Outfall 3 from Development Area A1 is estimated to be 0.069 Hectares i.e. 24% of the overall area calculated for A1 (0.291 Hectares).

The allowable surface water discharge rates calculated within Section 4.3.4 of this report gives 3.3l/s; 9.8l/s; and 15.1l/s respectively for the 1 in 2 year; 1 in 30 year; and 1 in 100 year plus climate change storm events.

Similarly the area contributing to Outfall 3 from Areas A2 & A3 is 0.394 Hectares; with allowable surface water discharge rates of 19.0l/s; 55.7l/s; and 85.8l/s respectively for the same rainfall events.

The combined allowable discharge rate from Outfall 3 therefore is 22.3l/s (1 in 2 year); 65.5l/s (1 in 30 year); and 100.9l/s (1 in 100 year) plus 30% climate change.

Table 15: Indicative Volume of Attenuation: Outfall 3 - Areas A1; A2 & A3 (0.463 Hectares)

Return Period	Storage Volume (m^3)
1 in 2 year + 30% climate change	16
1 in 30 year + 30% climate change	42
1 in 100 year + 30% climate change	62

Area B

Due to the proposed layout it is suggested that that a single outfall would be sufficient to serve the proposed development for area B.

Outfall 4: Discharge from Area B

The area contributing to Outfall 4 from Development Area B is estimated to be 0.215 Hectares.

The allowable surface water discharge rate for Development Area B is 5.9l/s; 17.2l/s; and 26.3l/s respectively for the 1 in 2 year; 1 in 30 year; and 1 in 100 year plus climate change event.

Table 16: Indicative Volume of Attenuation: Outfall 4 - Area B (0.215 Hectares)

Return Period	Storage Volume (m^3)
1 in 2 year + 30% climate change	14
1 in 30 year + 30% climate change	34
1 in 100 year + 30% climate change	48

General Comment

It is noted that the storage volumes provided are indicative only at this stage and should be recalculated during the detailed design stage to reflect the following:

- Planning Conditions
- Agreed allowable discharge from the site
- The finalised development proposals,
- The extent of impermeable areas and runoff to be generated.

4.4 Overland Flow

Spicer Hill is situated to the north west of the proposed development, with a top elevation of 349mAOD; and Hartcliff Hill to the south west with a crest level approximating 364mAOD.

From the Ordnance Survey Maps for the area, it is identified that surface water from these elevated areas is collected by a network watercourses and reservoirs.

Furthermore existing development at Thurlstone and within Penistone lies in between the site and these points; and so it is considered that surface water runoff along the overland flow routes will be intercepted by existing infrastructure, such as road gullies; highway drains and the public sewer network.

It is noted however that more immediate to the Nether Mill farm site, open field areas immediately to the north side of Development Areas A2 & A3 slope down towards the site boundary; providing an overland flow route.

In conclusion overland flows are considered to present a flood risk to the proposed development.

4.5 Groundwater

The following text in relation to the potential for groundwater flooding at the proposed development has been extracted from the Level 1 SFRA for Barnsley.

'*Groundwater flooding is caused by the emergence of water originating from underground, and is usually very local and governed by the local geology.*

Unlike flooding from rivers and the sea, groundwater flooding does not generally pose a significant risk to life, but is more associated with significant damage to property, with flooding persisting over a number of weeks for some types of groundwater flooding.

Groundwater flooding is a significant but localised issue that has attracted an increasing amount of public concern in recent years; and can also exacerbate fluvial flooding in certain circumstances.

Groundwater flooding arises from:

- *Natural exceptional rises in groundwater level, reactivating springs and short lived watercourses (often referred to as 'clearwater' flooding);*
- *Rising groundwater (rebound) following reductions in historic abstraction; Mine water recovering to natural levels following cessation of pumping; and*
- *Local shallow drainage/flooding problems unrelated to deep groundwater responses.*

Key issues are:

- *Groundwater flooding is sporadic in time and location, but when it occurs, it usually lasts longer than surface water flooding and interferes with property and infrastructure (such as roads).*
- *In most cases groundwater flooding cannot be easily managed or lasting solutions engineered.*

There are many other localised and site-specific reasons for water to emerge at the surface or to appear in basements, for example, leaking water mains and sewers, blocked drains, and impedance of natural drainage routes by urban development or deepening of cellars to below the natural water table.

Likely candidates for groundwater flooding in the Barnsley MBC area are:

- *Kingstone area of Barnsley*
- *Kingwell area of Worsbrough*
- *Millhouses area of Hoyland*
- *Upperwood area of Darfield*

The Coal Authority was consulted with respect to the possibility of flooding caused by the re-emergence of mine waters from the formerly very important South Yorkshire mining region following the cessation of mine water pumping. These discussions indicated that The Coal Authority have a comprehensive network of groundwater monitoring boreholes across South Yorkshire and, by working in partnership with the Environment Agency and other local coal

mining interests are developing a strategic forward plan to manage mine water levels to minimise the risk of re-emerging mine waters causing both flooding and/or initiating water quality problems in the major Sherwood Sandstone water resource aquifer.'

In conclusion groundwater flooding is deemed to present a low flood risk to all of the proposed development areas within the Nether Mill Farm site.

4.6 Reservoirs

The following text in relation to the potential for flooding from reservoirs at the proposed development has been extracted from the Level 1 SFRA for Barnsley.

'According to the Environment Agency's Register of Reservoirs, there are 19 operational 'large raised reservoirs' located within the boundaries of the Barnsley MBC boundary ranging in capacity between about 35,250m3 and 8,296,000m3.

