
Development at Lundwood, Barnsley

Flood Risk Assessment

Client:

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1.0 INTRODUCTION AND BACKGROUND

JOC Consultants Ltd is instructed by Gleeson Developments Ltd (the Client) to prepare a flood risk assessment report for a proposed housing development on land off Ellwood, Lundwood, Barnsley. The development is the subject of a planning application to Barnsley Metropolitan Borough Council.

References in this report to “the site” are references to the site to which the planning application applies. Specific references to sources of information used in the report are shown in square brackets and are listed in section 9. Figures 1 to 5 are presented immediately following page 10 and the appendices follow thereafter.

This report is prepared specifically for the Client for the purpose of the aforementioned planning application and the report may not be used for any purpose other than for the purpose for which it was commissioned, and it may not be assigned to any third party without our written permission.

In the preparation of this FRA, JOC Consultants Ltd has relied on information provided to us by statutory authorities and by the client and we accept no liability for its accuracy or adequacy or for the consequences of any changes to or re-assessment of this data in the future.

2.0 OBJECTIVES

The objectives of this flood risk assessment are:

1. to establish whether the proposed development is likely to be affected by current or future flooding from any source;
2. to establish whether the proposed development will increase flood risk elsewhere;
and
3. to recommend, as appropriate, measures for managing flood risk.

3.0 PLANNING POLICY ON FLOOD RISK

3.1 National Policy

National Planning Policy in relation to flood risk is set out in the National Planning Policy Framework (NPPF) [1] and the Technical Guidance thereto [2]. The NPPF revokes Planning Policy Statement 25 which previously stated the policy on development and flood risk.

3.1 Local Policy

Local policy on development and flood risk is informed by the Barnsley Strategic Flood Risk Assessment (SFRA) [3] which provides guidance to the planning authority on allocating sites or determining planning applications for sites in flood risk areas.

Reference to the SFRA is made in subsequent sections of this report.

4.0 LOCATION AND DESCRIPTION OF THE SITE

The site is situated to the north of Wilson Grove, Lundwood, as shown outlined in red in Figure 1. The NGR coordinates at the site are approximately 437512E, 407916N. Access to the site is from Ellwood.

The site, the gross area of which is approximately 3.5ha, is currently undeveloped and has a porous surface, being in the “greenfield” condition.

The topographical survey plan (see Appendix A), shows existing ground levels to fall towards the northern corner of the site. Ground levels vary between approximately 58.5m AOD(N) at the south-east corner and approximately 45.0m AOD(N) at the northern corner. The site slopes steeply down from the south-east boundary to a wide central valley on a SW – NE axis.

The site has a pervious surface of rough grassland and vegetation growth.

The SFRA Map A1 shows the site to be part of the housing allocation site HS7 and Table A1 indicates that the site lies in the River Dearne catchment.

The site is drained by open watercourses, one of which flows north-eastwards along the north-west boundary. Another open watercourse flows northwards adjacent to the eastern boundary and these watercourses converge close to the northern extremity of the site from where they flow north-eastwards in a single channel towards Small Bridge Dyke which then flows south-eastwards towards the River Dearne.

A 750mm diameter sewer crosses the site on a NE-SW axis, as shown on the Yorkshire Water sewer plan at Appendix B. This sewer pipe is laid on above-ground supports in the northern part of the site.

5.0 THE PROPOSED DEVELOPMENT

The proposed development is for 96 houses, as shown in the site layout plan at Appendix C.

Full details of the proposed development are provided in the plans and documents included with the planning application.

6.0 FLOOD RISK

6.1 Data collection and consultations

Enquiries to the Environment Agency

As the site is in flood zone 1, the Environment Agency was not consulted for this FRA.

Enquiries to Barnsley Metropolitan Borough Council

The Drainage Engineer at Barnsley Metropolitan Borough Council was consulted by telephone on 12th November 2013 for the purposes of this FRA. We were informed that the maximum surface water discharge from the site should not exceed 5l/s per ha. The Council would be prepared to adopt a sustainable drainage scheme (SUDS), subject to

approval of the detailed design. The Council would expect the proposed surface water drainage scheme for the development to include a 'treatment train', in accordance with SUDS principles; oversized pipes alone for storage of excess volume would not be considered to be acceptable.

6.2 Existing flood defences

The site does not benefit from flood defences, being in flood zone 1.

6.3 History of Flooding

The SFRA Map 2 shows that the site was unaffected by flooding events which occurred in 1947; January 1982; Autumn 2000 and June 2007.

There is no available evidence of the site having been affected by flooding resulting from other events.

6.4 Risk of fluvial flooding

The Environment Agency flood zone map shows the site to be in flood zone 1 where the annual probability of flooding in the absence of flood defences is less than 0.1%. This is corroborated by SFRA Maps 3 and 4 which confirm that the site does not lie within flood zones 2 or 3. SFRA Map 6 confirms that the site is not in the Functional Floodplain.

The annual probability of fluvial flooding is therefore assessed, based on current data, to be less than 0.1%.

6.5 Risk of surface water flooding

Risk to the site

The SFRA Map C1 shows the site generally to be unaffected by surface water flooding resulting from rainfall events having an A.E.P. of 1%. There is however, a small area at the northern corner of the site and beyond, which is shown to be within an area affected by surface water flooding resulting from a 1% A.E.P. rainfall event. The depth range of this flooding is indicated to be 1.0 to 1.5m.

The recently published Environment Agency surface water flood map indicates a high risk of surface water flooding close to the northern corner of the site, where the annual probability is stated to be greater than 3.3% (more frequent than 1 in 30 years). This map also indicates an annual probability of surface water flooding between 0.1% and 1% in the central valley of the site.

Comparison of the surface water flood maps with the topographical survey plan suggests that the high risk area of surface water flooding may be associated with land below the 44.5m contour at the northern end of the site. With the exception of this small affected area the risk of surface water flooding is assessed to be 'very low' over most of the site, and 'low' in the central valley area as stated on the Environment Agency flood map.

It was originally proposed to locate the public open space at the northern corner of the site but we understand the planning authority insisted that this should be placed more centrally. Houses are now proposed in the area close to the northern corner of the site where the risk of surface water flooding is high. This is unfortunate because this area,

being low in comparison to the rest of the site, is ideally suited to controlled flood storage, prior to the discharge of surface water to the watercourse.

