Below Ground Drainage

Initial design Concept

To support

Planning Application

For

Rugby Free School

At

Long Furlong,

Rugby.

November 2017.

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BAM Design Technical Report.

SUBJECT

Below Ground Drainage, Initial Design Concept.

CLIENT: BAM Construction Midlands.

PROJECT: Rugby Free School & Quest SEN Academy.

Contract no:
Prepared by: S Bliss.

Job no: 4726.
Checked by: SGB.

Date: 16th November 2017.

Status of drawings / specifications: For Approval.

AMENDMENTS				
ref.	date	amendment	amended by	checked by
In0	22/11/17	Issued for Discussion at Pre - Application Planning Meeting.	SB	SB
Ap1	25/1/18	General Revisions, Drainage Calculations added. Issued for Warwickshire CC Planning Approval.	SB / DRW	SB
Ap2	01/02/18	Minor Revisions regarding condition numbers.	BG	SB

Contents

Below ground drainage Initial Concept Design.

1.0 Introduction.

BAM Design have been nominated to be responsible for the below ground drainage design for the new Rugby Free Secondary School and Quest SEN School. Both schools share a common access road off Long Furlong and Anderson Avenue, Rugby.

A Flood Risk assessment has been produced by Alan Wood & Partners. This document has been produced following correspondence with the Warwickshire County Council, Lead Local Flood Authority.

Outline Planning Permission has been granted subject to various conditions being met. Conditions 18 and 28 refer to complying with the requirements of the above mentioned Flood Risk assessment.

It is therefore considered that the above Flood Risk assessment and planning conditions form our design brief in relation to the below ground drainage design.

This report and calculations must be read in conjunction with the following drainage design drawings:

RFS-BMD-ZZ-ZZ-DR-D-50000-P01.4 Below Ground Drainage Layout.

RFS-BMD-ZZ-ZZ-DR-D-50020-P01 Porous Car Park Sections. Sheet 1.

2.0 Site Description.

The site area is approximately 11.4 Hectares and is currently 100% soft landscape. This is made up from existing playing fields (6.01 Hectares) and farm land. (5.4 Hectares). Appendix A indicates the site location and boundaries.

The Ordnance Survey grid reference for the centre of the site development is approximately X: 450325, Y: 273390. The local post code is CV22 5PE.

The topographical Survey indicates the site highest points being along the Southern, Western and Northern boundaries. The land generally falls from these boundaries towards the lower Eastern boundary. This boundary is defined by an existing hedgerow, ditches and a pond. These features provide the outfalls for the overland storm water drainage flows. These ditches are routed across the adjacent farm land and eventually discharge to Sow Brook (North).
The farm land is owned by Rugby Private School whom will be advised of our drainage intentions.

Appendix B indicates the existing site overland storm water run-off flow routes.

Soil infiltration tests in accordance with BRE digest 365 have been performed in four locations. Unfortunately these tests have failed, indicating that local ground conditions are not suitable for the use of drainage infiltration methods. Appendix C provides the results of these tests.

The storm water drainage design will therefore follow the existing drainage exit routes with the flow limited to existing green field run-off rates provided within the Flood Risk Assessment and Planning Conditions.

3.0 Drainage General.

The new below ground drainage proposal will comprise completely separate foul and storm water systems.

The systems will be designed in accordance with BS EN 752, The Building Regulations section H and Environment agency Planning Policy Statement PPS25. Foul water flows will be calculated in accordance with BS EN 12056 part 3.

The provision of porous car parks over a granular storage medium has negated the need for petrol / oil interceptors as directed by the SUDS manual and EA document PPG 3.

All drainage calculations will be produced using the industry accepted Micro Drainage software suite.

Once the drainage design has been completed, a Section 106 application will be made to Severn Trent Water for two new foul water sewer connection to the STW sewer within Long Furlong.

3.0 Storm Water Drainage.

The Requirement H3 of the Building Regulations 2000 has been considered for this project. This establishes a preferred hierarchy for surface water disposal. Consideration should firstly be given to discharge to a soakaway infiltration system and secondly, to a watercourse, then thirdly to a public sewer, in that priority order.

As previously discussed, soil infiltration tests have failed. The site generally falls towards the existing ditches and pond on the Eastern Boundary. The proposed drainage installation will therefore mimic the current drainage scenario.

These discharges **MUST** be restricted to the agreed green field discharge of 11.8 Litres per second with the remainder of the water attenuated on site until the storm has receded. The Flood Risk Assessment and Planning condition 28 require a minimum attenuation volume 2180m³.
The current design provides a total storm water attenuation volume of **2347m³**.