Reservoirs can both store and attenuate flows in a similar manner to washlands and floodplains, depending upon how they are managed. At present these reservoirs are often full in winter and so would therefore provide little potential attenuation for flooding. Service reservoirs are not included in this register.

Reservoirs can also act as a major source of floor risk, as experienced recently during the 2007 summer floods in England and Wales, where 18 reservoirs were affected.

Reservoir flooding is therefore an important source of flood risk which has been noted within Pitt Review.

Whilst the probability of dam failure or breaching occurring is very small, the consequences of such an event can be devastating hence presenting a risk of flooding which has to be considered.

Currently the Water Act 2003, which amended the Reservoirs Act 1975, requires all reservoir undertakers to prepare reservoir flood plans for those reservoirs where the dam failure could put people's lives at risk or lead to major damage.

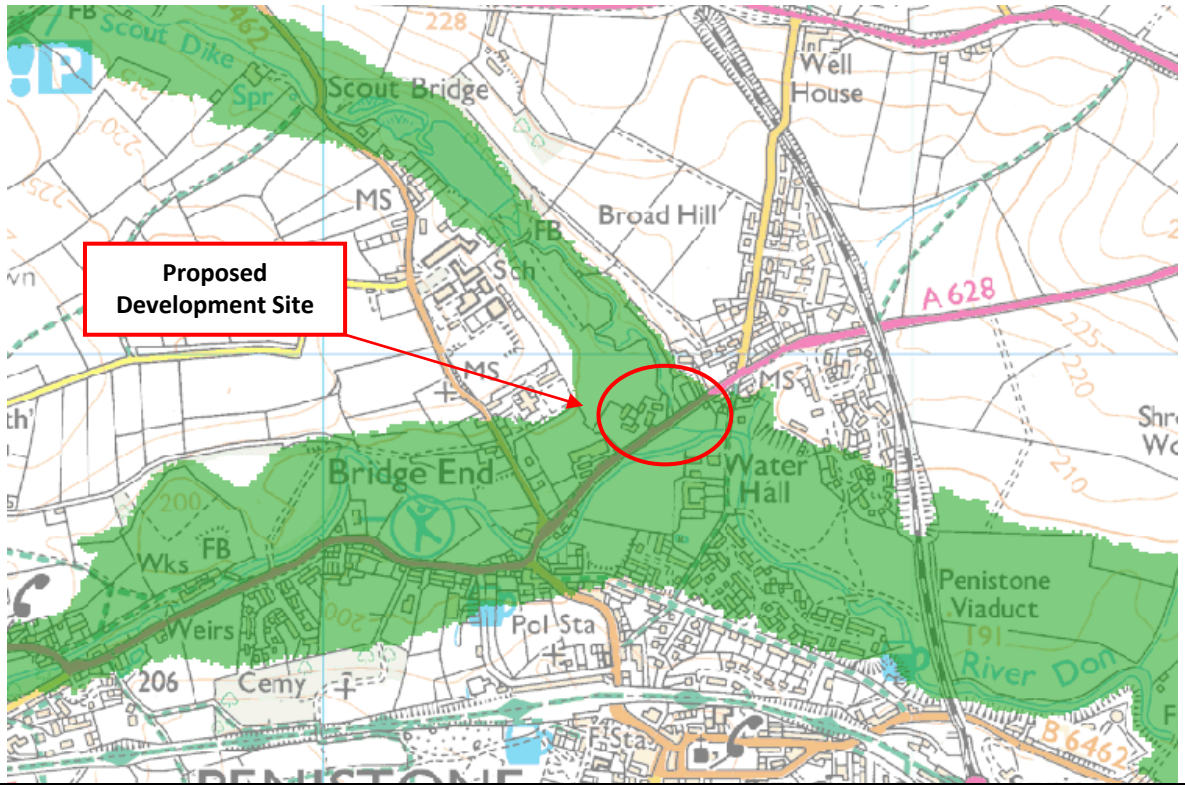
These plans are expected to become a legal requirement in spring 2009. DEFRA is currently funding a project to produce a 'Guide to Emergency Planning for UK Reservoirs', which will ultimately use the reservoir flood plans.

The reservoir flood plan includes:

- An inundation analysis to identify the extent and severity of flooding which could result from an uncontrolled release of water (i.e. breaching or failure).
- An on-site plan setting out what the undertaker would do in an emergency to try and to contain and limit the effects of the incident, and
- A communications plan with external organisations, mainly the emergency services.'

It is noted that there are a series of reservoirs upstream of the proposed development; the nearest being Scout Dike, located approximately 150 metres from the north boundary of Development Area A3; although Windleden Lower; Royd Moor; Ingbirchworth; Winscar; Windleden Upper; and Broadstone Reservoirs also impact the potential risk of flooding within the area surrounding the development site.

Figure 19: Risk of Flooding from Reservoirs



Souce: www.environment-agency.gov.uk

All of the reservoirs named are Yorkshire Water assets.

The map shown within Figure 19 above illustrates the largest area that might be flooded if a reservoir were to fail and release the water it holds. Since this is a prediction of a worst case scenario, it's unlikely that any actual flood would be this large.

In conclusion reservoir flooding is extremely unlikely. There has been no loss of life in the UK from reservoir flooding since 1925; and since this time reservoir safety legislation has been introduced to make sure reservoirs are well maintained.

As such the flood risk at the proposed development site presented by this source is considered to be low.

4.7 Ponding

The topographical survey indicates that in general there are no low points where localised ponding during heavy rainfall is likely to happen; with the exception of the access from Barnsley Road into Development Area A3.

Following redevelopment it is recommended that proposed levels are carefully designed to avoid any ponding within the site boundary from occurring; and where this is unavoidable suitable arrangements are incorporated within the design for drainage.