Effect of the proposed development on rapid-response run-off

Development of the site for housing will increase surface water run-off volume due to the conversion of a significant proportion of the site to impervious area. The extent of impervious area resulting from the proposed development is not known in detail but a reasonable estimate, based on the site layout plan (see Appendix C), would be approximately 50% of the gross site area.

The effect of the development on rapid response surface water run-off generated by a storm of critical duration in the 3.3% and 1% A.E.P. events is shown in Figures 2 and 3 respectively. In assessing the existing condition of the site, it is assumed that rapid response run-off from the permeable areas is equivalent to SPR HOST¹ which, for this catchment, is 27.2% of the rainfall.

Tables D1 to D4 (see Appendix D) show the effect of the development to be an increase in rapid response run-off volume of approximately 115%. This is a preliminary estimate based on 50% impervious area and this figure should be reviewed and verified at the detailed design stage.

The effect of the development on surface water run-off can be mitigated by the application of sustainable drainage techniques, as recommended in section 7.2 below. Provided such measures are implemented, the development will not increase flood risk elsewhere.

6.6 Risk of sewer flooding

The SFRA identifies Lundwood as being one of several locations in the Barnsley borough as being at risk from sewer flooding². It will therefore be important to ensure that this risk is not increased by the proposed development. As noted in section 4 above, there is a 750mm diameter elevated sewer crossing the site on a NE-SW axis. This is a sealed pipe above ground and the risk of flooding from the pipe is therefore negligible, except in the case of a catastrophic failure of the pipe. Diversion of the above-ground section of this sewer will be necessary as part of the development.

6.7 Risk of groundwater flooding

Lundwood is not identified in the SFRA as being one of the areas within the borough where groundwater flooding is likely and the site is not included in the list of allocated sites where the re-emergence of mine water is likely³. The risk of groundwater flooding at the site is therefore assessed to be low.

6.8 Appropriate Land Use

The flood risk vulnerability classifications of various types of development are set out in the NPPF Technical Guidance: Table 2, which classifies residential development as "More Vulnerable". As the site lies within flood zone 1 the proposed development is appropriate, in accordance with NPPF Technical Guidance Table 3, with no requirement to pass the Exception Test.

¹ Standard percentage run-off based on the HOST soils database.

² SFRA : s.5.8, p.45

³ SFRA : s.5.6, pp.43 - 44

6.9 Effects of Climate Change

The impact of climate change must be assessed over the lifetime of the development. The Technical Guidance to the NPPF is silent on the question of the lifetime of housing but its predecessor, the Practice Guide to PPS 25, recommended a minimum lifetime of 100 years. For the purposes of this assessment, climate change effects are therefore considered up to the year 2114.

Current estimates of climate change effects suggest an increase in peak river flows of 20% in the period after 2025 and an increase in peak rainfall intensity of 30% in the period 2085 to 2115[2]. A corresponding increase in rapid response run-off volumes can therefore be expected and should be taken into account in the detailed design of the drainage system for the development.

7.0 FLOOD RISK MANAGEMENT

7.1 Fluvial flood risk

No flood risk management measures are necessary in respect of fluvial flooding.

7.2 Surface water flood risk

The effect of the proposed development on surface water run-off volumes can be mitigated by the implementation of sustainable drainage principles. The Building Regulations require surface water to be discharged according to the following preference hierarchy:

1. to ground by infiltration;
2. to a watercourse;
3. to a sewer, if options (1) and (2) are not reasonably practicable.

It is unlikely, in view of the underlying geology, that infiltration drainage will be feasible. Low permeability siltstones and mudstones are typically associated with the coal measures underlying the site. A controlled surface water discharge to a local watercourse at a maximum rate of 5 l/s per ha, as indicated by Barnsley MBC is therefore likely to be the preferred option, subject to access.

The drainage system for the development should ensure:

- no surface water flooding resulting from a rainfall event having an A.E.P. of 33% (1 in 30 years);
- only "tolerable" flooding resulting from a rainfall event having an A.E.P. of 1% (1 in 100 years).

"Tolerable" flooding would be flooding to a depth that does not result in flooding of buildings and which does not prevent safe access and egress to and from the site.

Figures 4 and 5 show the run-off volumes from the impervious areas only, generated by storms having an annual probability of exceedence of 3.3% and 1% respectively,

including a 30% increase in rainfall due to climate change effects. It is assumed that run-off from permeable areas will not enter the piped drainage system. The controlled discharge volume, based on a controlled discharge rate of 5 l/s per ha is also shown and it is apparent that the critical duration in the 3.3% A.E.P. event is approximately 3.75 hours, and for the 1% A.E.P. event the critical duration is approximately 5 hours. The calculations supporting Figures 4 and 5 are shown in Appendix D Tables D5 and D6. The storage capacity required to detain the excess volume from these events is estimated to be 600m³ and 930m³ respectively.

It is emphasised that the estimates of storage capacity in this report are preliminary only and should be verified as part of the detailed drainage design.

7.3 Sewer flooding risk

No flood risk management measures are necessary in respect of sewer flooding, other than consultation with Yorkshire Water during the detailed design of the drainage systems.

7.4 Ground water flood risk

No flood risk management measures are necessary in respect of groundwater flooding.

8.0 CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

1. The site is situated in flood zone 1 where the annual probability of fluvial flooding is less than 0.1%.
2. There is no historical evidence of the site having been affected by flooding.
3. The risk of surface water flooding is assessed to be very low (annual probability less than 0.1%) and low in the central valley area, (annual probability between 0.1% and 1%). The current surface water flood maps however indicate a high risk, where the annual probability of surface water flooding is greater than 3.3%, at the northern corner of the site, and beyond the site boundary northwards.
4. The development will potentially increase surface water run-off volumes by approximately 115%. This can be mitigated by the application of sustainable drainage principles in the detailed drainage design.
5. The risk of sewer flooding at the site is assessed to be low, but Lundwood is identified in the SFRA as being one of several locations in the Barnsley borough as being at risk from sewer flooding. The detailed drainage design should therefore ensure that this risk is not exacerbated.
6. The risk of groundwater flooding at the site is assessed to be low.
7. The development will not result in the loss of any floodplain storage.
8. Climate change effects will increase surface water run-off volumes over the lifetime of the development but will not alter the assessments of flood risk at the site.