The preferred attenuation options for this project will include:

- Porous Car parking, pedestrian and games areas.
- Gravel filled filter trenches.
- Surface level Pond.
- Surface level dry swales / filter strips which will both store and convey water.
- 100 year event + 40% Climate Change detention basin on lowered grass sports pitch.

Porous Surfaces.
The granular fill sub base below porous car parking areas will have a 30% voids ratio. These voids provide a volume within which storm water can be stored for the duration of rainfall.
The complete granular fill and all perforated inlet / outlet pipes will be wrapped with Inbitex Geotextile fabric. This is a polypropylene and polyethelene non-woven fabric. During the manufacturing process, small dishes are created on the surface of the hairs from which the Geotextile is manufactured. This allows an early establishment of a microbial biomass which is responsible eating and degrading oils suspended in the water. It is also important during dry periods that the microbial population can retreat into the dishes where moisture can still be found. Thus when it rains again the microbial biomass is quickly re-established. This negates the need for traditional petrol interceptors. Silt removal at porous surface level provides two trains of improvement in water quality prior to discharge.

Gravel Filled filter trenches.
These will accept run-off laterally as sheet flow from impermeable footpaths, roads and car parks. Some point flow inlets will also be used where roadway kerbs are required. The filter trenches will be used to both store and convey water towards the outfalls. The entire trench will be wrapped with Inbitex geotextile, these trenches will act exactly the same as the porous surfaces and provide two trains of water treatment. Filter trenches also provide surface level attenuation within the granular voids and soakage into the ground if the local soil is receptive.

Surface Level Pond,
The use of ponds, provides storm water attenuation above the normal water level. The pond will receive silt free water with light loading of dissolved pollution that can be processed within the water column by micro-organisms. Ponds can therefore be seen as polishing mechanisms.

Surface level swales. (Detention Basins).
Swales are linear vegetated channels with a flat base that encourage sheet flow of water through grass and other robust vegetation. Suspended particles are then intercepted by this vegetation. Swales also provide surface level attenuation and soakage into the ground if the soil is receptive.

Detention Basins.
This is a recessed grassed area that will normally be used as a sports pitch. The area will only flood for storms that exceed the 1 in 30 year event and have the capacity to store the 1 in 100 year + 40% event.

All the above described structures are accepted SUDS Drainage techniques. In accordance with Environment Agency requirements the storm water drainage system will be designed to prevent flooding from a 1 in 30 year storm event.
The design will then be further interrogated against a 1 in 100 year storm event + 40% for future climate change. The run off from this storm must be retained on site whilst maintaining a safe exit route from the building.

We believe all of the above is in accordance current SuDS legislation and the requirements of the "Technical Guidance to the National Planning Policy Framework".

Off-site flows will be controlled using vortex flow limiters.

Appendix D provides the attenuation calculations for Car Parks labelled B, C & D. These also accept some run-off from building roofs, external areas and the access road.

Appendix E provides the Micro Drainage calculation for the above mentioned SUDS features.

5.0 Foul Water Drainage.

The two School buildings will each be provided with their own gravity foul water drainage systems. Each system will discharge to a foul water pumping chamber containing duty and stand-by submersible drainage pumps. From these pump chambers the sewage will be pumped to the water authority sewer network.
In accordance with building regulation requirements, each pump chamber will be stored 1 days foul water discharge. This will be based on a water usage of 20 litres per building occupant.

A Section 106 consent for a new foul water connection to the Severn Trent Water sewer within Long Furlong will be made once the design has been completed.

Access Chambers and rodding points will be provided to allow future maintenance of the system. Adequate ventilation pipes and trapped gullies will be provided to prevent the build-up of foul smells in or around the building.

