

FLOOD RISK ASSESSMENT

Project Number: **16017**

Report Reference (Revision): **FRA01 (B)**

Client: **Jones Homes**

Site Address: **Bloomhouse Ln, Darton**

Date: **July 2017**

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1. INTRODUCTION

This Site-Specific Flood Risk Assessment (FRA) and Drainage Strategy has been prepared for the proposed development at Bloomhouse Lane, Darton. The assessment investigates the potential flood risk impacts of the proposed development in accordance with the National Planning Policy Framework (NPPF) and supporting Planning Practice Guidance. This FRA is considered proportionate to the degree of flood risk and to the scale, nature and location of the development. This FRA has been prepared in accordance with non-statutory technical standards for sustainable drainage, published March 2015 and NPPF climate change allowances, published February 2016.

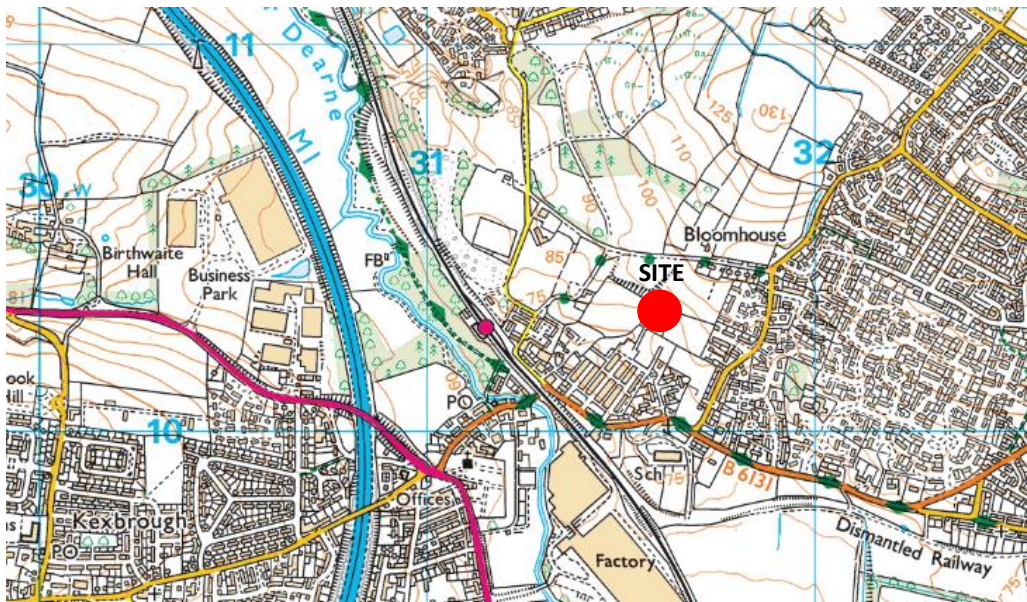
2. THE SITE

2.1 Site Location

The site lies within the village of Darton which is part of the urban area of Barnsley, South Yorkshire. The site has boundaries formed by Bloomhouse Lane to the north, Woolley Colliery Road to the west and residential housing to the south and east. The site is located 1 mile from the M1 motorway, 12 miles from Barnsley town centre and is within 500 metres of Darton Railway Station which provides rail services between Leeds and Sheffield. The site location is described below:

- Postcode S75 5AS
- OS X (Easting) 431789
- OS Y (Northing) 410401
- Nat Grid SE 31789 10401

The site location is illustrated in Figure 1 below.



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Figure 1: Site Location Plan

2.2 Site Description

The total site covers an area of 9.1 hectares and is predominantly undeveloped land. In the south-east corner, the site comprises previously developed land once occupied by Darton Primary School, which has subsequently been demolished. Manor House Farm is located to the West of the site, and will remain as part of the proposals. The remaining part of the application site is greenfield in character and comprises private land used for grazing of animals and open land. Figure 2 shows an aerial view of the site.



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Figure 2: Aerial Photograph

Appendix A shows a topographical survey of the site. The topographical survey shows that the site is steeply sloped from northeast to southwest with levels varying between 103.0mAOD and 72.100mAOD.

2.3 Proposed Development

The planning application proposes a 214-property residential development along with new vehicular access served from Station Road/Sackup Lane including a roundabout and associated drainage infrastructure. A new junction onto Woolley Colliery Road is to be constructed to facilitate access from the West. The proposed layout is contained within Appendix B.

3. SUITABILITY OF DEVELOPMENT PROPOSALS

3.1 Flood Risk Vulnerability

The Flood Risk Vulnerability Classification has been determined in accordance with Planning Practice Guidance, Flood Risk and Coastal Change. The Flood Risk Vulnerability Classification is '*More Vulnerable*'. This classification includes '*Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels*'.

3.2 Flood Zone Compatibility

The Flood Zone Compatibility has been reviewed in accordance with Planning Practice Guidance, Flood Risk and Coastal Change, paragraph 067.

Flood Zones	Flood Risk Vulnerability Classification				
	Essential infrastructure	Highly vulnerable	More vulnerable	Less vulnerable	Water compatible
Zone 1	✓	✓	✓	✓	✓
Zone 2	✓	Exception Test required	✓	✓	✓
Zone 3a †	Exception Test required †	X	Exception Test required	✓	✓
Zone 3b *	Exception Test required *	X	X	X	✓*

Key:

✓ Development is appropriate

X Development should not be permitted

Table 1: Flood Risk Vulnerability and Flood Zone Compatibility

The site is located within Flood Zone 1. The vulnerability classification is '*More Vulnerable*'. The scheme proposals are therefore considered appropriate in accordance with Planning Practice Guidance.

4. SOURCES OF FLOODING

4.1 Flood Map for Planning (Rivers and Sea)

Fluvial flooding occurs when high flows exceed the capacity of the river channel and spill out onto the floodplain, usually after a period of prolonged or heavy rainfall.

The Environment Agency Flood Map for Planning (rivers and sea) is shown in Figure 3. The site is located within Flood Zone 1, which comprises land assessed as having less than 1 in 1000 annual probability of river or sea flooding.

The flood zone is based upon the 'undefended' scenario. This is judged to be a precautionary scenario.



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Figure 3: Environment Agency Flood Map for Planning (Rivers and Sea)

4.2 Flooding from Land (Pluvial Flooding)

The Environment Agency Flood Map showing Risk of Flooding from Surface Water is shown in Figure 4. This type of flooding can be difficult to predict, much more so than river or sea flooding as it is hard to forecast exactly where or how much rain will fall in any storm.

The map indicates that areas of the site have a '*medium*' chance of flooding from surface water. The map is not definitive and is based on the best information available to the Environment Agency, such as ground levels and drainage.

The development does propose to alter levels on site. The site is to be positively drained by dedicated surface water drainage networks and will cater for storm events up to and including the 1 in 100 year Critical Duration Event, with an allowance for climate change. Further to this, overland flow paths will be considered during detailed design. This will mitigate the likelihood of pluvial flooding to and from the site.



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Figure 4: Risk of Flooding from Surface Water

The site has been surveyed to provide a more accurate assessment of the existing site levels. The site topographical survey is contained within Appendix A.

4.3 Flooding from Groundwater

Groundwater flooding occurs when water levels in the ground rise above surface levels, and is more likely to occur in low lying areas.

A Geotechnical Investigation has been conducted, with trial pits logged across the entirety of the site. Groundwater seepages were noted in four trial pits at various depths and in differing strata which suggests a localised perched groundwater table may be present across the site. A land drainage network should be installed in order to mitigate the risk. Localised de-watering may also be required.

The nearest British Geological Survey (BGS) borehole log is SE 31SW285, located to the north east of the site. Groundwater was not encountered in this borehole or any nearby, up to depths of 3m.

It should be noted that groundwater levels might fluctuate for a number of reasons including seasonal variations. Ongoing monitoring would be required to establish both the full range of conditions and any trends in groundwater levels.

The site is steeply sloping therefore, if groundwater flooding was to occur, flows would follow natural exceedance routes.

4.4 Flooding from Sewers

The only existing public sewer on site is a 150dia. combined system that connects Manor House Farm to the network in Woolley Colliery Road. As such the risk of flooding from sewers is considered low.

4.5 Flooding from Reservoirs

Reservoir flooding is extremely unlikely to happen. There has been no loss of life in the UK from reservoir flooding since 1925. All large reservoirs must be inspected and supervised by reservoir panel engineers. As the enforcement authority for the Reservoirs Act 1975 in England, the Environment Agency ensure that reservoirs are inspected regularly and essential safety work is carried out.

However, in the unlikely event that a reservoir dam failed, a large volume of water would escape at once and flooding could happen with little or no warning.

The Environment Agency Flood Map showing Risk of Flooding from Reservoirs is shown in Figure 5.



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Figure 5: Risk of Flooding from Reservoirs

The Environment Agency Data illustrates that the site is located within an area that would not be affected by reservoir failure.

5. DRAINAGE STRATEGY

5.1 Proposed Drainage Strategy

In accordance with NPPF, the following hierarchy of surface water drainage options has been considered:

- Discharge into the ground (infiltration);
- Discharge to a surface water body;
- Discharge to a surface water sewer, highway drain, or another drainage system;
- Discharge to a combined sewer.

Infiltration has been considered as the preferred method of surface water disposal. Intrusive investigations detail that the majority of the site is underlain by clay and coal measures which are unfavourable for infiltration (See Appendix C). Further to this, the use of soakaways on steeply sloping sites is generally not recommended as water can percolate through fissures, causing groundwater flooding to downstream properties. Infiltration techniques have been discounted given the natural (and proposed) topography, and the expected ground conditions.

Opportunities for discharge to watercourse have also been considered. Ordnance Survey mapping indicates that the site is located approximately 250 m Northeast of the River Dearne. Correspondence with Yorkshire Water however has highlighted the presence of a culverted watercourse at the southern boundary of the site adjacent to the existing allotment gardens off School Street (See Appendix E). Further investigation is required to confirm the presence of this watercourse. The site is riparian and therefore outfall to watercourse should be considered as the primary means of discharge of surface water where practicable.

In order to achieve gravity outfalls for the on-site surface water drainage, given the steeply sloping nature of the site, it is proposed that the site be split into two catchment areas with separate dedicated surface water networks (See Appendix B). Catchment 1 is proposed to discharge to the existing combined sewer in Station Road utilising existing connections where possible and catchment 2 to discharge to watercourse at the southern boundary of the site.

As previously detailed the Southeast corner of the site formerly consisted of Darton Primary School buildings along with associated hardstanding. Given the historic connection to the public combined sewer from these the proposed discharge rate for catchment 1 has been calculated to provide a 30% betterment on the existing brownfield condition using the modified rational method (See Appendix D). Catchment 2 consists of undeveloped land therefore the proposed discharge rate has been calculated using IH124 methodology in order to mimic the existing peak greenfield run-off rate (See Appendix D). The proposed discharge rates are detailed below.

Proposed Discharge Rate:

- Catchment 1: 40.4l/s
- Catchment 2: 26.7l/s

In accordance with current policy the surface water systems will accommodate flows on-site up to and including the 1 in 100-year critical duration event, with an allowance for climate change. It is intended to utilise below ground attenuation to store excess flows on-site. Storage will be sited within public open space wherever possible to allow for future maintenance and inspection by the sewerage undertaker. Where this cannot be achieved storage will be situated within the proposed public highway. In order to minimise the impact of this attenuation on localised areas of the development and to allow phased development, we would propose that storage is staggered. Required attenuation volumes are based on an assumed impermeable area of 60% of total site area.