9. Infiltration drainage is unlikely to be feasible due to the underlying geology, but this should be investigated further.
10. The effect of the development on surface water run-off can be reduced to an acceptable level by the implementation of the flood risk management measures stated in section 7 of this report.
11. The development falls within the “More Vulnerable” classification in Table 2 of the Technical Guidance to the NPPF.
12. The development is not required to pass the Exception Test.

8.2 Recommendations

1. It is recommended that a ground investigation is undertaken prior to the detailed drainage design, in order to establish the feasibility of infiltration drainage.
2. A detailed surface water drainage design should be prepared and submitted to Barnsley Metropolitan Borough Council and Yorkshire Water for approval.

9.0 REFERENCES

1. National Planning Policy Framework. Department for Communities and Local Government. March 2012.
2. Technical Guidance to the National Planning Policy Framework. Department for Communities and Local Government. March 2012.
3. Barnsley Metropolitan Borough Council SFRA, September 2010.
4. Development and flood risk. Guidance for the construction industry. CIRIA Report No. C624. 2004.

Development at Lundwood, Barnsley



Figure 1: Location Plan

**Figure 2: Effect of the development on rapid response surface water run-off
(3.3% A.E.P event)**

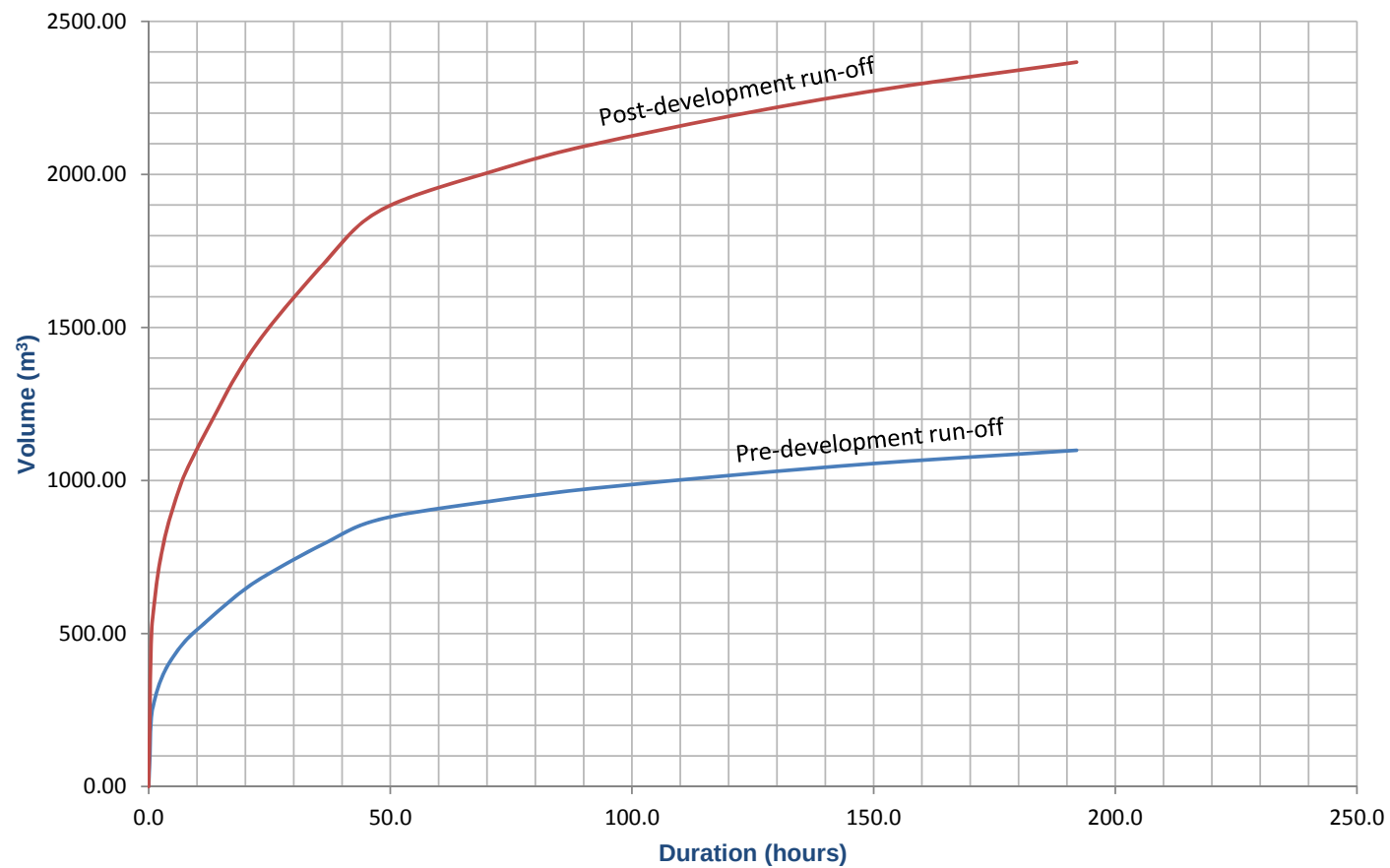


**Figure 3: Effect of the development on rapid response surface water run-off
(1% A.E.P. event)**

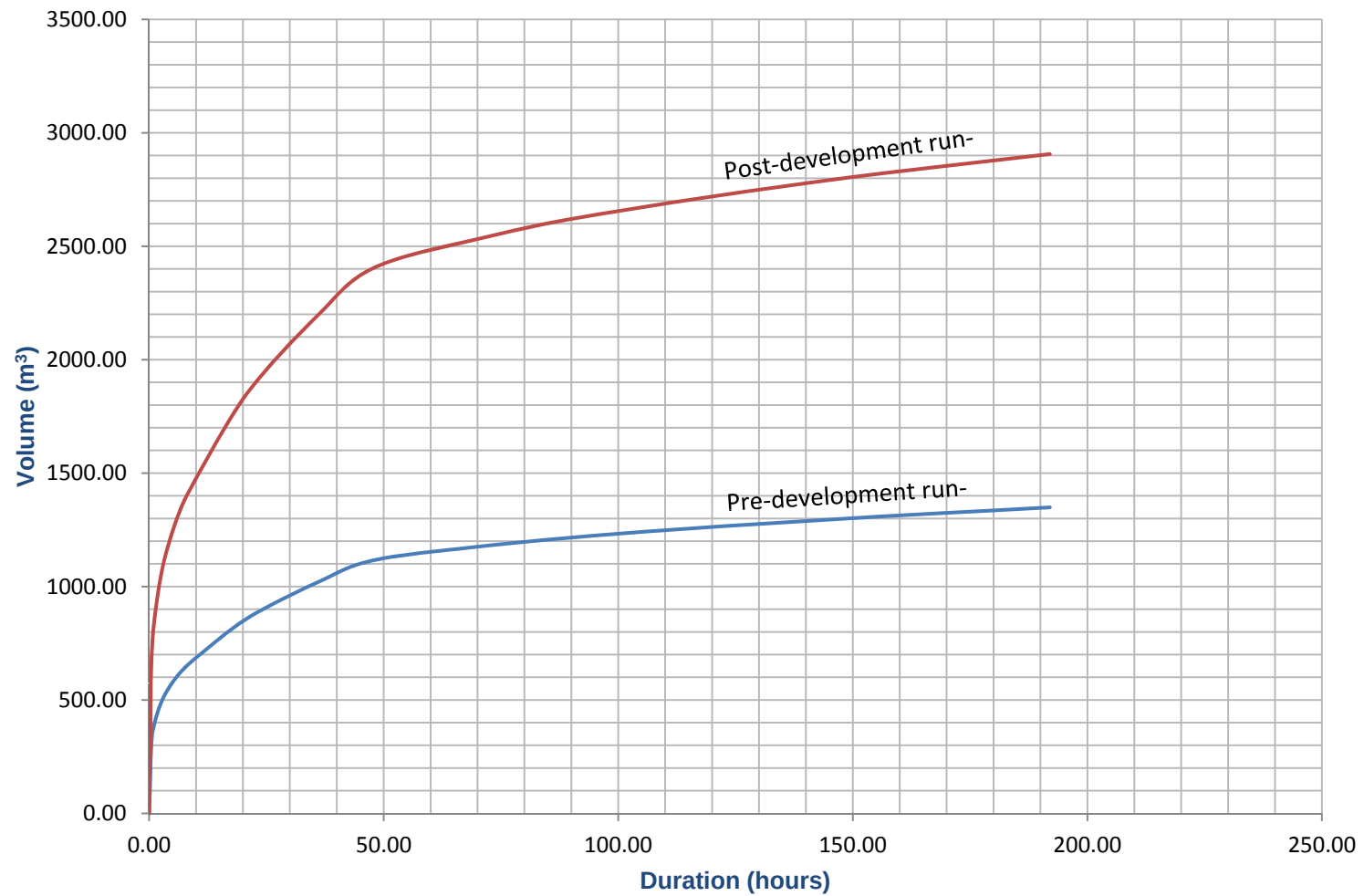


**Figure 4: Surface water run-off from a 3.3% A.E.P. rainfall event including CCA
(post-development)**

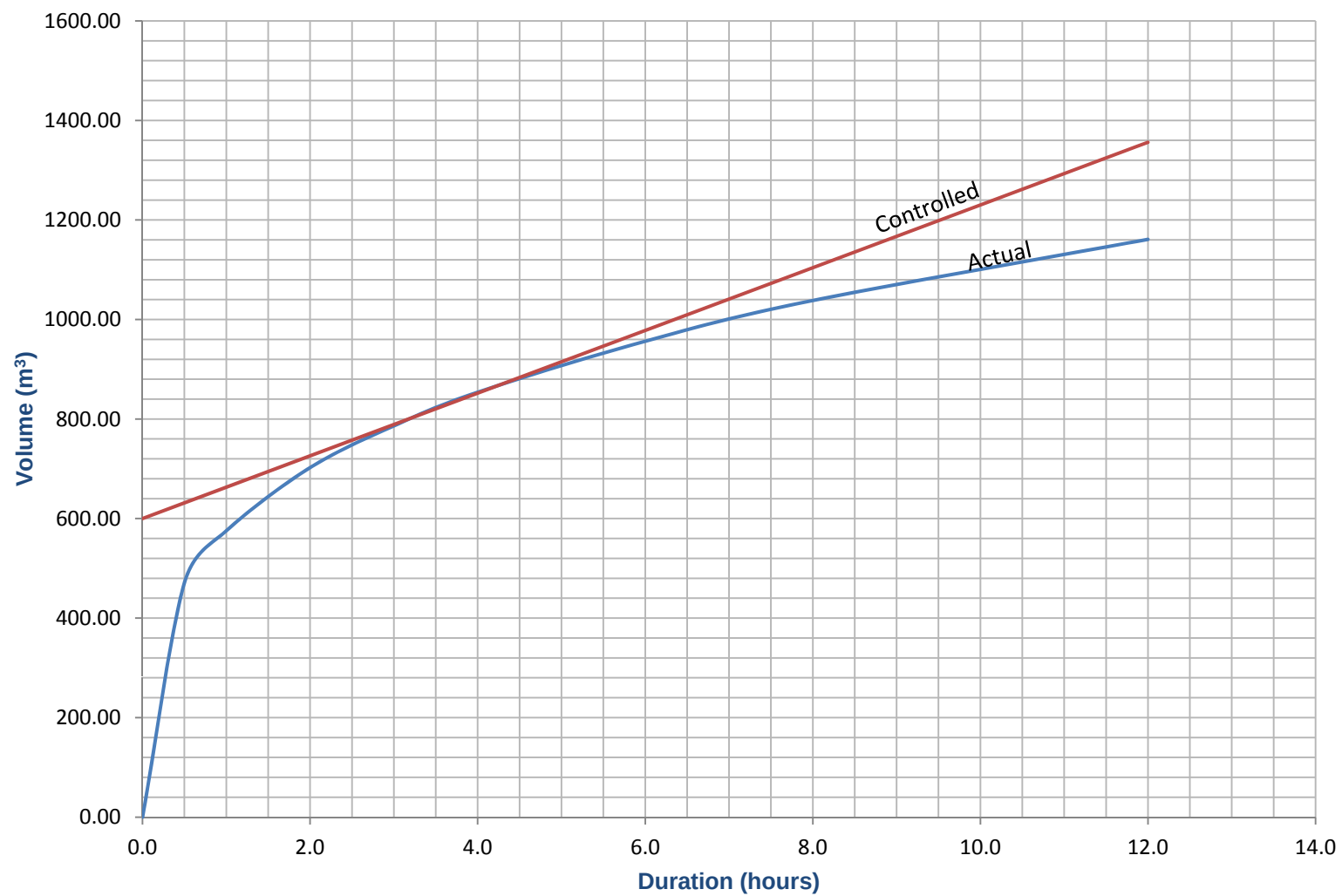
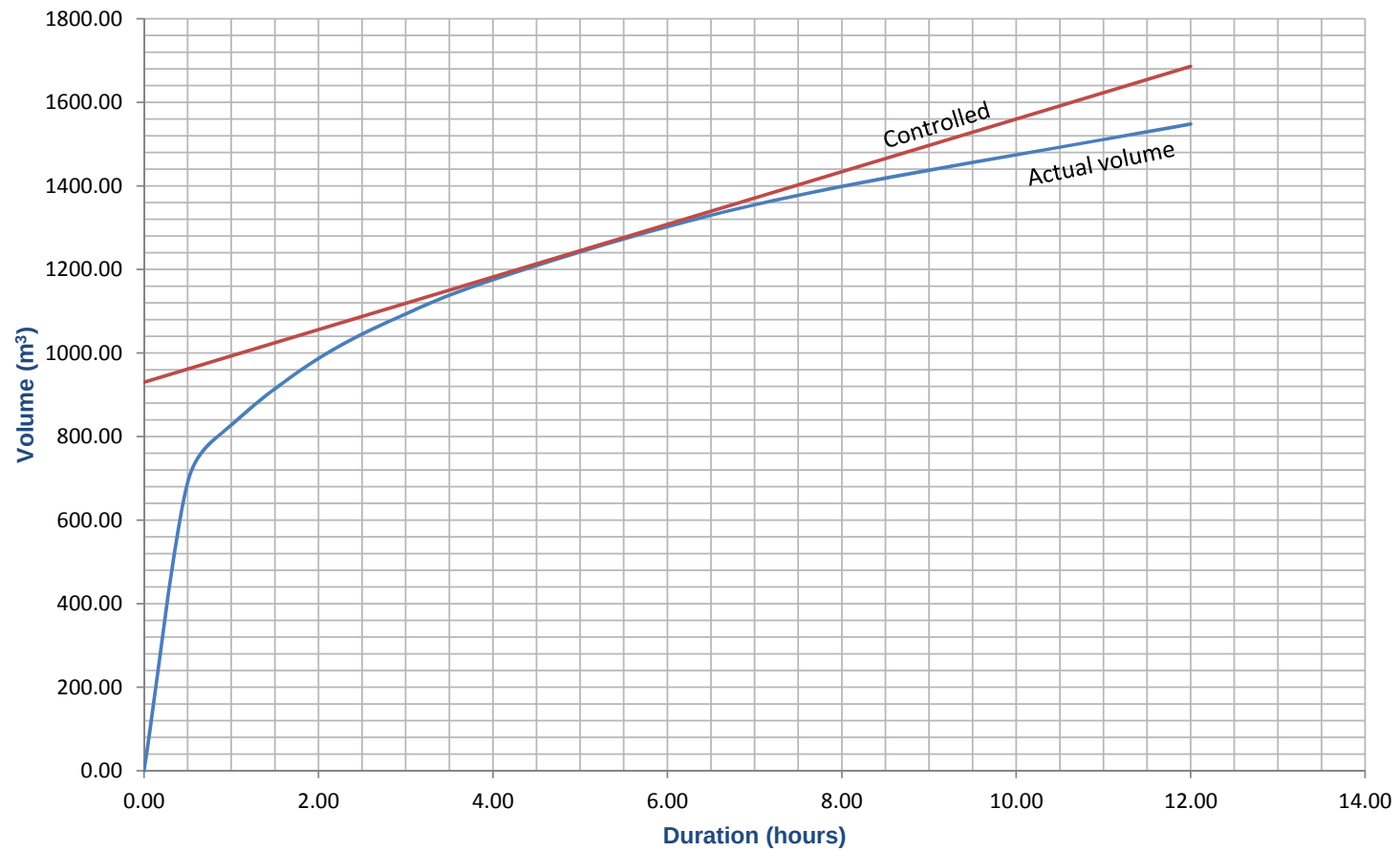


**Figure 5: Surface water run-off from a 1% A.E.P. rainfall event including CCA
(post-development)**



APPENDIX A

Topographical survey plan

LEGEND

Manhole shown thus
Inspection Cover
Lamphole
Gully
Lampost
Telegraph Post
Electricity Poles
Road Traffic Signs
Traffic Lights
General Post Office
Post Office Telephones
Fire Hydrant
Safety Valve
Stopcock Water
Stopcock Gas
Unknown Stopcock

Spot Level
Kerb Line
Fence Line

Hedge Line
Contours 5m interval
Contours 1m interval
Tree Spread
Girth
Cover Level
Invert Level
Foul Drain
Surface Water
Unknown Service
Survey Station

Floor Level
Height floor to structural
Height floor to false ceiling
Height floor to sill
Height of window
Height of Door
Height floor to underside
of Beam

Vent
Fall Pipe
Sky Light
Water Closet
Sink
Boxed Columns
Shop fitting or cladding

V

SITE
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BA

UNDW
Y

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Diagram

Datum

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Point Locati
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Grid North.