6.0 Conclusion.

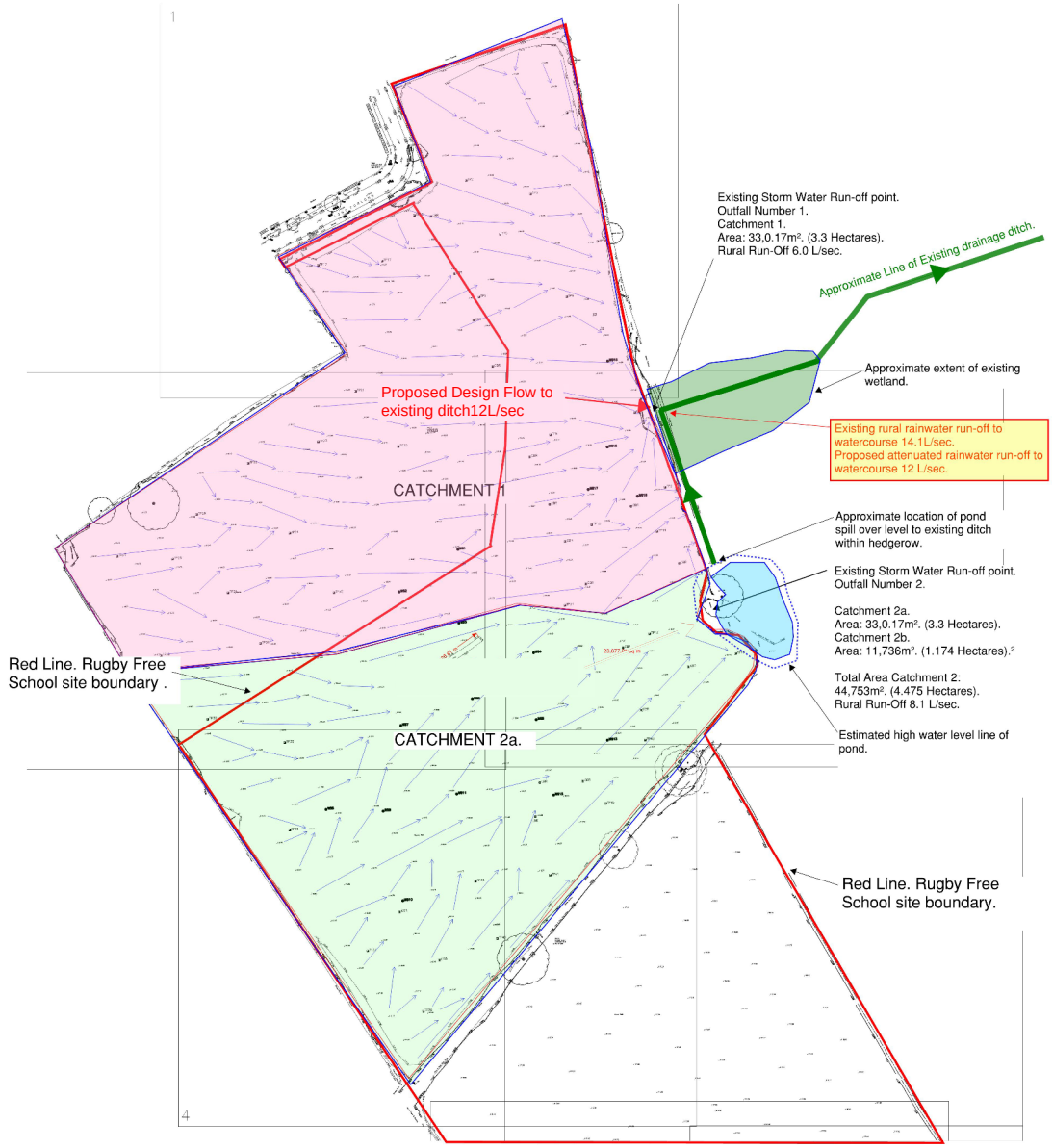
Vortex flow controllers will limit the discharge off-site to 12 Litres per second as detailed within the Warwickshire County Council planning conditions.

Appendix D provides an initial drainage strategy which is subject to future development as the scheme progresses.

Appendix A. Rugby Free School, Site Boundary.

Appendix B. Existing Site Overland Flow Routes.

Rugby Free School. Existing & Proposed Rainwater Run-off onto Adjacent Property.