Required Attenuation Volume:

- Catchment 1: 350m³
- Catchment 2: 2300m³

The drainage strategy and storage calculations are contained within Appendix D.

Foul water flows will be collected by dedicated gravity networks, designed in accordance with BS EN 752, before discharging to existing combined sewer, subject to agreement under Section 106 of the Water Industry Act.

Both surface and foul water networks are to be offered for adoption to Yorkshire Water under Section 104 of the Water Industry Act.

5.2 Climate Change

The drainage strategy will include an increase in the storm intensity of 40%, which is consistent with the effects of climate change for a development with a design life of 100 years, as outlined in NPPF.

5.3 Consultation

Prior to the planning application process, the Lead Local Flood Authority and Sewerage Undertaker were consulted and the correspondence is contained within appendix E.

6. CONCLUSIONS

The full planning application proposes a 214-property residential redevelopment, with new vehicular access served from Station Road/Sackup Lane including a roundabout and associated drainage infrastructure. A new junction onto Woolley Colliery Road is to be constructed to facilitate access from the West.

The site is located in Darton, Barnsley and is a greenfield site within Flood Zone 1. The Flood Risk Vulnerability Classification for the proposed development is 'More Vulnerable'. The development is considered appropriate in accordance with Planning Practice Guidance.

Environment Agency data indicates a very low risk of flooding from rivers and sea.

Environment Agency data indicates a very low risk of flooding from surface water across the majority of the site. A small portion of the site is at medium risk of flooding from surface water. Overland flood flow routes have been considered as part of the on-site civil engineering scheme design.

Surface water flows will be collected by dedicated gravity networks and discharge to watercourse where practicable (catchment 2) at a rate of 26.7l/s. Where a gravity connection cannot be achieved to watercourse (catchment 1) it is proposed that flows will outfall to Yorkshire Water combined sewer at a rate of 40.4l/s.

Flow Control devices will be used to restrict discharge rates of surface water to the maximum permissible rates.

Approximately 2650m³ of below ground attenuation storage will be utilised to store storm water up to and including the 1 in 100 year return period with an allowance for climate change.

Foul water flows will be collected by separate dedicated gravity networks and will discharge to the existing Yorkshire Water combined network.

Both surface and foul water networks are to be offered for adoption to Yorkshire Water under Section 104 of the Water Industry Act.

This Flood Risk Assessment has assessed the risks of all forms of flooding to and from the development and has demonstrated how these flood risks will be managed so that the development remains safe throughout its lifetime, taking climate change into account.

7. APPENDICES

Appendix A: Topographical Survey

Appendix B: Site Layout

Appendix C: Ground Investigation Report

Appendix D: Drainage Strategy and Calculations

Appendix E: Consultation

APPENDIX A:

TOPOGRAPHICAL SURVEY



APPENDIX B:

SITE LAYOUT

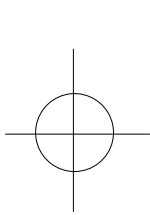


For Highways and Drainage Proposal please refer to Dudley's Structural & Civil Consultants submission information.
For Landscape Proposal please refer to Spawforth's submission information.

- REV A - 12/05/2016 The site plan has been revised in line with the clients comments raised at the Design Team Meeting.
- REV B - 19/05/2016 The site plan has been revised in line with the clients comments.
- REV C - 01/03/2017 The site plan has been revised in line with the clients comments.
- REV D - 31/03/2017 Site plan revised as per clients comments. SJW.
- REV E - 06/03/2017 Site plan revised as per clients comments. MB.
- REV F - 30/06/2017 Site plan revised. 214 Plots. MB.
- REV G - 03/07/2017 Site plan revised to clients comments. MB.
- REV H - 04/07/2017 Site plan revised to clients comments. MB.
- REV I - 06/07/2017 Site plan revised to clients and Sundersons comments. MB.
- REV J - 12/07/2017 Site plan development.

Site Name: Bloomhouse Lane Darton									
PHASE I									
Date: 2017/07/12									
Drawings No	HOUSE TYPE	Bedrooms	NUMBER	sq. FEET	TOTAL SQ FEET	sq. METRES	TOTAL sq METRES	%	plot nos
1	Cranford	2	52	748	38896	69.49	3613.53	24.3%	
2	Langley	3	21	732	15372	68.00	1428.09	9.8%	
3	Birch	3	44	806	35464	74.88	3294.69	20.6%	
4	Bavenham	4	24	1264	30336	117.43	2818.28	11.2%	
5	Banbury	4	32	1354	43328	125.79	4025.27	15.0%	
6	Stratton	5	4	1693	6772	157.28	629.13	1.9%	
7	Bowdon	5	5	1680	9400	174.66	873.28	2.3%	
8	Catchford	5	6	1790	10740	166.30	997.77	2.8%	
9	Hollin	4	7	1335	9345	124.02	868.17	3.3%	
10	Bayswater	4	19	1452	27588	134.89	2562.99	8.9%	
TOTALS:			214		227241		21111	100%	

Planning Application Area: 9.1 Hectares
POS: 1.365 Hectares



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Client Name Jones Homes		Project Title Bloomhouse Lane, Darton	
Project No 3967	Drawn By MB	Project Title Bloomhouse Lane, Darton	Discipline Architecture
Scale 500	Revised By GW	Revision L	Date February 16
Drawing No. 0000-030-010	Drawing Title Indicative Site Plan-Phase I	Revision L	

File Path
Report notes
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APPENDIX C:

GROUND INVESTIGATION

REPORT



Jones Homes (Yorkshire) Limited

Land off Bloomhouse Lane, Darton

Geo-environmental site assessment and coal mining risk
assessment report

301645-01 (00)

MARCH 2016



5 GROUND CONDITIONS

The results of the intrusive investigation and subsequent laboratory analysis undertaken are detailed below. The descriptions of the strata encountered, notes regarding visual or olfactory evidence of contamination, list of samples taken, field observations of soil and groundwater, in-situ testing and details of monitoring well installations are included on the exploratory hole records presented in Appendix H.

5.1 Soil

The exploratory holes revealed that the site is underlain by a variable thickness of topsoil, possible made ground or made ground over the Pennine Middle Coal Measures, which grades from weathering Class E at the upper boundary to Weathering Class B encountered at depth (within the trial pits). This appears to confirm the stratigraphical succession described within the initial conceptual model. For the purpose of discussion, the ground conditions are summarised in Table 11 and the strata discussed in subsequent subsections.

Table 11: General succession of strata encountered

Strata	Exploratory holes encountered	Depth to top of stratum m bgl	Thickness (m)
Topsoil	TP10, TP11, TP18, PH1 – PH7 BH1 – BH4	Ground level	0.30m
Possible made ground	TP01, TP09 BH5	Ground level	0.30m – 0.50m 3.00m in BH5
Made ground	TP02, TP04 - TP08, TP12, TP13, TP14, TP15, TP16, TP17, TP19 - TP24 PH8, BH6	Ground level	0.15m – 0.60m (average) More than 4.60m in TP13, to 3.20m in TP14, to 1.80m in TP15, to 1.70m in TP16, to 3.00m in TP21
Pennine Middle Coal Measures (Weathering Class E/D)	TP01 - TP07, TP09 - TP12, TP15 – TP20, TP22 - TP24 PH1 – PH8 BH1 – BH4, BH6	Ground level – 0.60m (average) 1.80m in TP15 and 1.70m in TP16	0.40m – 2.70m
Pennine Middle Coal Measures (Weathering Class B)	TP01 - TP06, TP08, TP09, TP11, TP12, TP14, TP15, TP17 -	0.55m – 3.20m	0.20m – 2.45m

Class C/B)	TP24 PH1 – PH8 BH1 – BH6		
Pennine Middle Coal Measures (Coal)	TP01, TP02, TP04 PH4, PH8 BH1, BH2, BH3, BH3A, BH4, BH5, BH6	0.65m - 2.40m 12.00m in PH4, 10.30m, 20.80m and 26.50m in PH8 5.80m in BH1, 11.00m and 11.80m in BH2, 5.00m in BH3, 5.00m in BH3A, 0.710m in BH4, 6.70m and 9.00m in BH5, 4.70m in BH6	0.15m - 0.30m 3.80m in PH4, 0.20m – 0.30m in PH8 0.20m in BH1, 0.50-0.60m in BH2, 0.20m in BH3, 0.20m in BH3A, 0.40m in BH4, 0.10-0.50m in BH5, 0.30m in BH6

5.1.1 Made ground and Topsoil

The composition of the made ground varied across the site depending on the area. In Area 1, the Western Area, made ground generally comprised reworked natural cohesive clay, with occasional pieces of pottery and wood.

In Area 2, the Central Area, there were two areas of made ground noted. The northern field that historically had been raised according to the historical plans, indicated depths of over 4.60m of made ground in the centre of this area, tapering out at the edges to thicknesses of around 1.70m. The made ground encountered in this area comprised sandy gravelly clay with many pieces of glass, pottery, tiles, plastic, brick, metal and tarmac, often noted to have an organic odour. TP12 is located in the southern part of Area 2 and encountered made ground to 0.60m, which comprised sandy gravelly clay; the gravel comprised sandstone, brick and pottery, pieces of metal and pipes were also noted.

Area 3, the Eastern Area, was predominantly covered with natural soils or reworked natural soils with occasional pieces of plastic noted. In the south west corner of this area 3, TP17 encountered made ground to 0.30m which contained pieces of plastic, tyre and glass. The trial trenches were completed in this area to attempt to locate the presence of the mine adits. Close to the area of trial trench 4 a pile of broken tiles were noted suspected to be asbestos containing material in the form of corrugated tiles.

In the area of made ground associated with the building next to Manor House farm, Area 4, the made ground comprised concrete over sandy gravelly clay. Made ground was typical of demolition type materials including brick and concrete to a depth of around 0.60m. Brick footings were noted in this area.

In Area 5, the former school, brick footings were noted to a depth of 3.00m in TP21, which suggests that a basement may have been present which appears to have been

infilled. The made ground material comprised sandy gravelly clay with some tarmac, sandstone, brick and concrete.

5.1.2 Pennine Middle Coal Measures – Class E to D

This stratum was encountered beneath the made ground or topsoil and comprised a layer of firm to stiff slightly sandy slightly gravelly clay between 0.40m and 2.70m in thickness. Based on the in-situ and laboratory test data this layer has a modified plasticity index or between 12% and 33% and as such is likely to have a low to medium volume change potential.

A summary of the in-situ and laboratory test results in this stratum is presented in Table 12 and laboratory test results can be found in Appendix Q.

Table 12: Summary of in-situ and laboratory test results for Pennine Middle Coal Measures – Class E to D

Soil parameters	Range	Reference
Liquid limit (%)	33-61	Appendix Q
Plasticity limit (%)	20-36	Appendix Q
Plasticity index (%)	13-33	Appendix Q
Plasticity term	Low to High	Appendix Q
Moisture content (%)	13-40	Appendix Q

5.1.3 Pennine Middle Coal Measures – Class C to B

Mudstone and sandstone was encountered at a depth of between 0.55m and 3.20m below ground level and was recorded to the full extent of the investigation.