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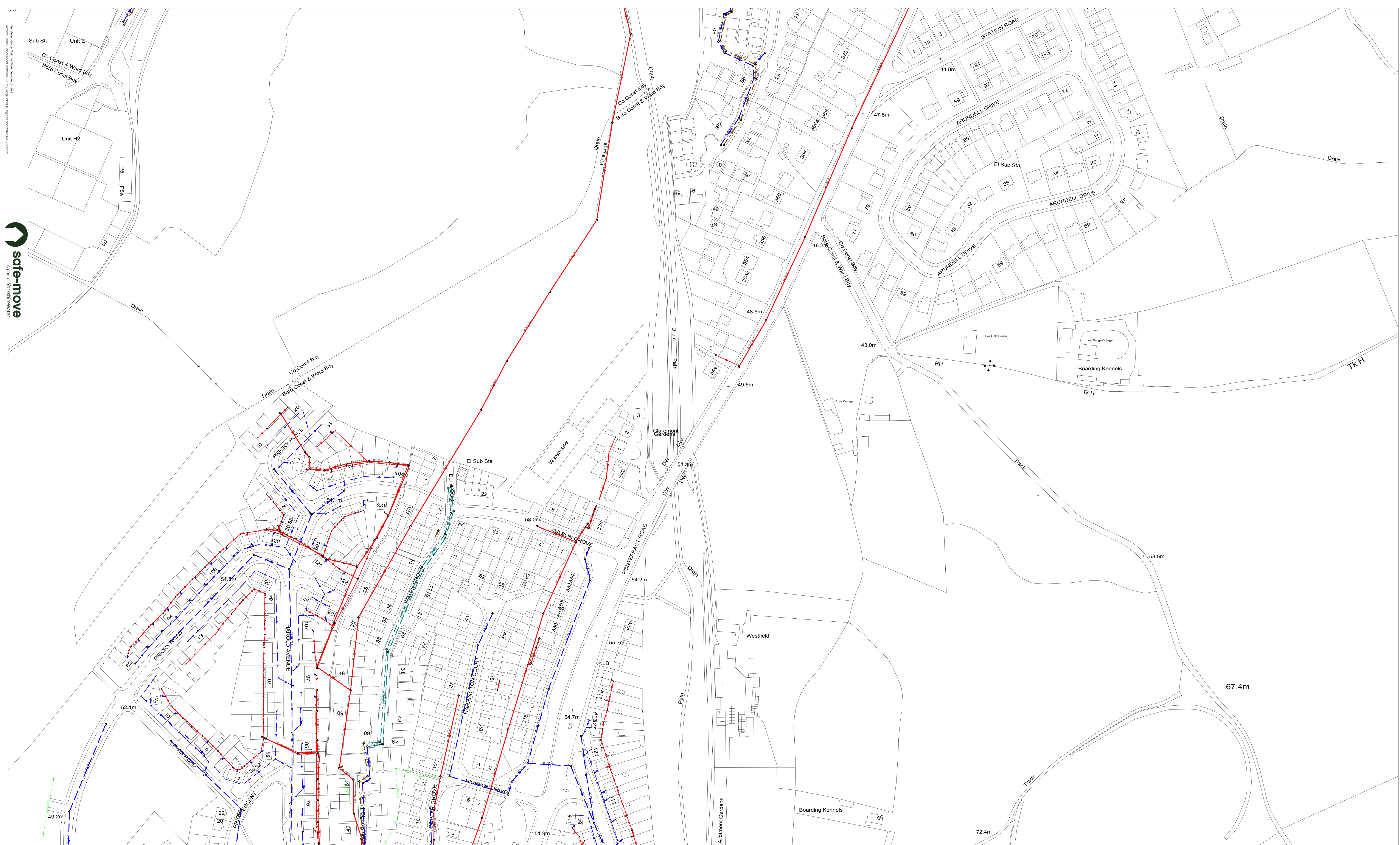
Job No. 57
Date of Survey
October 2013

1/500

7988

APPENDIX B

Yorkshire Water sewer plan



43740 - 407717	Map Name : SE3707NW	Title	Partial Key
	Yorkshire Water, PO Box 500, Halifax Road, Bradford BD6 2LZ	Notes	Four Sewer = F Combined Sewer = C Surface Water Sewer = SW Trade Sewer = TD Partially Separate = PS
	Contact Name : Key	(Only) COPYRIGHT STATEMENTS: Reproduced by permission of Ordnance Survey on behalf of HMRC © Crown copyright and database 2006. All rights reserved Ordnance Survey (license number 100019559)	This plan is furnished as a general guide only and only for use in connection with the sewerage system shown. It is not to be used for any other purpose and no liability is accepted for any loss or damage arising from its use. The plan must be read in conjunction with the sewerage system shown. The plan must be read in conjunction with the sewerage system shown. The plan must be read in conjunction with the sewerage system shown.
	Contact Tel :		Date Req : 18/10/2013, 14:51:04 Source : Sewer Network Enquiry Date Gen : 18/10/2013, 14:51:12

APPENDIX C

Site layout plan

Drawing No: 1313.03.01 rev: D

LUNDWOOD BARNSELEY
sketch housing layout



House Type Schedule			
201	Cork	2 bed semi-det	17
202	Kerry	2 bed semi-det	8
301	Tyrone	3 bed semi-det	13
302	Galway	3 bed semi-det	8
303	Wicklow	3 bed semi-det	14
309	Fergus	3 bed detached	8
304	Kilkenny	3 bed detached	10
307	Kildare	3 bed detached	6
310	Liffey	3 bed detached	5
400	Stoneyford	4 bed detached	3
401	Longford	4 bed detached	2
403	Carlow	4 bed detached	2
			96

- Footpath links thro' site
- Indicative planting only
- Existing trees, hedgerow and scrub
- Existing trees, hedgerow and scrub, dead, felled or to be removed

- D 10.12.13 Layout amended in line with title boundary. (DLM)
- C 25.11.13 Amended generally following planning comments. P.O.S. & Play area repositioned. Direct rear access to all plots. Plots 16-17 & 40-42 rotated to front parkland. Shared surface road widths amended. (DLM)
- B 11.11.13 Amended generally in line with clients instruction. House Type 307 added to scheme. 1 No. plot omitted. Survey information added. (DLM)
- A 23.10.13 P.O.S. and Play Area added. Road layout amended. Plot substitutions to suit. (DLM)



client
Gleeson Regeneration & Homes

project
Land at
Lundwood, Barnsley

drawing title
SKETCH HOUSING LAYOUT

orig. no. 1313.03.01 rev D scale 1:500 @ A1

date September 2013 drawn DLM checked by DLM

The Well Garden, Branton Green,
Great Ouseburn, North Yorks, YO26 9RT
Tel: 01423 579105
Email: Mail@ACERarchitectural.co.uk

1. Do not scale off drawing
2. All dimensions to be checked on site
3. Any discrepancy between drawn and specified information to be notified immediately
4. If in doubt - ASK

Layout based on Ordnance Survey information provided by client and is subject to topographical site survey. All external boundaries to be checked against the Land Registry title plan prior to commencement on site and any discrepancies to be notified to ACER Architectural Limited.