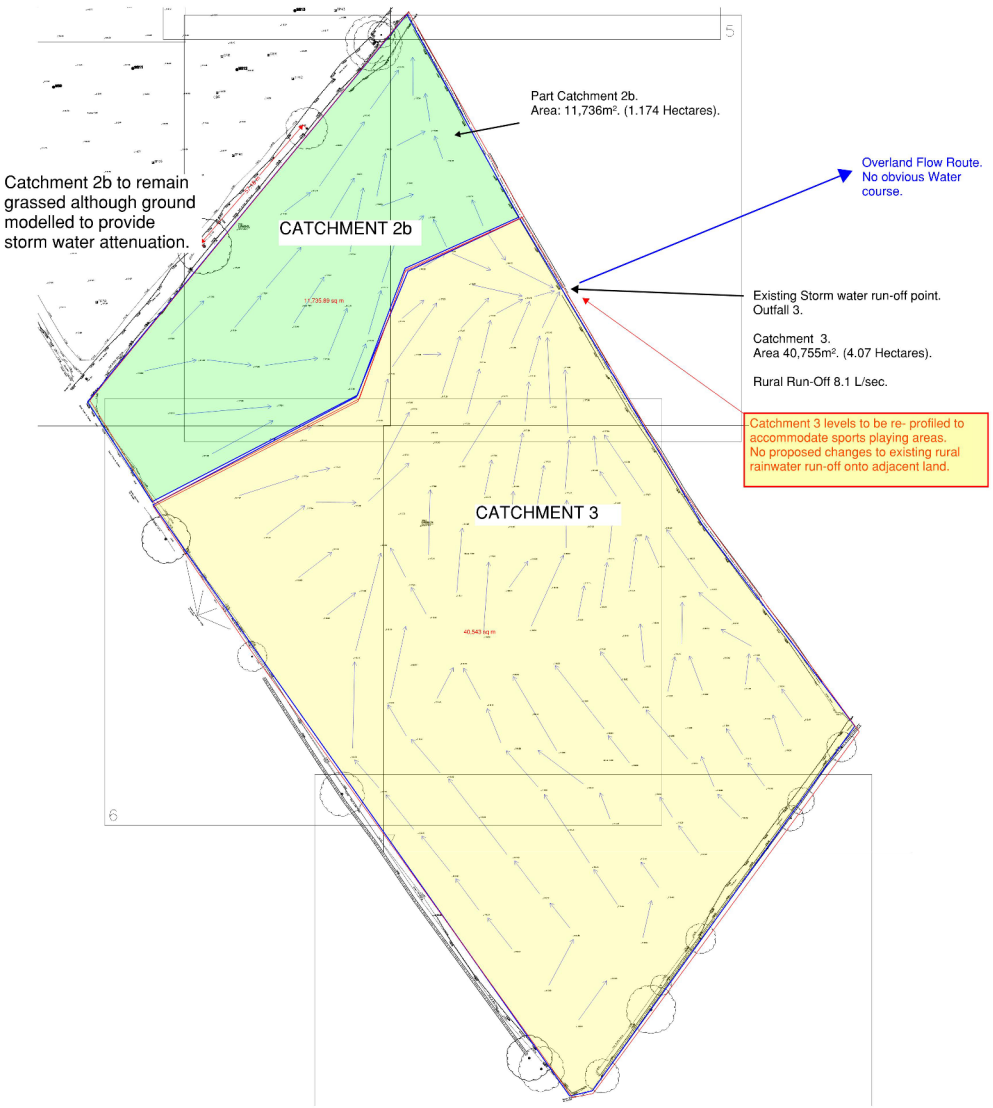
Rugby Free School
Green Field Site
Storm Water Overland Flow Paths.

bam design

Rev A. Amended Following Site Survey. 16/6/17

4726/ BAM Design / Sketch PH 101 Rev A.

Rugby Free School. Existing & Proposed Rainwater Run-off to Adjacent Property.



Rugby Free School
Green Field Site
Storm Water Overland Flow Paths.

bam design

4726/ BAM Design / Sketch PH 102 Rev A.

Rev A. Amended Following Site Survey. 16/6/17

Appendix C. Soil Infiltration test Results.

Rugby Free School

SOAKAWAY TEST RESULTS

INSITU SOAKAWAY TEST RESULTS

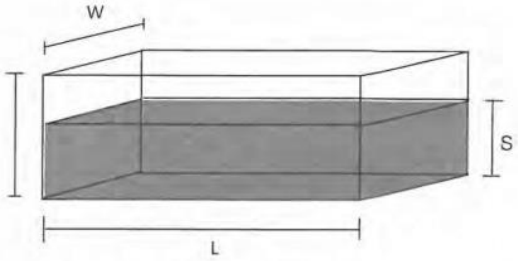
Trialpit No.: SA-TP11

Soil Profile:

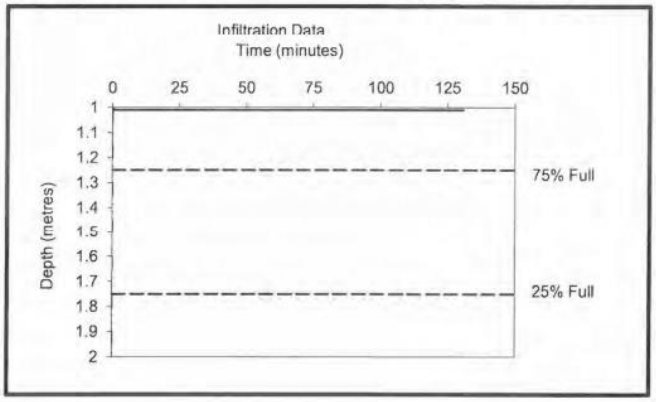
Depth (m) From:	To:	Description
0.00	0.40	TOPSOIL
0.40	2.00	Brown clayey gravelly fine to coarse SAND.