A summary of the in-situ and laboratory test results in this stratum is presented in Table 13 and laboratory test results can be found in Appendix Q.

Table 13: Summary of soil parameters for Pennine Middle Coal Measures – Class C to B

Soil parameters	Range	Reference
Liquid limit (%)	36-45	Appendix Q
Plasticity limit (%)	21-23	Appendix Q
Plasticity index (%)	15-22	Appendix Q
Plasticity term	Intermediate	Appendix Q
Moisture content (%)	12-24	Appendix Q

Coal seams were encountered at the exploratory locations and the depths and thicknesses are presented in Table 14.

Table 14: Summary of coal seams encountered

Exploratory hole location	Depth (m)	Thickness (m)
TP01	2.40–2.70	0.30
TP02	0.65–0.80	0.15
TP04	1.05–1.20	0.15
	2.45–2.70	0.25
PH4	12.00–15.80	3.80
PH8	10.30–10.50	0.20
	20.80–21.00	0.20
	26.50–26.80	0.30
BH1	5.80–6.00	0.20
BH2	11.00–11.60	0.60
	11.80–12.30	0.50
BH3	5.00–5.20	0.20
BH3A	5.00–5.20	0.20
BH4	0.70–1.10	0.40
BH5	6.70–7.20	0.50
	9.00–9.10	0.10
BH6	4.70–5.00	0.30

5.1.4 Mining

The preliminary mining risk assessment in section 3.10 highlighted the presence of historical mining between the late 1800s and 1986. The seams that were worked included the Barnsley and Low Haigh Moor (Netherton Thick) seams. A series of six boreholes (BH1 to BH6) have been completed to depths ranging from 9.1m to 31.0m and eight rotary probeholes (PH1 to PH8) have been completed to depths ranging from 9.0m to 30.0m to establish the presence of coal or workings underlying the site.

The probing investigation encountered evidence of shallow workings (broken ground or possible voids) across the site, as presented in Table 15.

Table 15: Summary of coal workings/voids encountered

Exploratory hole location	Depth (m)	Thickness (m)	Details and Assumed Coal Seam
PH2	3.00–7.50	4.50	Void – Barnsley Seam
PH3	10.00–14.50	4.50	Soft ground – Barnsley Seam
PH5	8.80–15.20	6.40	Soft ground – Barnsley Seam

Exploratory hole location	Depth (m)	Thickness (m)	Details and Assumed Coal Seam
PH6	2.00-8.00	6.00	Soft ground – Barnsley Seam
PH7	4.50-9.00	5.00	Soft ground – Barnsley Seam
BH4	17.00-19.00	2.00	Void – Barnsley Seam

To the south of the southeast-northwest trending fault lines the Barnsley Rider Coal has been confirmed to exist at shallow depth across the north eastern part of the site (as shallow as 0.70m) at BH4 with a thickness of 0.40m.

Underlying the Barnsley Rider, the crop of the Barnsley Seam across the north eastern area of the site is confirmed. The Barnsley Seam is encountered as an intact thickness of 3.80m at 12.00m to 15.80m in PH04. The seam however, is encountered as voids or soft ground as detailed in Table 15 above. These voids / soft ground horizons confirm the Barnsley Seam has been worked.

The unnamed seam that is shown to crop to the south west of the site is confirmed as an intact 0.5m thick coal seam at BH05 at depths of 6.70m to 7.20m. The Top Haigh Moor Coal Seam is encountered as a 0.10m thick intact coal seam at BH05 (between 9.00m to 9.10m bgl), at BH06 as a 0.30m thick intact seam (between 4.70m and 5.00m bgl) and at PH08 as an intact 0.20m thick coal seam (between 10.30m to 10.50m bgl).

To the north of the southeast-northwest trending fault line, the same sequence of seams is encountered, with similar thicknesses, but as intact seams suggesting the seams were not extensively worked north of the southeast-northwest trending fault line.

Figure 7 and Figure 8 show a representative cross-section of geological profile of the boreholes and probholes that intersect the voids/working of the Barnsley Seam. The line of the cross-sections are shown on Figure 6.

In addition to the coal seam investigation, a series of trial trenches were excavated to attempt to locate the presence of the mine adits that are detailed in the Coal Authority report. A detailed Shaft Plan and Data Sheet was obtained from the Coal Authority to investigate further any records held by the Coal Authority, the report is included in Appendix F. The details are listed in Table 7 in section 3.10.

The trial trenching was able to identify one of the mine adits, as shown on Figure 10. Photographs are included in Appendix I.

5.1.5 Groundwater

Due to the nature of the drilling (rotary that uses added water for flush throughout drilling) significant groundwater strikes were not encountered during this investigation. Groundwater seepages were noted in four trial pits at various depths and in differing strata which suggests a localised perched groundwater table may be present across the site.

It should be noted that groundwater levels might fluctuate for a number of reasons including seasonal variations. Ongoing monitoring would be required to establish both the full range of conditions and any trends in groundwater levels.

The results of the subsequent groundwater monitoring and well surveying exercise are summarised in Table 16. The limited data available is unable to confirm the groundwater flow direction.

Table 16: Groundwater monitoring data (22.02.2016)

Monitoring well	Depth to water (mb TOC)
BH01	8.404
BH02	8.070
BH03A	3.735
BH04	1.880
BH05	Dry
BH06	Dry

5.1.6 Visual/olfactory evidence of soil and groundwater contamination

Generally, no significant visual or olfactory evidence of anthropogenic contamination was noted during the investigation and no further source areas were identified. Significant depths of made ground were noted in the northern central part of the site, however the made ground did not contain any notable evidence of contamination.

5.2 Ground gas regime

The results of the ground gas monitoring and testing carried out are given in Appendix J. The results are summarised in Table 17.

Table 17: Summary of ground gas monitoring results

Borehole	Response zone/strata	Probable source(s) of ground gas	Number of monitoring visits	Methane (%)	Carbon dioxide (%)	Oxygen (%)	Flow rate (l/hr)	Water level (m b TOC)	Atmospheric pressure (mbar)
BH1	PMCM	Coal measures strata	2	<0.1	<0.1	20.8	2.5	8.404	996 - 1018
BH2			2	<0.1	1.9	18.7	0.1	8.070	997-

									1018
BH3A			2	<0.1	<0.1	21.1	0.2	3.735	996-1018
BH4			2	<0.1	1.4	20.3	0.0	1.48	995-1018
BH5			2	<0.1	0.3	21.4	0.2	0.882	997-1020
BH6			2	0.1	0.9	18.6	0.3	Dry	997-1021
Note: PMCM = Pennine Middle Coal Measures									

5.3 Refinement of the initial conceptual site model

The ground, groundwater and ground gas conditions confirmed by the intrusive investigation are generally in accordance with those considered in the PRA. Three areas of significant made ground were noted associated with the building next to Manor House Farm (Area 4), the northern portion of the Central Area (Area 2), and associated with the former school (Area 5). There are some other areas of made ground present in the south of the site and across the site, assumed to be from disturbance of the ground due to agricultural activities.

Firm to stiff clay believed to represent the residual upper surface of the Pennine Middle Coal Measures in its completely weathered state was encountered between ground level and a depth of 0.60m below ground level at a thickness varying between 0.40 and 2.70m. Mudstone and sandstone of the Pennine Middle Coal Measures were encountered at a depth of between 0.55 and 3.20m to the full depth of investigation. Bands of coal were encountered in four locations at shallow depth of between 0.65 and 2.70 m and at five locations slightly deeper between 4.70 and 9.10 m depth. Deeper bands of coal were encountered in three locations between 10.30 and 26.80 m depth.

This generally confirms the stratigraphical succession described in the initial conceptual model.

Shallow groundwater was encountered as seepages during the trial pit investigation at depths ranging between 0.60 and 2.55m in the made ground and underlying Pennine Middle Coal Measures. The standing water levels in monitoring wells installed in boreholes were between 1.880 and 8.404 mb TOC.

Shallow groundwater beneath the site is not expected to be in continuity with the underlying secondary A Aquifer, which is expected to be encountered at depth. The groundwater seepages encountered during the investigation are believed to be discrete pockets within the various strata. The groundwater is unlikely to be in continuity with the River Dearne located 177m west of the site, as discussed within the PRA.

Concentrations of ground gas were found to be low in the first two rounds of monitoring; however, it is considered that the monitoring carried out to date is insufficient to characterise the ground gas regime adequately.

The following potential pollutant linkages, which were identified in the PRA, are considered as still requiring assessment:

- 1) Direct contact of contaminated soils to future site users
- 2) Inhalation exposure of future site users to asbestos fibres
- 3) Plant uptake of contaminants within the soils, which may affect plant growth
- 4) Chemical attack on infrastructure including concrete and potable water supply pipes from contaminated soils
- 5) Inhalation and explosion of hazardous ground gases from build up within buildings

These linkages are assessed in Section 6.

5.3.1 Uncertainty

Close to the area of trial trench 4, a pile of broken suspected asbestos containing corrugated tiles were noted. This was not sampled due to specialist equipment not being available at the time of the excavation. A photograph was taken and was assessed by an RSK asbestos specialist who confirmed the material is highly likely to be ACM. The photograph has been provided in Appendix I.

6 QUANTITATIVE RISK ASSESSMENT

In line with CLR11 (EA, 2004a), there are two stages of quantitative risk assessment, generic and detailed. The GQRA comprises the comparison of soil, groundwater, soil gas and ground gas results with generic assessment criteria (GAC) that are appropriate to the linkage being assessed. The results of the soil laboratory testing are provided in Appendix K.

6.1 Linkages for assessment

Section 5.3 presents the refined conceptual model which identified the linkages that required assessment after the findings of the site investigation had been considered. These linkages together with the method of assessment are presented in Table 18.

Table 18: Linkages for generic quantitative risk assessment

Potentially relevant pollutant linkage	Assessment method
1. Direct contact with impacted soil by future residents	Human health GAC in Appendix L for a proposed residential end use with private gardens since proposed end use includes residential gardens.
2. Inhalation exposure of future residents to asbestos fibres	Qualitative assessment based on the asbestos minerals present, their form, concentration, location and the nature of the proposed development.
3. Uptake of contaminants by vegetation potentially impacting plant growth	Comparison of soil data to GAC in Appendix N.
4. Contaminants permeating potable water supply pipes	Comparison of soil data to GAC in Appendix O for plastic water supply pipes using UKWIR (2010) guidance.
5. Concentrations of methane and carbon dioxide in ground gas entering and accumulating in: depressions and excavations that could affect workers enclosed spaces or small rooms in new buildings, which could affect future residents. In the case of methane this could create a potentially explosive atmosphere, while death by asphyxiation could result from carbon dioxide.	Gas screening values (GSV) have been calculated using maximum methane and carbon dioxide concentrations with maximum flow rates recorded at the site. The GSV have been compared with the generic Traffic Lights, as presented within the NHBC ground gases guide (Boyle and Witherington, 2007) and the aforementioned CIRIA report C665, owing to the development comprising low-rise housing with suspended floors. In addition, the gas regime is considered within the context of a conceptual model as required by both aforementioned guidance documents and BS8576

6.2 Methodology and results

The methodology and results of the GQRA are presented for each relevant pollutant linkage in turn.