All materials, landscape details and boundary treatments are subject to approval by the Local Planning Authority.



APPENDIX D

Surface water run-off calculations: Tables D1 to D6

Table C1: Rapid response run-off from 3.3% A.E.P. rainfall event: existing condition							
Duration hours	Rainfall at Site mm	Area (m ²)			Volume (m ³)		
		Impervious Area (ha)	Pervious Area (ha)	Total Area (ha)	Impervious Area	Pervious Area	Run-off Volume
		C _v 90.0%	C _v 27.2%				
0.0	0.0	0.00	3.50	3.50	0.00	0.00	0.00
0.5	23.0	0.00	3.50	3.50	0.00	218.96	218.96
1.0	28.1	0.00	3.50	3.50	0.00	267.51	267.51
2.0	34.3	0.00	3.50	3.50	0.00	326.54	326.54
3.0	38.4	0.00	3.50	3.50	0.00	365.57	365.57
4.0	41.7	0.00	3.50	3.50	0.00	396.98	396.98
6.0	46.7	0.00	3.50	3.50	0.00	444.58	444.58
8.0	50.7	0.00	3.50	3.50	0.00	482.66	482.66
12.0	56.7	0.00	3.50	3.50	0.00	539.78	539.78
18.0	65.3	0.00	3.50	3.50	0.00	621.66	621.66
24.0	72.2	0.00	3.50	3.50	0.00	687.34	687.34
36.0	83.1	0.00	3.50	3.50	0.00	791.11	791.11
48.0	91.8	0.00	3.50	3.50	0.00	873.94	873.94
72.0	98.2	0.00	3.50	3.50	0.00	934.86	934.86
96.0	103.0	0.00	3.50	3.50	0.00	980.56	980.56
144.0	110.1	0.00	3.50	3.50	0.00	1048.15	1048.15
192.0	115.4	0.00	3.50	3.50	0.00	1098.61	1098.61

Table C2: Rapid response run-off from 1% A.E.P. rainfall event: existing condition							
Duration hours	Rainfall at Site mm	Area (m ²)			Volume (m ³)		
		Impervious Area (ha)	Pervious Area (ha)	Total Area (ha)	Impervious Area	Pervious Area	Run-off Volume
		Cv 90.0%	Cv 27.2%				
0.00	0.0	0.00	3.50	3.50	0.00	0.00	0.00
0.50	33.7	0.00	3.50	3.50	0.00	320.82	320.82
1.00	40.4	0.00	3.50	3.50	0.00	384.61	384.61
2.00	48.2	0.00	3.50	3.50	0.00	458.86	458.86
3.00	53.4	0.00	3.50	3.50	0.00	508.37	508.37
4.00	57.4	0.00	3.50	3.50	0.00	546.45	546.45
6.00	63.6	0.00	3.50	3.50	0.00	605.47	605.47
8.00	68.3	0.00	3.50	3.50	0.00	650.22	650.22
12.00	75.6	0.00	3.50	3.50	0.00	719.71	719.71
18.00	86.0	0.00	3.50	3.50	0.00	818.72	818.72
24.00	94.2	0.00	3.50	3.50	0.00	896.78	896.78
36.00	107.1	0.00	3.50	3.50	0.00	1019.59	1019.59
48.00	117.3	0.00	3.50	3.50	0.00	1116.70	1116.70
72.0	123.9	0.00	3.50	3.50	0.00	1179.53	1179.53
96.0	128.8	0.00	3.50	3.50	0.00	1226.18	1226.18
144.0	136.0	0.00	3.50	3.50	0.00	1294.72	1294.72
192.0	141.7	0.00	3.50	3.50	0.00	1348.98	1348.98

Table C3: Rapid response run-off from 3.3% A.E.P. rainfall event: post development condition

Duration hours	Rainfall at Site mm	Area (m ²)			Volume (m ³)			% increase in run-off volume
		Impervious Area (ha)	Pervious Area (ha)	Total Area (ha)	Impervious Area	Pervious Area	Run-off Volume	
		Cv 90.0%	Cv 27.2%					
0.0	0.0	1.75	1.75	3.50	0.00	0.00	0.00	
0.5	23.0	1.75	1.75	3.50	362.25	109.48	471.73	115%
1.0	28.1	1.75	1.75	3.50	442.58	133.76	576.33	115%
2.0	34.3	1.75	1.75	3.50	540.23	163.27	703.49	115%
3.0	38.4	1.75	1.75	3.50	604.80	182.78	787.58	115%
4.0	41.7	1.75	1.75	3.50	656.78	198.49	855.27	115%
6.0	46.7	1.75	1.75	3.50	735.53	222.29	957.82	115%
8.0	50.7	1.75	1.75	3.50	798.53	241.33	1039.86	115%
12.0	56.7	1.75	1.75	3.50	893.03	269.89	1162.92	115%
18.0	65.3	1.75	1.75	3.50	1028.48	310.83	1339.30	115%
24.0	72.2	1.75	1.75	3.50	1137.15	343.67	1480.82	115%
36.0	83.1	1.75	1.75	3.50	1308.83	395.56	1704.38	115%
48.0	91.8	1.75	1.75	3.50	1445.85	436.97	1882.82	115%
72.0	98.2	1.75	1.75	3.50	1546.65	467.43	2014.08	115%
96.0	103.0	1.75	1.75	3.50	1622.25	490.28	2112.53	115%
144.0	110.1	1.75	1.75	3.50	1734.08	524.08	2258.15	115%
192.0	115.4	1.75	1.75	3.50	1817.55	549.30	2366.85	115%

Table C4: Rapid response run-off from 1% A.E.P. rainfall event: post development condition