Sketch plan of test zone

Not to scale
All dimensions in metres.
D = Depth of test pit = 2.00
W = Width of test pit = 0.30
L = Length of test pit = 2.50
S= Storage depth (of water) = 1.00
N = Porosity = 0.42



Soakaway Test Run 1 **Test Date: 24/05/2016**



Time (minutes)	Depth (m)
0	1.00
1	1.01
6	1.01
11	1.01
41	1.01
71	1.01
101	1.01
131	1.01

Notes:

Water did not sufficiently dissipate during test period.
The soils at this location are therefore considered to be practically impermeable.

Test and analysis carried out in general accordance with BRE Digest 365 : 2007

Job No.: G16157
Site: Rokeby Infant School, Rugby
Client: Alan Wood & Partners

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INSITU SOAKAWAY TEST RESULTS

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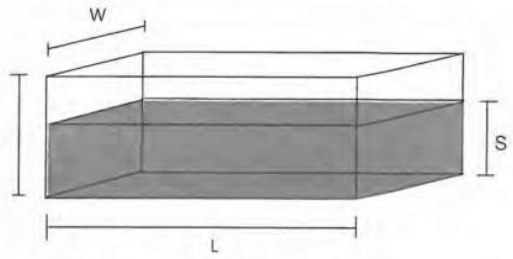
Trialpit No.: SA-TP20

Soil Profile:

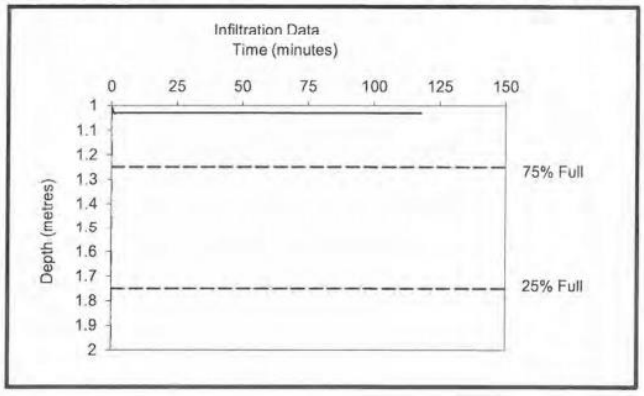
Depth (m) From:	To:	Description
0.00	0.40	TOPSOIL
0.40	2.00	Brown clayey very gravelly fine to coarse SAND with occasional cobbles.

Sketch plan of test zone

Not to scale
All dimensions in metres.
D = Depth of test pit = 2.00
W = Width of test pit = 0.30
L = Length of test pit = 2.00
S= Storage depth (of water) = 1.00
N = Porosity = 0.42



Soakaway Test Run 1 **Test Date: 24/05/2016**



Time (minutes)	Depth (m)
0	1.00
1	1.03
3	1.03
8	1.03
13	1.03
18	1.03
28	1.03
43	1.03
73	1.03
103	1.03
118	1.03

Notes:

Water did not sufficiently dissipate during test period.
The soils at this location are therefore considered to be practically impermeable.

Test and analysis carried out in general accordance with BRE Digest 365 : 2007

Job No.: G16157
Site: Rokeby Infant School, Rugby
Client: Alan Wood & Partners

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INSITU SOAKAWAY TEST RESULTS

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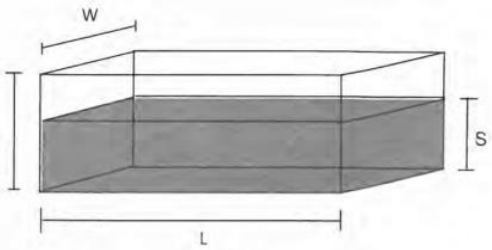
Trialpit No.: SA-TP35

Soil Profile:

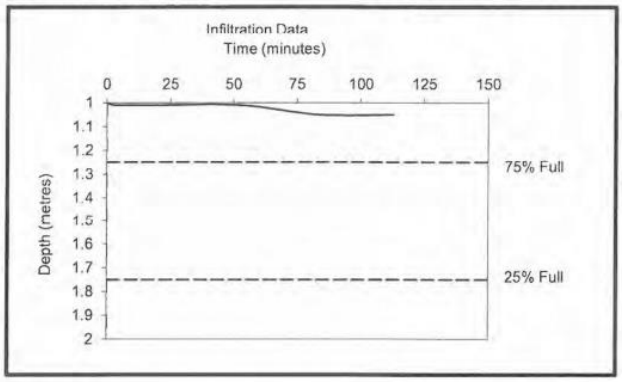
Depth (m) From:	To:	Description
0.00	0.40	TOPSOIL
0.40	2.00	Brown gravelly fine to coarse SAND mixed with occasional firm grey mottled brown slightly sandy clay.