6.2.1 Direct contact with impacted soil by future residents

Both targeted and non-targeted soil samples were obtained during the site investigation, however, this investigation was aimed at providing an indicative assessment of the site and only a limited number of samples were tested from each area. The results of the laboratory testing have been evaluated in the following subsections depending on the site area. A comparison table of the soil laboratory results to the corresponding GAC is provided in Appendix M.

6.2.1.1 Area 1 – The Western Area

One sample of made ground and one sample of the underlying natural soils was tested for a suite of contaminants. The results were directly compared to the GACs for a residential end use. All of the results were below the GACs, which indicates that the made ground and underlying natural soils are suitable for the proposed end use.

6.2.1.2 Area 2 – The Central Area

Two samples of made ground or possible made ground were tested from the southern part of this area, and four samples were tested from the raised area of infilled ground in the north. All results were compared directly to the GACs and were below the GAC values for all contaminants except the following:

- TP13 at 0.00-0.25m, result of 47mg/kg for Arsenic, which is above the GAC of 37mg/kg
- TP13 at 0.30-0.50m, result of 45mg/kg for Arsenic, which is above the GAC of 37mg/kg
- TP16 at 1.10-1.40m, result of 382mg/kg for Lead, is above the GAC of 200mg/kg

These results indicate there may be some elevated concentrations of metals within the infilled ground in the northern part of Area 2.

6.2.1.3 Area 3 – The Eastern Area

Two samples of made ground and one sample of the topsoil was tested for a suite of contaminants. The results were directly compared to the GACs for a residential end use. All of the results were below the GACs, which indicates that the made ground and topsoil are suitable for the proposed end use.

6.2.1.4 Area 4 – Manor House Farm Area

Two samples of made ground was tested for a suite of contaminants. The results were directly compared to the GACs for a residential end use. All of the results were below the GACs, which indicate that the made ground is suitable for the proposed end use.

6.2.1.5 Area 5 – Former School Area

Two samples of made ground were tested from this area. All results were compared directly to the GACs and were below the GAC values for all contaminants except the following:

- TP21 at 0.00-0.50m, result of 42.1mg/kg for Benzo(a)anthracene, which is above the GAC of 11mg/kg
- TP21 at 0.00-0.50m, result of 35.6mg/kg for Benzo(a)pyrene, which is above the GAC of 5mg/kg
- TP21 at 0.00-0.50m, result of 40.8mg/kg for Benzo(b)fluoranthene, which is above the GAC of 3.3mg/kg
- TP21 at 0.00-0.50m, result of 50.6mg/kg for Chrysene, which is above the GAC of 22mg/kg
- TP21 at 0.00-0.50m, result of 3.81mg/kg for Dibenzo(ah)anthracene, which is above the GAC of 0.28mg/kg

These results indicate some elevated concentrations of PAH within one sample (TP21 at 0-0.5m). This is likely to be due to the presence of tarmac gravel within this material.

6.2.1.6 Summary

On the basis of the above assessment it is considered that there are potentially significant risks associated with the soil contamination and, as such, either additional risk assessment or remediation is required.

6.2.2 Inhalation exposure of future residents to asbestos fibres

The visual inspection at the laboratory identified no materials suspected of potentially containing asbestos and the scheduled laboratory screening for asbestos found no detectable asbestos fibres within the samples of made ground.

However, during the site works, broken piece of possible asbestos containing material in cement form were noted at ground level, close to the area of trial trench 4. The material was left in-situ in order to not disturb the area, as specialist sampling equipment was not available. A photograph was taken and has been assessed by an asbestos specialist, who confirmed it is highly likely to be ACM. The photograph is included in Appendix I.

6.2.3 Uptake of contaminants by vegetation potentially inhibiting plant growth

The results have been compared with the GAC presented in Appendix N for this linkage. The results indicate that a relevant pollutant linkage associated with phytotoxic effects is likely to exist. The results for zinc from TP12 at 0.00-0.60 m of 647 mg/kg (pH 7.66) and from TP16 at 1.10-1.40 m of 606 mg/kg (pH 7.33) are above the GAC of 300 mg/kg for both the appropriate pH bands.

However, the depth of an analysis for uptake of contaminants by vegetation is not required to be any deeper than 0.25 m depth, according to the guidance. Therefore, it is likely that the sample from TP16 at 0.80 m be discounted, depending on the proposed final ground levels.

In the area of TP12, a suitable thickness of capping material may be required, depending on the layout of the proposed development.

6.2.4 Impact of organic contaminants on potable water supply pipes

For initial assessment purposes, the results of the investigation have been compared with the GAC presented in Appendix O for this linkage, which are reproduced from *UKWIR Report 10/WM/03/21. Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites* (UKWIR, 2010).

The results indicate that a relevant linkage is unlikely to exist associated with organic contaminants across the majority of the site. Therefore pollutant polyethylene (PE) and/or polyvinyl chloride (PVC) water supply pipes are expected to be suitable for use on the majority of the development, except for within the vicinity of TP21, where elevated results for mineral oils were noted. Further assessment of this area should be completed once the proposed routes of the pipelines are known.

It should be noted that at the time of this investigation the future routes of water supply pipes had not been established, hence the investigation and sampling strategy may not be fully compliant with UKWIR recommendations. Consequently, a targeted investigation and specific sampling/analytical strategy may be required at a later date once the route(s) of the supply pipes are known. In addition, it is recommended that the relevant water supply company be contacted at an early stage to confirm its requirements for assessment, which may not necessarily be the same as those recommended by UKWIR.

6.2.5 Ground gas

The results have been assessed in accordance with the guidance provided in BS8576 and *CIRIA Report C665*. In the assessment of risks and selection of appropriate mitigation measures, both reports highlight the importance of the conceptual model.

CIRIA C665 identifies two types of development, termed Situation A (modified Wilson and Card method), appropriate to all development excluding traditional low-rise

construction, and Situation B (National House-Building Council, NHBC) only appropriate to traditional low-rise construction with ventilated sub-floor voids.

Both methods are based on calculations of the limiting borehole gas volume flow for methane and carbon dioxide, renamed as the gas screening value (GSV). The GSV (litres of gas per hour) is calculated by multiplying borehole flow rate (litres per hour) and gas concentration (percent by volume).

In both situations, it is important to note that the GSV thresholds are guideline values and not absolute. The GSV thresholds may be exceeded in certain circumstances, if the site conceptual model indicates it is safe to do so. Similarly, consideration of additional factors such as very high concentrations of methane, should lead to consideration of the need to adopt a higher risk classification than the GSV threshold indicates.

The site is to be redeveloped with low rise housing, however the foundation solutions have yet to be finalised and therefore both Situation A and B have been considered.

Situation A relates to all development types except low-rise housing and, by combining the qualitative assessment of risk (see refined conceptual model in Section 5.3) with the gas monitoring results, provides a semi-quantitative estimate of risk for a site. The method uses both gas concentrations and borehole flow rates to define a characteristic situation for a site based on the limiting borehole gas volume flows for methane and carbon dioxide. Having calculated the worst case GSVs for methane and carbon dioxide, the Characteristic Situation is then determined from Table 8.5 of CIRIA C665.

Situation B is a characterisation system developed by the NHBC (Boyle and Witherington, 2007), which relates only to low rise housing development constructed with a clear ventilated underfloor void. The system provides a risk-based approach that is designed to allow an identification of the required gas protection measures for low-rise housing by comparing the measured gas emission rates to generic “Traffic Lights”. The Traffic Lights include typical maximum concentrations that are provided for initial screening purposes and risk-based GSVs for situations where the typical maximum concentrations are exceeded. Based on the typical maximum gas concentrations and the GSVs, the appropriate Traffic Light, ranging from Green through Amber 1 and Amber 2 to Red, is determined from Table 8.7 of CIRIA C665.

The GSV calculations for each borehole are included in Appendix P. The gas monitoring data has identified a maximum methane concentration of <0.1% and a maximum concentration of carbon dioxide of 1.9%. A maximum gas flow rate of 2.4 l/hr has been recorded. Please note CIRIA C665 recommends using the highest gas concentration and highest flow rate recorded at the site even if recorded in different boreholes, unless the characterisation of the site has clearly indicated that the values are associated with different soil gas regimes, e.g. different sources of gas. The calculated GSV for methane is 0.00 l/hr and the GSV for carbon dioxide is 0.00 l/hr. Based on the GSVs the site has been characterised as Green or as Characteristic Situation 1.

For both types of development, CIRIA C665 provides details of the typical scope of protective measures to be adopted for the relevant site characterisation.

The gas monitoring programme carried out to-date provides some evidence for an initial assessment of redevelopment requirements. However, it is considered that the monitoring undertaken during this investigation has not established the 'worst-case' scenario and therefore further monitoring is required to characterise adequately the ground gas regime. Adequate monitoring should be carried out to enable the confident assessment of risk and subsequent design of an appropriate gas protection scheme(s) for the proposed development.

6.3 Environmental assessment conclusions

This investigation aimed to provide information on the ground conditions to provide an initial assessment of the geo-environmental liabilities associated with the development of the site. At the time of writing the layout of proposed development has not been finalised and only an indicative plan has been provided.

The potential pollutant linkages were looked at in turn. The following conclusions can be drawn from the findings:

The intrusive investigation indicated that a number of areas of made ground were present in discrete locations across the site. The results of the contamination testing indicate elevated levels of metals within the northern raised area and a single location with elevated levels of PAH in the south eastern corner of the site associated with the former school were present. The testing completed this far is intended to represent an exploratory level survey of chemical conditions, generally in accordance with BS10175:2001.

In line with BS10175 and CLR 11, further investigations may subsequently be required to achieve full characterisation of the site and development of a detailed conceptual site model to provide full site characterisation to a level that will enable the design of a remediation strategy for the site and / or the discharge of planning conditions relating to contamination.

Whilst asbestos containing materials were not identified during the laboratory analysis of the eight samples, significant depths of made ground, both historical and recent are noted at the site and therefore the risk from asbestos fibres should not be discounted completely.

Furthermore, a pile of suspected ACM was noted close to the location of trial trench 4. The ACM was broken corrugated tiles/cement. Analysis by an RSK asbestos specialist indicated that it is highly likely to be ACM. It is likely to be present due to localised fly tipping. The risk of inhalation exposure to future site users cannot be discounted.

The results from the laboratory analysis indicated an area around TP12 which would be unsuitable for the growth of plants due to the presence of zinc. The results provide an indication of the chemical constituents of the soils on site, although due to the presence of made ground across certain parts of the site, it is likely that further intensive sampling and testing will be required in the proposed garden areas to ensure the soils are suitable for the growth of plants.

The proposed routes of the potable water supply pipes are currently unknown. A targeted soil sampling and testing investigation should be completed in the route of the proposed pipes once they are known to fully assess the risk of chemical attack on the supply pipes from contaminated soils.

Two rounds of ground gas monitoring have been completed to date. The results indicate that ground gas protection measures will not be required in the construction of the new dwellings. However, it would be prudent to note that the site lies within an intermediate probability radon area, as between 3 and 5% of homes are above the action level as defined by the British Geological Survey, National Geoscience Information Service.

Therefore, the risk of significant ingress of radon into structures on-site is considered to be medium and basic radon protective measures are required within new dwellings at the site.