Duration hours	Rainfall at Site mm	Area (m ²)			Volume (m ³)			% increase in run-off volume
		Impervious Area (ha)	Pervious Area (ha)	Total Area (ha)	Impervious Area	Pervious Area	Run-off Volume	
		C _v 90.0%	C _v 27.2%					
0.00	0.0	1.75	1.75	3.50	0.00	0.00	0.00	
0.50	33.7	1.75	1.75	3.50	530.78	160.41	691.19	115%
1.00	40.4	1.75	1.75	3.50	636.30	192.30	828.60	115%
2.00	48.2	1.75	1.75	3.50	759.15	229.43	988.58	115%
3.00	53.4	1.75	1.75	3.50	841.05	254.18	1095.23	115%
4.00	57.4	1.75	1.75	3.50	904.05	273.22	1177.27	115%
6.00	63.6	1.75	1.75	3.50	1001.70	302.74	1304.44	115%
8.00	68.3	1.75	1.75	3.50	1075.73	325.11	1400.83	115%
12.00	75.6	1.75	1.75	3.50	1190.70	359.86	1550.56	115%
18.00	86.0	1.75	1.75	3.50	1354.50	409.36	1763.86	115%
24.00	94.2	1.75	1.75	3.50	1483.65	448.39	1932.04	115%
36.00	107.1	1.75	1.75	3.50	1686.83	509.80	2196.62	115%
48.00	117.3	1.75	1.75	3.50	1847.48	558.35	2405.82	115%
72.00	123.9	1.75	1.75	3.50	1951.43	589.76	2541.19	115%
96.00	128.8	1.75	1.75	3.50	2028.60	613.09	2641.69	115%
144.00	136.0	1.75	1.75	3.50	2142.00	647.36	2789.36	115%
192.00	141.7	1.75	1.75	3.50	2231.78	674.49	2906.27	115%

Table C5: Post-development rapid response run-off from impervious area (3.3% A.E.P. rainfall event including CCA)

Duration hours	Rainfall at Site mm	Area (m ²)			Volume (m ³)			Controlled run off m ³	Tangent m ³
		Impervious Area (ha)	Pervious Area (ha)	Total Area (ha)	Impervious Area	Pervious Area	Run-off Volume		
		C _v 90.0%	C _v 0.0%					Controlled rate (l.s ⁻¹ .ha ⁻¹) 5.0	
0.0	0.0	1.75	1.75	3.50	0.00	0.00	0.00	0.00	600.00
0.5	29.9	1.75	1.75	3.50	470.93	0.00	470.93	31.50	631.50
1.0	36.5	1.75	1.75	3.50	575.35	0.00	575.35	63.00	663.00
2.0	44.6	1.75	1.75	3.50	702.29	0.00	702.29	126.00	726.00
3.0	49.9	1.75	1.75	3.50	786.24	0.00	786.24	189.00	789.00
4.0	54.2	1.75	1.75	3.50	853.81	0.00	853.81	252.00	852.00
6.0	60.7	1.75	1.75	3.50	956.18	0.00	956.18	378.00	978.00
8.0	65.9	1.75	1.75	3.50	1038.08	0.00	1038.08	504.00	1104.00
12.0	73.7	1.75	1.75	3.50	1160.93	0.00	1160.93	756.00	1356.00
18.0	84.9	1.75	1.75	3.50	1337.02	0.00	1337.02	1134.00	1734.00
24.0	93.9	1.75	1.75	3.50	1478.30	0.00	1478.30	1512.00	2112.00
36.0	108.0	1.75	1.75	3.50	1701.47	0.00	1701.47	2268.00	2868.00
48.0	119.3	1.75	1.75	3.50	1879.61	0.00	1879.61	3024.00	3624.00
72.00	127.7	1.75	1.75	3.50	2010.65	0.00	2010.65	4536.00	5136.00
96.00	133.9	1.75	1.75	3.50	2108.93	0.00	2108.93	6048.00	6648.00
144.00	143.1	1.75	1.75	3.50	2254.30	0.00	2254.30	9072.00	9672.00
192.00	150.0	1.75	1.75	3.50	2362.82	0.00	2362.82	12096.00	12696.00
Total Storage Requirement (m ³)									600.00

Table C6: Post-development rapid response run-off from impervious area (1% A.E.P. rainfall event including CCA)

Duration hours	Rainfall at Site mm	Area (m ²)			Volume (m ³)			Controlled run off m ³	Tangent m ³
		Impervious Area (ha)	Pervious Area (ha)	Total Area (ha)	Impervious Area	Pervious Area	Run-off Volume		
		C _v 90.0%	C _v 0.0%					Controlled rate (l/s) 5.0	
0.00	0.0	1.75	1.75	3.50	0.00	0.00	0.00	0.00	930.00
0.50	43.8	1.75	1.75	3.50	690.01	0.00	690.01	31.50	961.50
1.00	52.5	1.75	1.75	3.50	827.19	0.00	827.19	63.00	993.00
2.00	62.7	1.75	1.75	3.50	986.90	0.00	986.90	126.00	1056.00
3.00	69.4	1.75	1.75	3.50	1093.37	0.00	1093.37	189.00	1119.00
4.00	74.6	1.75	1.75	3.50	1175.27	0.00	1175.27	252.00	1182.00
6.00	82.7	1.75	1.75	3.50	1302.21	0.00	1302.21	378.00	1308.00
8.00	88.8	1.75	1.75	3.50	1398.44	0.00	1398.44	504.00	1434.00
12.00	98.3	1.75	1.75	3.50	1547.91	0.00	1547.91	756.00	1686.00
18.00	111.8	1.75	1.75	3.50	1760.85	0.00	1760.85	1134.00	2064.00
24.00	122.5	1.75	1.75	3.50	1928.75	0.00	1928.75	1512.00	2442.00
36.00	139.2	1.75	1.75	3.50	2192.87	0.00	2192.87	2268.00	3198.00
48.00	152.5	1.75	1.75	3.50	2401.72	0.00	2401.72	3024.00	3954.00
72.00	161.1	1.75	1.75	3.50	2536.85	0.00	2536.85	4536.00	5466.00
96.00	167.4	1.75	1.75	3.50	2637.18	0.00	2637.18	6048.00	6978.00
144.00	176.8	1.75	1.75	3.50	2784.60	0.00	2784.60	9072.00	10002.00
192.00	184.2	1.75	1.75	3.50	2901.31	0.00	2901.31	12096.00	13026.00
Total Storage Requirement (m ³)									930.00

End of Report