Sketch plan of test zone

Not to scale
All dimensions in metres.
D = Depth of test pit = 2.00
W = Width of test pit = 0.30
L = Length of test pit = 2.30
S= Storage depth (of water) = 1.00
N = Porosity = 0.42



Soakaway Test Run 1 **Test Date: 25/05/2016**



Time (minutes)	Depth (m)
0	1.00
3	1.01
13	1.01
23	1.01
53	1.01
83	1.05
113	1.05

Notes:

Water did not sufficiently dissipate during test period.
The soils at this location are therefore considered to be practically impermeable.

Test and analysis carried out in general accordance with BRE Digest 365 : 2007

Job No.: G16157
Site: Rokeby Infant School, Rugby
Client: Alan Wood & Partners

NICHOLLS COLTON GEOTECHNICAL

INSITU SOAKAWAY TEST RESULTS

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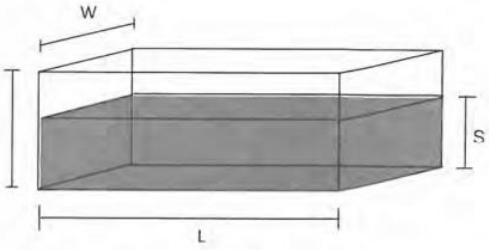
Trialpit No.: SA-TP42

Soil Profile:

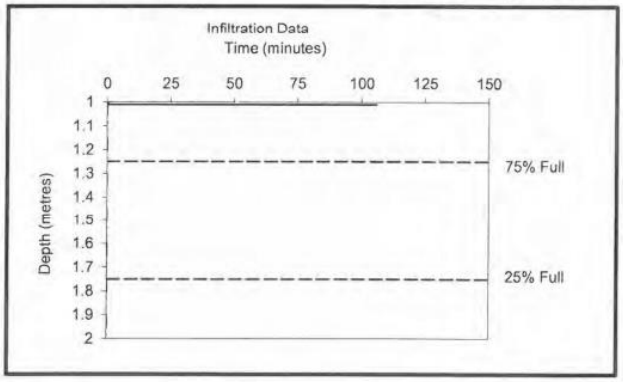
Depth (m) From:	To:	Description
0.00	0.40	TOPSOIL
0.40	2.00	Brown gravelly fine to coarse SAND mixed with occasional firm grey mottled brown slightly sandy clay.

Sketch plan of test zone

Not to scale
All dimensions in metres.
D = Depth of test pit = 2.00
W = Width of test pit = 0.30
L = Length of test pit = 2.50
S= Storage depth (of water) = 1.00
N = Porosity = 0.42



Soakaway Test Run 1 **Test Date: 25/05/2016**



Time (minutes)	Depth (m)
0	1.00
1	1.01
6	1.01
11	1.01
16	1.01
46	1.01
76	1.01
106	1.01

Notes:

Water did not sufficiently dissipate during test period.
The soils at this location are therefore considered to be practically impermeable.

Test and analysis carried out in general accordance with BRE Digest 365 : 2007

Job No.: G16157
Site: Rokeby Infant School, Rugby
Client: Alan Wood & Partners

NICHOLLS COLTON GEOTECHNICAL

Appendix D. Attenuation Calculations for car parks B, C & D granular sub structures.

BAM Design Ltd		Page 1
Centrium, Griffiths Way St Albans Herts AL1 2RD	Rugby Free School Car Park B, C + part bldg For planning approval	Micro Drainage
Date 25/01/2018 File Car Park B, C + Buildin...	Designed by S Bliss Checked by SGB	
Micro Drainage	Source Control 2017.1	