7 GEOTECHNICAL SITE ASSESSMENT

7.1 Engineering considerations

It is understood that the proposed development is to involve the construction of approximately 300 residential properties and associated infrastructure. At this stage no specific information relating to building loads has been provided and therefore a wall loading of 100kN/m has been considered. It has been assumed the ground-bearing floor slabs will not be required and that beam and block flooring will be utilised.

7.2 Geotechnical hazards

A summary of commonly occurring geotechnical hazards is given in Table 19 together with an assessment of whether the site may be affected by each of the stated hazards.

Table 19: Summary of main potential geotechnical hazards that may affect site

Hazard category (excluding contamination issues)	Hazard status based on investigation findings and proposed development			Engineering considerations if hazard affects site
	Found to be present on site	Could be present but not found	Unlikely to be present and/or affect site	
Sudden lateral changes in ground conditions		Ē	Two fault line shown to dissect the site may cause variable change in depth to bedrock	Likely to affect ground engineering and foundation design and construction
Shrinkable clay soils	Ē	Clays have been found to be low to medium plasticity and there are a number of established trees on the site which will affect the shrinkability of the soils		Design to NHBC Standards Chapter 4.2 or similar
Highly compressible and low bearing capacity soils, (including peat and soft clay)		Ē		Likely to affect ground engineering and foundation design and construction

Hazard category (excluding contamination issues)	Hazard status based on investigation findings and proposed development			Engineering considerations if hazard affects site
	Found to be present on site	Could be present but not found	Unlikely to be present and/or affect site	
Silt-rich soils susceptible to rapid loss of strength in wet conditions	Ė	Variable silt content in the weathered Middle Coal Measures		Likely to affect ground engineering and foundation design and construction
Running sand at and below water table			Ė	Likely to affect ground engineering and foundation design and construction
Ground subject to or at risk from landslides			Ė	Likely to require special stabilisation measures
Ground subject to or at risk from coastal or river erosion			Ė	Likely to require special protection/stabilisation measures
High groundwater table (including waterlogged ground)		Ė		May affect temporary and permanent works
Underground mining	Ė	Evidence of mine workings and mine adits present on site		Likely to require special stabilisation measures
Existing sub-structures (e.g. tunnels, foundations, basements, and adjacent sub- structures)	Ė	Evidence of basements noted in Area 5, former school area		Likely to affect ground engineering and foundation design and construction
Filled and made ground (including embankments, infilled ponds and quarries)	Ė	Areas of filled ground associated with former buildings and infilled raised area in north of Area 2.		Likely to affect ground engineering and foundation design and construction
Adverse ground chemistry (including expansive slags and weathering of sulphides to sulphates)		Ė (See section 7.3.7)		May affect ground engineering and foundation design and construction
Note: Seismicity is not included in the above table as this is not normally a design consideration in the UK.				

7.3 Foundations

7.3.1 General suitability

Generally, firm to stiff clay is present at a relatively shallow depth across the site beneath the made ground, therefore it is considered that traditional shallow spread footings will be suitable for the majority of the proposed development.

Localised areas of deeper made ground and possible made ground were encountered as follows:

- Raised area in central northern part of site (TP13, at least 4.6m; TP14, 3.2m; TP15, 1.8m and TP16, 1.7m)
- BH05, 3.0m (possible made ground)
- TP21, 3.0m in the south eastern part of site

Where made ground is less than 2.5m deep in these areas, trench fill foundations are considered suitable.

Where made ground is over 2.5m deep, alternative foundations will be required. Alternative foundation options will depend on final ground levels and may include piled and/or raft foundations; production of a final foundation design layout is recommended.

For areas affected by shallow underground coal workings, spread foundations will need to be suitably reinforced.

7.3.2 Shallow spread foundations

The recommendations for the design and construction of spread foundations in relation to the ground conditions are set out in Table 20.

Table 20: Design and construction of spread foundations

Design/construction considerations	Design/construction recommendations
Founding stratum	Residual soils (Class E to Class C weathered Coal Measures)
Depth	Foundations should be taken to a minimum depth of 0.9m below finished ground level and at least 0.1m into the founding stratum below any overlying topsoil or made ground or to any greater depth required in respect of the special design considerations given below.
Special design considerations	Owing to the presence of low to medium shrinkable clay soils, foundations should be designed taking into account all the normal precautions, including minimum founding depths, to minimise the risk of future foundation movements in accordance with NHBC standards or similar.

Design/construction considerations	Design/construction recommendations
	Owing to the potential for significant lateral and vertical variability of the founding strata, consideration should be given to incorporating appropriate reinforcement into the strip foundations to minimise the risk of future differential foundation movements.
Bearing capacity	Spread foundations constructed on the weathered Coal Measures at a minimum depth of 0.90 m bgl can be designed using a net allowable bearing pressure of 120 kN/m². The allowable bearing capacity includes an overall factor of safety of 3 against bearing capacity failure with the total settlements associated with the bearing pressure estimated to be less than 25 mm.
Stability of excavations	Generally the trial pits remained stable during excavation which indicates that foundation excavations should also remain stable in the short term. In the event that excavations are to remain open for longer periods, consideration should be given to the use of trench support systems.
Dewatering	During ground investigation works, groundwater seepage was occasionally recorded in the trial pits. Subsequent groundwater monitoring indicated standing water at it's highest in BH4 and BH5 at depths ranging between 0.88m and 1.88m bgl, therefore allowance should be made for localised water control in these parts of the site (eastern area) during foundation excavation. The highest standing water level in the remaining monitoring wells was 3.6m bgl, indicating that dewatering may not be required in the western part of site.
Construction considerations	All foundation excavations should be inspected, and any made ground and soft, organic or otherwise unsuitable materials removed and replaced with mass concrete. The proposed founding stratum is a relatively silt-rich soil, hence susceptible to rapid softening once exposed. Hence all foundation excavations should immediately be blinded with concrete or the full foundation constructed.

7.3.3 Foundation works risk assessment

It is anticipated that a foundation works risk assessment report will not be required for the development because concentrations of chemicals of potential concern (COPC) within made ground and natural soils were typically below corresponding GAC. Where exceedances were noted, these were found to be marginal and of the same order of magnitude as the associated GAC. It may be prudent to further investigate the area of elevated PAH in the south east corner of the site, as a localised foundation works risk assessment may be required for this area.

7.3.4 Development risk from coal mining assessment

There are a number of lines of evidence that show the Barnsley Rider Coal and Barnsley Coal outcrop within the site boundary. Additionally, the unnamed seam and the Top Haigh Moor Coal Seam outcrop to the southwest of the site. Therefore, there are

significant areas of the site that are underlain by either intact or worked coal seams at relatively shallow depth.

It is recommended that the thickness of competent rock overlying an underlying coal / worked seam required to ensure ground stability at the surface is ten times that of the underlying coal / worked seam. On this basis there are substantial areas of the site that do not have the required 'ten times' seam thickness, and these areas will require stabilisation prior to development. These areas are shown on Figure 11.

In addition four mining adits have been identified from the Coal Authority records to be present close to the crop of the Barnsley Coal. The position of each of these adits should be identified and each of them stabilised to mitigate potential risk to the proposed development.

7.3.5 Floor slabs

It is assumed that during construction of the proposed housing development, a block and beam flooring system will be utilised and therefore floor slabs will be suspended across the whole development.

7.3.6 Roads, hardstanding and drainage

The near surface ground conditions consist of made ground over firm to stiff clay. Therefore, for preliminary purposes a California bearing ratio (CBR) value of 3% can be considered for pavement design. It is recommended that in situ CBR determination be carried out targeting areas of hardstanding prior to construction works, to confirm this value.

7.3.7 Chemical attack on buried concrete

This assessment of the potential for chemical attack on buried concrete is based on current BRE guidance. The desk study and site walkover indicate that, for the purposes of this assessment of the aggressive chemical environment, the site should be considered as a brownfield site.

The laboratory results indicate 2:1 water soil extract sulphate contents of up to 60mg/l with pH values varying between 6.62 and 7.70. Based on the results, an Aggressive Chemical Environment for Concrete classification of AC-1 with a Design Sulphate Class of DS-1 may be assumed for design purposes. This assumes nominally mobile groundwater conditions and that no significantly disturbed clay comes into contact with concrete foundations or structures.

8 REUSE OF MATERIALS AND WASTE

8.1 Reuse of suitable materials

Under the Waste Framework Directive naturally occurring soils are not considered waste if re-used on the site of origin for the purposes of development.

In accordance with the definition provided in the Waste Framework Directive, materials are only considered waste if 'they are discarded, intended to be discarded or required to be discarded, by the holder'. Thus, soils that are not of clean and natural origin, i.e. made ground (whether contaminated or not) and other materials such as recycled aggregate, do not become waste until the aforementioned criteria are met.

The Definition of Waste: Development Industry Code of Practice (CL:AIRE, 2011) (CoP) was developed in consultation with the Environment Agency and development industry to enable the re-use of materials under certain scenarios and subject to demonstrating that specific criteria are met. The current re-use scenarios covered by the CoP comprise:

- Re-use on the site of origin (with or without treatment)
- Direct transfer of clean and natural soils between sites
- Use in the development of land other than the site of origin following treatment at an authorised Hub site (including a fixed Soil Treatment Facility).

The importation of made ground soils (irrespective of contamination status) or crushed demolition materials is not currently permitted under the CoP and requires either a standard rules environmental permit or a U1 waste exemption (see below).

In the context of excavated materials used on sites undergoing development, four factors are considered to be of particular relevance in determining if the material is a waste or when it ceases to be waste:

- the aim of the Waste Framework Directive is not undermined, i.e. if the use of the material will create an unacceptable risk of pollution of the environment or harm to human health it is likely to be waste
- the material is certain to be used
- the material is suitable for use both chemically and geotechnically
- only the required quantity of material will be used.

The CoP requires the preparation of a materials management plan (MMP) that confirms the above factors will be met. This plan needs to be reviewed by a 'Qualified Person' (QP) who will then issue a declaration form to the EA. As the project progresses, data must be collated and on completion a verification report produced that shows the MMP was followed and describes any changes.

The MMP establishes whether specific materials are classified as waste and how excavated materials will be treated and/or re-used in line with the CoP. The MMP is likely to form part of the site waste management plan.

Although generally undeveloped, the site has had several phases of construction and demolition of buildings, industrial uses (the tramline) and an area of infilled ground and the investigation has confirmed the presence of made ground. Therefore, before any excavation works begin on-site, an MMP will need to be prepared, reviewed by a QP; and a Declaration lodged with the EA.

As noted above, under the Waste Framework Directive naturally occurring soils are not considered waste and therefore arisings of clean natural soils, e.g. from foundation and drainage excavations, may be re-used on the site. However, it is important that these soils should be stockpiled separately and not become cross-contaminated with made ground / contaminated soils or construction wastes.

If it is proposed to import clean and naturally occurring soils direct from another site, the receiving site's MMP would need to be updated in advance of importation.

8.2 Treatment to meet suitable-for-use criteria

Where materials do not meet the suitable for use criteria it may be possible to treat them under an environmental permit (mobile treatment licence) to enable them to be reused onsite.

To enable the treatment options to be determined, an options appraisal and a remediation strategy document will be necessary to support discussion of the issues with regulators and third parties.

8.3 Reuse of waste materials

If material is discarded as waste then its reuse on site may still be possible. Waste soils and recycled aggregate can be reused on site under a standard rules environmental permit or a U1 waste exemption from the Environmental Permitting (England and Wales) Regulations 2010 provided that they are suitable for the proposed use, i.e. not cause harm to human health or the environment. However, it should be noted that these have strict limits on the quantity of material that can be reused.

8.4 Wastes for landfill disposal

Wastes require pre-treatment prior to disposal at landfill. Pre-treatment must be a physical, thermal, chemical or biological process (including sorting) that changes the characteristics of the waste to reduce its volume, reduce its hazardous nature, facilitate its handling and enhance its recovery.

The latest, edition of the EA's 'Technical Guidance WM3' (2015) Guidance on the classification and assessment of waste, requires that within a mixed waste* the separately identifiable wastes are assessed separately. Mixing of different types of hazardous waste and hazardous waste with other waste substances is prohibited under the Waste Framework Directive. Wastes that have been mixed must be separated whenever possible.

It is best practice to provide your waste carrier (or the disposal site) with details of how the waste has been treated. Your waste carrier may provide a pre-treatment confirmation form or space on the waste transfer note to detail the pre-treatment.

The classification of waste soil is a two-stage process, the first being an assessment of whether the soil is considered hazardous or not following the guidance within Technical Guidance WM3. For off-site disposal to landfill the results of Waste Acceptance Criteria (WAC) testing must then be reviewed to establish if the soil is acceptable at the relevant class of landfill or requires pre-treatment to reduce specific hazardous properties.

8.4.1 Waste acceptance criteria

All inert, stable non-reactive hazardous and hazardous wastes have limit values (waste acceptance criteria) set out in legislation that must be met before that class of landfill can accept the waste. Currently, no WAC are in place for non-hazardous waste.

Soil and other materials that are found not to be hazardous may be classified as either non hazardous or inert. In order to determine whether they can be classed as inert the soil must be tested and found to be below the inert waste acceptance criteria.

8.4.2 Waste sampling plan

Technical Guidance WM3 sets out in Appendix D requirements for waste sampling. It is a legal requirement to correctly assess and classify waste. The level of sampling should be proportionate to the volume of waste and its heterogeneity. At this stage RSK consider that the level of soil sampling is/is not sufficient to robustly/fully categorise the material.

RSK recommends that a Sampling Plan be prepared to support any waste classifications and hazardous waste assessments, prior to development.

8.4.3 Preliminary waste assessment

Given the level of data obtained, scale of the development and heterogeneity of the site soils the following assessment should be considered indicative and further assessment should be undertaken following the preparation of a Waste Sampling Plan.

EnviroLab (an RSK company) has developed a waste soils characterisation assessment tool (HASWASTE), which follows the guidance within Technical Guidance WM3. The

analytical results have been assessed using this tool for potential off-site disposal of materials in the future. The results are presented in Table 21.

Table 21: Results of waste soils characterisation assessment (HASWASTE)

Sample ref/location	Waste classification
TP02, 0m	Not hazardous
TP05, 0.6m	Not hazardous
TP07, 0.3m	Not hazardous
TP07, 0.8m	Not hazardous
TP09, 0.2m	Not hazardous
TP12, 0m	Not hazardous
TP13, 0m	Not hazardous
TP13, 0.3m	Not hazardous
TP14, 1.5m	Not hazardous
TP16, 1.1m	Not hazardous
TP17, 0m	Not hazardous
TP18, 0m	Not hazardous
TP20, 0m	Not hazardous
TP21, 0m	Hazardous
TP23, 0m	Not hazardous

Made ground at one location (sample TP21 at ground level) was classified as hazardous waste, owing to the presence of tarmac gravel within the material and therefore must be disposed of at a suitably licensed hazardous waste landfill.

None of the other samples were classified as hazardous waste. Therefore to determine whether waste might be classified as inert or non hazardous WAC testing will need to be undertaken.

8.4.4 Asbestos within waste soils

The latest, edition of Technical Guidance WM3, requires that within a mixed waste the separately identifiable wastes be assessed separately.

For instance where waste soil contains identifiable pieces of asbestos (visible to the naked eye) the asbestos should, where feasible, be separated from the soil and classified separately.

No asbestos fibres were detected in soil samples analysed for asbestos, however suspected ACM was noted at one location (trial trench 4). Furthermore, asbestos is

often present in discrete areas and since localised made ground is present, asbestos may be found during more extensive ground works.

8.5 Landfill tax

Waste producers disposing of material to landfill are required to pay landfill tax by HM Revenue and Customs.

The tax is chargeable by weight (tonnage) and two rates apply, either standard or lower rate. The lower rate only applies to those less polluting wastes as set out in the Landfill Tax (Qualifying Material) Order 2011, which include naturally occurring rock and soil, concrete, some minerals, some furnace slags and ash, and some low-activity organic compounds. Evidence confirming that the waste qualifies for the lower rate will be required, and standard rate tax will apply for the whole waste load for any loads of mixed waste.

Currently (since April 2015), standard rate landfill tax is £82.60 per tonne and rising to £84.40 after the 1st April 2016.

The lower rate of landfill tax applicable to less polluting wastes (i.e. 'inert' wastes) remains at £2.60 per tonne.

Material disposed of at a soil treatment centre will not be subject to landfill tax.

8.6 Groundwater

When there is an intention to discard groundwater, chemical test results will indicate the appropriate disposal options. This could include disposal to treatment facility, via consent (issued by the water authority) to foul sewer or via consent (issued by the EA) to a watercourse or land.

8.7 Recommendations

RSK recommends that consideration as to how potentially waste soils will be dealt with as part of this development/remediation is given as early in the project planning process as possible. Such planning can lead to cost savings where potentially waste soils are viewed as a resource and retained on-site as part of the development. We also recommend, where off-site disposal is being considered, that appropriate facilities are identified and discussions initiated to confirm suitability of the facility to take the material. Potentially, these may include soil treatment facilities as well as landfills.

RSK can provide specialist advice to assist in this process, which can be complex and subject to regular regulatory change.

9 CONCLUSIONS AND RECOMMENDATIONS

9.1 Environmental

On completion of the GQRA the following pollutant linkages that require further action are:

1. Direct contact of contaminated soils to future site users associated with localised contamination in made ground
2. Inhalation exposure of future site users to asbestos fibres
3. Plant uptake of contaminants within the soils, which may affect plant growth in certain areas of the site
4. Permeation of contaminants to water supply pipes in certain areas of the site
5. Inhalation and explosion of hazardous ground gases from build up within buildings

Localised made ground is present across the site. Three exceedances of the GAC for metals were identified in the area of raised ground (north of Area 2) and five exceedances of the GAC for PAH at a single location in Area 5 (former school area), due to the presence of tarmac gravel. This indicates potential risk associated with soil contamination in these areas of the site. The testing completed to date is intended to represent an exploratory level survey of chemical conditions. It is recommended that additional sampling and analysis of made ground is undertaken to further investigate this linkage and to delineate areas of contamination. It is recommended that a clean cover, with a minimum thickness of 600mm be placed within garden areas of affected plots.

Asbestos fibres were not detected in any of the samples analysed for this contaminant, however the presence of suspected ACM was encountered on site and as such this potential linkage and the potential for encountering further ACM at the site cannot be discounted. It is recommended that a watching brief is undertaken during ground works in areas where fly-tipping and made ground are present. ACM should be removed from site by a suitably licensed and qualified company.

Two exceedances of the GAC for zinc with respect to plant uptake were identified at a single location. It is unlikely that the soils will pose a risk to plant growth site-wide, however it would be prudent to undertake additional assessment of this linkage.

The proposed routes of the potable water supply pipes are currently unknown. A targeted soil sampling and testing investigation should be completed in the route of the proposed pipes once they are known to fully assess the risk of chemical attack on the supply pipes from contaminated soils.

In summary, further investigations may subsequently be required to achieve full characterisation of the site and development of a detailed conceptual site model to provide full site characterisation to a level that will enable the design of a remediation strategy for the site and / or the discharge of planning conditions relating to contamination.

Assessment of the ground gas regime is ongoing with a further four rounds to be completed. Currently the site is considered 'Green', however final determination of the requirement for gas protection measures should be reserved until the monitoring programme is completed. The ground gas risk assessment will be completed as an addendum report.

The site lies within an intermediate probability radon area, as between 3 and 5% of homes are above the action level as defined by the British Geological Survey, National Geoscience Information Service.

Therefore, the risk of significant ingress of radon into structures on-site is considered to be medium and basic radon protective measures are required within new dwellings at the site.

The presence of Japanese Knotweed in discrete locations within Area 2 has been highlighted. It is recommended that the site be re-surveyed during the growing season. A competent knotweed contractor should be employed manage and perform the treatment/ eradication works.

9.2 Reuse of materials and waste

The results of the waste soils and characterisation assessment (HASWASTE) indicates that all soil samples are classified as not hazardous, with the exception of shallow made ground at TP21, which contained tarmac gravel.

9.3 Geotechnical

The firm to stiff natural soils (weathered Coal Measures) would be considered suitable to support shallow spread foundations. Trench fill foundations are considered suitable in areas of deeper made ground (less than 2.5m deep) and alternative foundation options will be required in areas where made ground is deeper than 2.5m. Production of a final foundation design layout is recommended. For areas affected by shallow underground coal workings, spread foundations will be required to be reinforced.

The preliminary recommended sub-grade soil CBR value for road pavement design is 3% based on the ground conditions encountered. It is recommended that in-situ CBR determination be carried out targeting areas of hardstanding prior to construction works to confirm this value.

The Aggressive Chemical Environment for Concrete classification is indicated to be AC-1, with a Design Sulphate Class of DS-1 in accordance with current BRE guidance.