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

Half Drain Time : 1984 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	15.376	0.176	0.0	1.0	1.0	84.5	O K
30 min Summer	15.433	0.233	0.0	1.0	1.0	111.8	O K
60 min Summer	15.490	0.290	0.0	1.0	1.0	139.3	O K
120 min Summer	15.546	0.346	0.0	1.0	1.0	166.2	O K
180 min Summer	15.577	0.377	0.0	1.1	1.1	180.7	O K
240 min Summer	15.596	0.396	0.0	1.1	1.1	189.9	O K
360 min Summer	15.618	0.418	0.0	1.1	1.1	200.6	O K
480 min Summer	15.632	0.432	0.0	1.1	1.1	207.3	O K
600 min Summer	15.640	0.440	0.0	1.1	1.1	211.2	O K
720 min Summer	15.644	0.444	0.0	1.1	1.1	213.3	O K
960 min Summer	15.646	0.446	0.0	1.1	1.1	214.3	O K
1440 min Summer	15.634	0.434	0.0	1.1	1.1	208.5	O K
2160 min Summer	15.607	0.407	0.0	1.1	1.1	195.1	O K
2880 min Summer	15.583	0.383	0.0	1.1	1.1	184.0	O K
4320 min Summer	15.546	0.346	0.0	1.0	1.0	166.3	O K
5760 min Summer	15.513	0.313	0.0	1.0	1.0	150.4	O K
7200 min Summer	15.483	0.283	0.0	1.0	1.0	135.8	O K
8640 min Summer	15.454	0.254	0.0	1.0	1.0	121.9	O K
10080 min Summer	15.427	0.227	0.0	1.0	1.0	108.8	O K
15 min Winter	15.399	0.199	0.0	1.0	1.0	95.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	134.715	0.0	80.6	23
30 min Summer	87.677	0.0	82.5	38
60 min Summer	54.368	0.0	142.3	68
120 min Summer	32.619	0.0	166.8	126
180 min Summer	23.901	0.0	168.7	186
240 min Summer	19.071	0.0	169.8	246
360 min Summer	13.769	0.0	170.9	366
480 min Summer	10.943	0.0	171.5	484
600 min Summer	9.148	0.0	171.7	604
720 min Summer	7.899	0.0	171.5	724
960 min Summer	6.262	0.0	170.9	962
1440 min Summer	4.507	0.0	168.3	1430
2160 min Summer	3.240	0.0	308.2	1752
2880 min Summer	2.561	0.0	321.0	2112
4320 min Summer	1.836	0.0	299.5	2936
5760 min Summer	1.449	0.0	358.4	3744
7200 min Summer	1.205	0.0	369.0	4544
8640 min Summer	1.036	0.0	377.3	5360
10080 min Summer	0.912	0.0	383.4	6144
15 min Winter	134.715	0.0	81.5	23

BAM Design Ltd		Page 2
Centrium, Griffiths Way St Albans Herts AL1 2RD	Rugby Free School Car Park B, C + part bldg For planning approval	Micro Drainage
Date 25/01/2018 File Car Park B, C + Buildin...	Designed by S Bliss Checked by SGB	
Micro Drainage	Source Control 2017.1	

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

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	15.463	0.263	0.0	1.0	1.0	126.4	O K
60 min Winter	15.528	0.328	0.0	1.0	1.0	157.5	O K
120 min Winter	15.591	0.391	0.0	1.1	1.1	187.9	O K
180 min Winter	15.626	0.426	0.0	1.1	1.1	204.6	O K
240 min Winter	15.649	0.449	0.0	1.1	1.1	215.4	O K
360 min Winter	15.675	0.475	0.0	1.1	1.1	228.2	O K
480 min Winter	15.693	0.493	0.0	1.1	1.1	236.5	O K
600 min Winter	15.704	0.504	0.0	1.1	1.1	241.8	Flood Risk
720 min Winter	15.711	0.511	0.0	1.1	1.1	245.2	Flood Risk
960 min Winter	15.717	0.517	0.0	1.1	1.1	248.1	Flood Risk
1440 min Winter	15.712	0.512	0.0	1.1	1.1	245.6	Flood Risk
2160 min Winter	15.684	0.484	0.0	1.1	1.1	232.2	O K
2880 min Winter	15.652	0.452	0.0	1.1	1.1	217.0	O K
4320 min Winter	15.602	0.402	0.0	1.1	1.1	192.8	O K
5760 min Winter	15.554	0.354	0.0	1.0	1.0	169.8	O K
7200 min Winter	15.508	0.308	0.0	1.0	1.0	147.8	O K
8640 min Winter	15.465	0.265	0.0	1.0	1.0	127.2	O K
10080 min Winter	15.425	0.225	0.0	1.0	1.0	108.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	87.677	0.0	83.6	37
60 min Winter	54.368	0.0	160.6	66
120 min Winter	32.619	0.0	169.8	126
180 min Winter	23.901	0.0	171.9	184
240 min Winter	19.071	0.0	173.1	242
360 min Winter	13.769	0.0	174.3	360
480 min Winter	10.943	0.0	174.9	476
600 min Winter	9.148	0.0	175.1	594
720 min Winter	7.899	0.0	175.0	710
960 min Winter	6.262	0.0	174.2	938
1440 min Winter	4.507	0.0	171.4	1386
2160 min Winter	3.240	0.0	334.7	2012
2880 min Winter	2.561	0.0	330.7	2256
4320 min Winter	1.836	0.0	312.1	3160
5760 min Winter	1.449	0.0	405.1	4088
7200 min Winter	1.205	0.0	417.6	4904
8640 min Winter	1.036	0.0	427.0	5784
10080 min Winter	0.912	0.0	434.7	6560