9.4 Mining

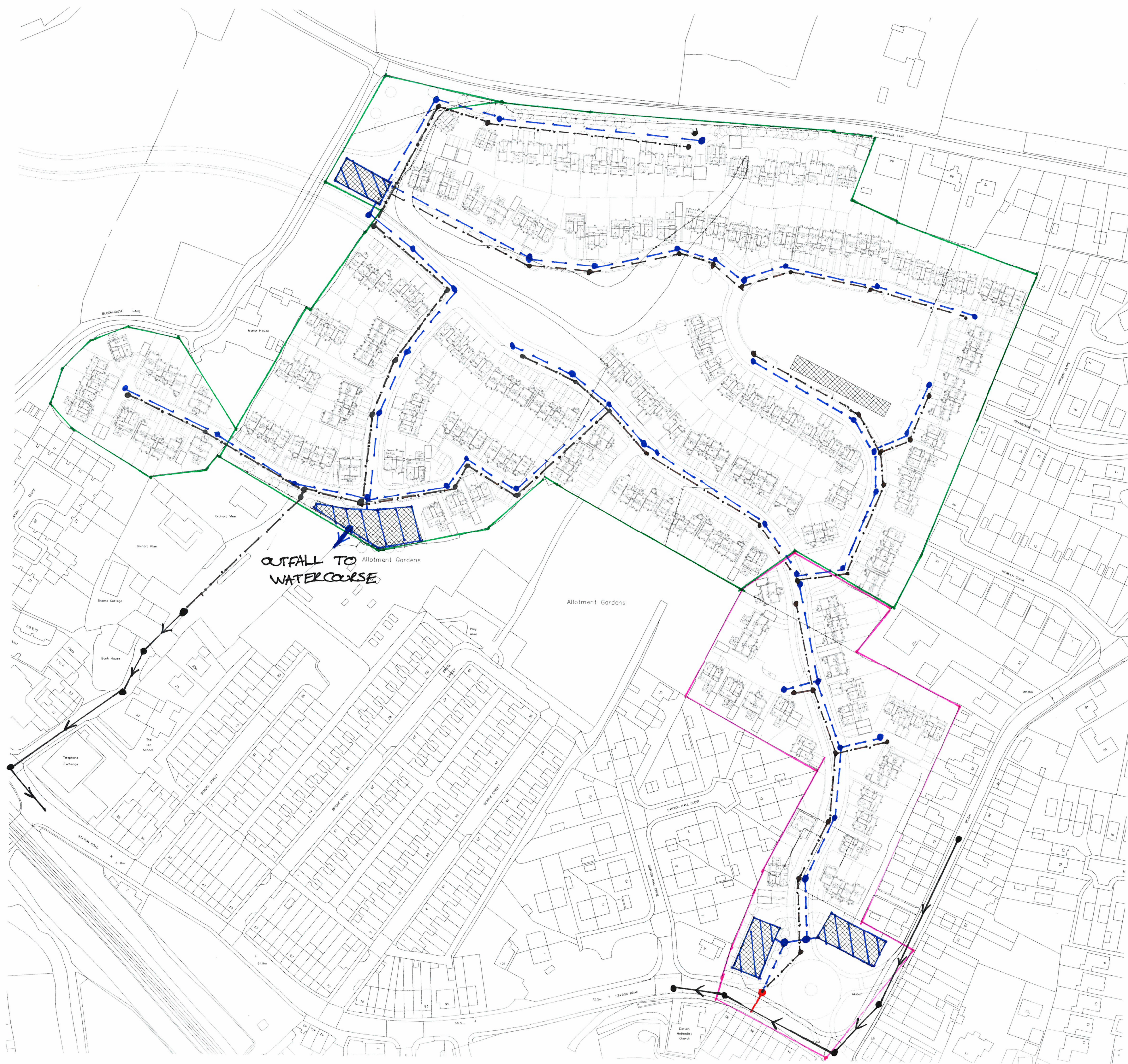
The Barnsley Rider Coal and Barnsley Coal are indicated to outcrop within the site boundary. Additionally, the unnamed seam and the Top Haigh Moor Coal Seam outcrop to the southwest of the site. Significant areas of the site that are underlain by either intact or worked coal seams at relatively shallow depth.

The probing investigation encountered evidence of shallow working (broken ground or possible voids) at six exploratory locations across the site.

It is recommended that the thickness of competent rock overlying a coal / worked seam required to ensure ground stability at the surface is ten times that of the underlying coal / worked seam. On this basis there are substantial areas of the site that do not have the required 'ten times' seam thickness, and these areas will require stabilisation prior to development. These areas are shown on Figure 11.

In addition, four mining adits have been identified from the Coal Authority records to be present close to the crop of the Barnsley Coal. Evidence of an adit was encountered at one location during the trial trenching exercise. The position of each of the adits should be identified and each of them stabilised to mitigate potential risk to the proposed development.

APPENDIX D: DRAINAGE STRATEGY AND CALCULATIONS



KEY

- Catchment 1
- Catchment 2
- Attenuation
- - - ● - - - - SW Drainage
- - - ● - - - - Existing Combined
- - - ● - - - - Proposed Combined
- - - ● - - - - Proposed FW

dudleys
Structural & Civil Consultants

NT - 10/7/17
Drainage
Catchments
(Surface Water)

 Tithe House 35 Town Street Leeds LS18 5LJ T 0113 258 3611	PROJECT Darton, Barnsley Run-off Analysis of existing Impermeable Area	PROJECT No. 16017
		SHEET No. 01
		BY NT
		DATE 10.07.2017

The following analysis has been undertaken to establish the peak discharge from the existing (brownfield) development. The analysis relates peak discharge to contributing area, average rainfall intensity and a dimensionless coefficient. The coefficient is generally termed the 'runoff coefficient' and has a range from 0 (no runoff produced) to 1 (perfect conversion of rainfall intensity). A unit conversion factor of 2.78 is applied to account for the units typically used.

The Modified Rational Method can be expressed as:

$$Q_p = 2.78 CiA$$

Where:

Q_p is the peak discharge

C is a dimensionless coefficient

i is the average rainfall intensity during the time of concentration, 50 mm/hr

A is the contributing catchment area

The impermeable area contributing to the combined outfall is:

0.415 ha

$$Q_p = 57.7 \text{ l/s}$$

Proposed Discharge Rate:

A 30 per cent betterment will be applied to the existing peak flow rate.

$$Q_{MAX} = 40.4 \text{ l/s} *$$

*This is the maximum permissible rate. Therefore the outgoing pipe flow rate must not exceed this rate in any design storm event up to and including the 1 in 100 year Critical Duration Event, with an allowance for climate change.

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Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m ³)	Status
15 min Summer	98.132	1.132	40.4	198.1	O K
30 min Summer	98.442	1.442	40.4	252.3	O K
60 min Summer	98.628	1.628	40.4	285.0	O K
120 min Summer	98.656	1.656	40.4	289.7	O K
180 min Summer	98.593	1.593	40.4	278.7	O K
240 min Summer	98.501	1.501	40.4	262.6	O K
360 min Summer	98.287	1.287	40.4	225.2	O K
480 min Summer	98.059	1.059	40.4	185.4	O K
600 min Summer	97.871	0.871	40.4	152.5	O K
720 min Summer	97.715	0.715	40.4	125.1	O K
960 min Summer	97.492	0.492	40.1	86.1	O K
1440 min Summer	97.283	0.283	36.9	49.6	O K
2160 min Summer	97.214	0.214	28.6	37.4	O K
2880 min Summer	97.183	0.183	23.1	32.0	O K
4320 min Summer	97.150	0.150	16.7	26.2	O K
5760 min Summer	97.131	0.131	13.4	22.9	O K
7200 min Summer	97.118	0.118	11.1	20.7	O K
8640 min Summer	97.109	0.109	9.7	19.1	O K
10080 min Summer	97.102	0.102	8.6	17.9	O K
15 min Winter	98.287	1.287	40.4	225.2	O K
30 min Winter	98.639	1.639	40.4	286.8	O K
60 min Winter	98.871	1.871	40.4	327.4	O K
120 min Winter	98.895	1.895	40.4	331.6	O K
180 min Winter	98.800	1.800	40.4	315.0	O K
240 min Winter	98.661	1.661	40.4	290.6	O K
360 min Winter	98.343	1.343	40.4	235.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m ³)	Discharge Volume (m ³)	Time-Peak (mins)
15 min Summer	125.006	0.0	225.8	17
30 min Summer	83.918	0.0	303.3	32
60 min Summer	53.779	0.0	389.1	60
120 min Summer	33.289	0.0	481.7	90
180 min Summer	24.779	0.0	537.9	126
240 min Summer	19.956	0.0	577.6	160
360 min Summer	14.657	0.0	636.3	230
480 min Summer	11.773	0.0	681.5	290
600 min Summer	9.924	0.0	718.0	350
720 min Summer	8.626	0.0	749.0	406
960 min Summer	6.909	0.0	799.8	520
1440 min Summer	5.043	0.0	875.6	738
2160 min Summer	3.673	0.0	957.0	1100
2880 min Summer	2.930	0.0	1017.7	1468
4320 min Summer	2.126	0.0	1107.7	2200
5760 min Summer	1.692	0.0	1175.4	2896
7200 min Summer	1.416	0.0	1229.6	3672
8640 min Summer	1.225	0.0	1276.3	4344
10080 min Summer	1.084	0.0	1317.6	5136
15 min Winter	125.006	0.0	252.9	17
30 min Winter	83.918	0.0	339.7	31
60 min Winter	53.779	0.0	435.8	58
120 min Winter	33.289	0.0	539.5	96
180 min Winter	24.779	0.0	602.4	134
240 min Winter	19.956	0.0	646.9	174
360 min Winter	14.657	0.0	712.7	250

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Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m ³)	Status
480 min Winter	97.976	0.976	40.4	170.7	O K
600 min Winter	97.704	0.704	40.4	123.2	O K
720 min Winter	97.508	0.508	40.2	88.9	O K
960 min Winter	97.297	0.297	37.3	52.0	O K
1440 min Winter	97.213	0.213	28.5	37.3	O K
2160 min Winter	97.172	0.172	20.9	30.0	O K
2880 min Winter	97.150	0.150	16.7	26.2	O K
4320 min Winter	97.124	0.124	12.2	21.7	O K
5760 min Winter	97.109	0.109	9.7	19.1	O K
7200 min Winter	97.099	0.099	8.1	17.3	O K
8640 min Winter	97.091	0.091	7.0	16.0	O K
10080 min Winter	97.086	0.086	6.2	15.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m ³)	Discharge Volume (m ³)	Time-Peak (mins)
480 min Winter	11.773	0.0	763.3	308
600 min Winter	9.924	0.0	804.2	364
720 min Winter	8.626	0.0	838.9	416
960 min Winter	6.909	0.0	895.8	512
1440 min Winter	5.043	0.0	980.7	736
2160 min Winter	3.673	0.0	1071.8	1100
2880 min Winter	2.930	0.0	1139.8	1464
4320 min Winter	2.126	0.0	1240.7	2200
5760 min Winter	1.692	0.0	1316.4	2936
7200 min Winter	1.416	0.0	1377.1	3672
8640 min Winter	1.225	0.0	1429.5	4400
10080 min Winter	1.084	0.0	1475.8	5016

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	19.000	Shortest Storm (mins)	15
Ratio R	0.353	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.965

Time (mins)		Area
From:	To:	(ha)
0	4	0.965

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Model Details

Storage is Online Cover Level (m) 100.000

Tank or Pond Structure

Invert Level (m) 97.000

Depth (m)	Area (m ²)	Depth (m)	Area (m ²)	Depth (m)	Area (m ²)
0.000	175.0	2.000	175.0	2.001	0.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0256-4040-2000-4040
Design Head (m)	2.000
Design Flow (l/s)	40.4
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	256
Invert Level (m)	97.000
Minimum Outlet Pipe Diameter (mm)	300
Suggested Manhole Diameter (mm)	2100

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	2.000	40.4	Kick-Flo®	1.302	32.9
Flush-Flo™	0.598	40.4	Mean Flow over Head Range	-	34.9

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

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)
0.100	8.2	0.800	39.8	2.000	40.4	4.000	56.4	7.000	74.0
0.200	26.2	1.000	38.6	2.200	42.3	4.500	59.8	7.500	76.6
0.300	37.4	1.200	35.7	2.400	44.1	5.000	62.9	8.000	79.0
0.400	39.3	1.400	34.0	2.600	45.8	5.500	65.9	8.500	81.4
0.500	40.2	1.600	36.3	3.000	49.1	6.000	68.7	9.000	83.7
0.600	40.4	1.800	38.4	3.500	52.9	6.500	71.4	9.500	85.9

- Catchment 2 Greenfield Peak Run-off Estimation

FH124 Methodology

$$Q_{BAR(rural)} = 0.00108 \text{ AREA}^{0.89} \times \text{SAAR}^{1.17} \times \text{SOIL}^{2.17}$$

$$\text{Area} = 50 \text{ ha} = 0.5 \text{ km}^2$$

$$\text{SAAR} = 740$$

$$\text{SOIL} = 4 \therefore \text{SPR} = 0.47$$

$$\begin{aligned} Q_{BAR(50ha)} &= 0.00108 (0.5)^{0.89} \times 740^{1.17} \times 0.47^{2.17} \\ &= 0.258 \text{ m}^3/\text{s} \end{aligned}$$

$$\text{Catchment Area} = 5.966 \text{ ha}$$

$$\begin{aligned} Q_{BAR(5.966ha)} &= \left(\frac{0.258}{50} \right) \times 5.966 \\ &= 0.031 \text{ m}^3/\text{s} \\ &= \underline{31 \text{ L/s.}} \end{aligned}$$

Applying a growth curve factor for a 1 yr return period
in hydrological region 3

$$\text{Factor} = 0.86$$

$$\begin{aligned} Q_i &= Q_{BAR(5.966ha)} \times 0.86 \\ &= 31 \times 0.86 \\ &= \underline{\underline{26.7 \text{ L/s}}} \end{aligned}$$

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Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m ³)	Status
15 min Summer	97.713	0.713	26.7	819.7	O K
30 min Summer	97.948	0.948	26.7	1090.4	O K
60 min Summer	98.195	1.195	26.7	1374.8	O K
120 min Summer	98.437	1.437	26.7	1652.6	O K
180 min Summer	98.556	1.556	26.7	1789.7	O K
240 min Summer	98.621	1.621	26.7	1864.5	O K
360 min Summer	98.683	1.683	26.7	1936.0	O K
480 min Summer	98.702	1.702	26.7	1957.5	O K
600 min Summer	98.695	1.695	26.7	1949.5	O K
720 min Summer	98.680	1.680	26.7	1932.5	O K
960 min Summer	98.645	1.645	26.7	1892.1	O K
1440 min Summer	98.562	1.562	26.7	1796.4	O K
2160 min Summer	98.428	1.428	26.7	1642.2	O K
2880 min Summer	98.286	1.286	26.7	1479.2	O K
4320 min Summer	97.981	0.981	26.7	1127.6	O K
5760 min Summer	97.745	0.745	26.7	857.2	O K
7200 min Summer	97.569	0.569	26.7	654.3	O K
8640 min Summer	97.444	0.444	26.4	510.5	O K
10080 min Summer	97.356	0.356	25.6	409.6	O K
15 min Winter	97.800	0.800	26.7	919.8	O K
30 min Winter	98.066	1.066	26.7	1225.5	O K
60 min Winter	98.347	1.347	26.7	1548.6	O K
120 min Winter	98.619	1.619	26.7	1862.3	O K
180 min Winter	98.758	1.758	26.7	2021.8	O K
240 min Winter	98.836	1.836	26.7	2111.8	O K
360 min Winter	98.918	1.918	26.7	2205.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m ³)	Discharge Volume (m ³)	Time-Peak (mins)
15 min Summer	125.006	0.0	814.6	19
30 min Summer	83.918	0.0	1097.0	34
60 min Summer	53.779	0.0	1431.1	64
120 min Summer	33.289	0.0	1772.9	122
180 min Summer	24.779	0.0	1979.8	182
240 min Summer	19.956	0.0	2126.0	242
360 min Summer	14.657	0.0	2341.9	362
480 min Summer	11.773	0.0	2507.3	480
600 min Summer	9.924	0.0	2641.0	584
720 min Summer	8.626	0.0	2753.6	630
960 min Summer	6.909	0.0	2937.0	760
1440 min Summer	5.043	0.0	3201.8	1024
2160 min Summer	3.673	0.0	3540.9	1448
2880 min Summer	2.930	0.0	3765.0	1848
4320 min Summer	2.126	0.0	4094.0	2596
5760 min Summer	1.692	0.0	4355.3	3296
7200 min Summer	1.416	0.0	4555.0	3968
8640 min Summer	1.225	0.0	4725.9	4672
10080 min Summer	1.084	0.0	4873.6	5344
15 min Winter	125.006	0.0	913.8	19
30 min Winter	83.918	0.0	1228.9	33
60 min Winter	53.779	0.0	1603.5	62
120 min Winter	33.289	0.0	1986.1	120
180 min Winter	24.779	0.0	2217.7	180
240 min Winter	19.956	0.0	2381.1	238
360 min Winter	14.657	0.0	2622.5	352

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Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m ³)	Status
480 min Winter	98.951	1.951	26.7	2243.4	O K
600 min Winter	98.955	1.955	26.7	2248.4	O K
720 min Winter	98.942	1.942	26.7	2233.4	O K
960 min Winter	98.890	1.890	26.7	2172.9	O K
1440 min Winter	98.783	1.783	26.7	2050.8	O K
2160 min Winter	98.592	1.592	26.7	1830.7	O K
2880 min Winter	98.386	1.386	26.7	1594.2	O K
4320 min Winter	97.912	0.912	26.7	1049.2	O K
5760 min Winter	97.584	0.584	26.7	672.1	O K
7200 min Winter	97.384	0.384	25.9	441.5	O K
8640 min Winter	97.272	0.272	24.3	312.2	O K
10080 min Winter	97.221	0.221	22.6	253.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m ³)	Discharge Volume (m ³)	Time-Peak (mins)
480 min Winter	11.773	0.0	2807.3	466
600 min Winter	9.924	0.0	2956.4	576
720 min Winter	8.626	0.0	3081.7	682
960 min Winter	6.909	0.0	3284.8	798
1440 min Winter	5.043	0.0	3568.9	1094
2160 min Winter	3.673	0.0	3966.2	1556
2880 min Winter	2.930	0.0	4217.1	2020
4320 min Winter	2.126	0.0	4587.5	2764
5760 min Winter	1.692	0.0	4878.5	3408
7200 min Winter	1.416	0.0	5102.4	4040
8640 min Winter	1.225	0.0	5294.3	4664
10080 min Winter	1.084	0.0	5461.2	5240

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	19.000	Shortest Storm (mins)	15
Ratio R	0.353	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 3.579

Time (mins)		Area
From:	To:	(ha)
0	4	3.579

Dudleys		Page 4
Tithe House 35 Town Street Leeds LS18 5LJ		
Date 7/11/2017 4:42 PM File	Designed by nick.turner Checked by	
XP Solutions	Source Control 2017.1	

Model Details

Storage is Online Cover Level (m) 100.000

Tank or Pond Structure

Invert Level (m) 97.000

Depth (m)	Area (m ²)	Depth (m)	Area (m ²)	Depth (m)	Area (m ²)
0.000	1150.0	2.000	1150.0	2.001	0.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0211-2670-2000-2670
Design Head (m)	2.000
Design Flow (l/s)	26.7
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	211
Invert Level (m)	97.000
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1800

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	2.000	26.7	Kick-Flo®	1.253	21.4
Flush-Flo™	0.581	26.7	Mean Flow over Head Range	-	23.2

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

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)
0.100	7.2	0.800	26.2	2.000	26.7	4.000	37.2	7.000	48.8
0.200	20.4	1.000	25.1	2.200	27.9	4.500	39.4	7.500	50.5
0.300	24.8	1.200	22.5	2.400	29.1	5.000	41.5	8.000	52.1
0.400	26.1	1.400	22.5	2.600	30.3	5.500	43.4	8.500	53.6
0.500	26.6	1.600	24.0	3.000	32.4	6.000	45.3	9.000	55.1
0.600	26.7	1.800	25.4	3.500	34.9	6.500	47.1	9.500	56.6

APPENDIX A: CONSULTATION



YorkshireWater

Mr C Paton
Dudleys
Tithe House
35 Town Street
Horsforth
Leeds
LS18 5LJ

Yorkshire Water Services
Developer Services
Sewerage Technical Team
PO BOX 52
Bradford
BD3 7AY

Tel: 0345 120 8482
Fax: (01274) 372 834

Your Ref: 16017
Our Ref: S008951

Email:
Technical.Sewerage@yorkshirewater.co.uk

For telephone enquiries ring:
Chris Roberts on 0345 120 8482

20th June 2016

Dear Mr Paton,

Bloomhouse Lane, Darton, Barnsley - Pre Planning Sewerage Enquiry on R202169 - Residential.

Thank you for your recent enquiry and remittance. Our official VAT receipt has been sent to you under separate cover. Please find enclosed a complimentary extract from the Statutory Sewer Map which indicates the recorded position of the public sewers. Please note that as of October 2011 and the private to public sewer transfer, there are many uncharted Yorkshire Water assets currently not shown on our records.

The following comments reflect our view, with regard to the public sewer network only, based on a 'desk top' study of the site and are valid for a maximum period of twelve months.

Existing Infrastructure

The anticipated domestic foul flows can be accommodated at the WWTW, however it is imperative that a separate outfall is provided for surface water

Foul Water

Development of the site should take place with separate systems for foul and surface water drainage. The separate systems should extend to the points of discharge to be agreed.

I will require proposed connection positions and connection numbers to agree foul connection points. Previous proposal show the Yorkshire Water's preferred point of connection would be into the public 450mm combined sewer in Sackup Lane to the east.

From the information supplied, it is not possible to determine if the whole site will drain by gravity to the public sewer network. If the site, or part of it, will not drain by gravity, then it is likely that a sewage pumping station will be required to facilitate connection to the public sewer network. If sewage pumping is required foul water discharge must not exceed 5 (five) litres per second.

Surface Water

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.

As the proposal site is currently undeveloped no surface water is known to have previously discharged to the public sewer network

As such, the local public sewer network does not have capacity to accept any surface water from the proposed site. If SuDS are not viable, the developer is advised to contact the Environment Agency/local Land Drainage Authority with a view to establishing a suitable watercourse for discharge.

It is understood that a {culverted} watercourse is located to the south of the site next to the allotment gardens and north of School Street. This appears to be the obvious place for surface water disposal (if SuDS are not viable).

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, with regard to surface water disposal from the site.

Other Observations

Any new connection to an existing public sewer will require the prior approval of Yorkshire Water. You may obtain an application form from our website (www.yorkshirewater.com) or by telephoning 0345 120 84 82.

An off-site foul and surface water sewer may be required which may be provided by the developer and considered for adoption under Section 104 of the Water Industry Act 1991. Please telephone 0345 120 84 82 for advice on sewer adoptions. Alternatively, the developer may in certain circumstances be able to requisition off-site sewers under Section 98 of the Water Industry Act 1991 for which an application must be made in writing. For further information, please telephone 0345 120 84 82.

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 0345 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. No land drainage to be connected/discharged to public sewer.

As a last resort, highway drainage may be accepted under certain circumstances. If it can be demonstrated, through satisfactory evidence, that SUDS are not a viable option, there are no watercourses or highway drains available and if capacity is available within the public sewer network, highway drainage discharges to the public sewer network may be permitted. In this event, the developer may 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.

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.



YorkshireWater

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 sincerely

A handwritten signature in black ink, appearing to read 'Chris Roberts'.

Chris Roberts
Sewerage Technician
Developer Services