BAM Design Ltd		Page 3
Centrium, Griffiths Way St Albans Herts AL1 2RD	Rugby Free School Car Park B, C + part bldg For planning approval	
Date 25/01/2018 File Car Park B, C + Buildin...	Designed by S Bliss Checked by SGB	
Micro Drainage	Source Control 2017.1	

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)	19.200	Shortest Storm (mins)	15
Ratio R	0.423	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.370

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.185	4	8	0.185

BAM Design Ltd		Page 4
Centrium, Griffiths Way St Albans Herts AL1 2RD	Rugby Free School Car Park B, C + part bldg For planning approval	Micro Drainage
Date 25/01/2018 File Car Park B, C + Buildin...	Designed by S Bliss Checked by SGB	
Micro Drainage	Source Control 2017.1	

Model Details

Storage is Online Cover Level (m) 16.000

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.00000
Membrane Percolation (mm/hr)	1000
Max Percolation (l/s)	444.4
Safety Factor	2.0
Porosity	0.30
Invert Level (m)	15.200
Width (m)	16.0
Length (m)	100.0
Slope (1:X)	0.0
Depression Storage (mm)	5
Evaporation (mm/day)	3
Membrane Depth (m)	0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0045-1200-1680-1200
Design Head (m)	1.680
Design Flow (l/s)	1.2
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	45
Invert Level (m)	14.320
Minimum Outlet Pipe Diameter (mm)	75
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.680	1.2
Flush-Flo™	0.202	0.8
Kick-Flo®	0.405	0.6
Mean Flow over Head Range	-	0.9

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)
0.100	0.7	1.000	0.9	2.400	1.4
0.200	0.8	1.200	1.0	2.600	1.5
0.300	0.7	1.400	1.1	3.000	1.6
0.400	0.6	1.600	1.2	3.500	1.7
0.500	0.7	1.800	1.2	4.000	1.8
0.600	0.8	2.000	1.3	4.500	1.9
0.800	0.9	2.200	1.4	5.000	2.0

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Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
5.500	2.1	7.000	2.3	8.500	2.5
6.000	2.1	7.500	2.4	9.000	2.6
6.500	2.2	8.000	2.4	9.500	2.7

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Micro Drainage	Source Control 2017.1	

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

Half Drain Time : 1102 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	114.611	0.211	0.0	2.1	2.1	115.4	Flood Risk
30 min Summer	114.678	0.278	0.0	2.2	2.2	152.0	Flood Risk
60 min Summer	114.744	0.344	0.0	2.2	2.2	188.0	Flood Risk
120 min Summer	114.806	0.406	0.0	2.3	2.3	221.8	Flood Risk
180 min Summer	114.837	0.437	0.0	2.3	2.3	238.8	Flood Risk
240 min Summer	114.855	0.455	0.0	2.4	2.4	248.6	Flood Risk
360 min Summer	114.872	0.472	0.0	2.4	2.4	257.5	Flood Risk
480 min Summer	114.878	0.478	0.0	2.4	2.4	261.0	Flood Risk
600 min Summer	114.877	0.477	0.0	2.4	2.4	260.6	Flood Risk
720 min Summer	114.872	0.472	0.0	2.4	2.4	258.0	Flood Risk
960 min Summer	114.856	0.456	0.0	2.4	2.4	249.0	Flood Risk
1440 min Summer	114.825	0.425	0.0	2.3	2.3	231.9	Flood Risk
2160 min Summer	114.790	0.390	0.0	2.3	2.3	213.0	Flood Risk
2880 min Summer	114.760	0.360	0.0	2.3	2.3	196.4	Flood Risk
4320 min Summer	114.705	0.305	0.0	2.2	2.2	166.3	Flood Risk
5760 min Summer	114.655	0.255	0.0	2.1	2.1	139.0	Flood Risk
7200 min Summer	114.609	0.209	0.0	2.1	2.1	114.3	Flood Risk
8640 min Summer	114.569	0.169	0.0	2.1	2.1	92.4	O K
10080 min Summer	114.533	0.133	0.0	2.1	2.1	72.8	O K
15 min Winter	114.639	0.239	0.0	2.1	2.1	130.5	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	135.484	0.0	117.6	26
30 min Summer	88.169	0.0	155.8	41
60 min Summer	54.663	0.0	195.2	70
120 min Summer	32.785	0.0	236.1	128
180 min Summer	24.016	0.0	260.2	188
240 min Summer	19.157	0.0	277.1	246
360 min Summer	13.835	0.0	300.6	364
480 min Summer	10.992	0.0	318.4	484
600 min Summer	9.188	0.0	332.9	602
720 min Summer	7.934	0.0	344.8	720
960 min Summer	6.289	0.0	357.3	866
1440 min Summer	4.527	0.0	352.0	1110
2160 min Summer	3.253	0.0	421.7	1496
2880 min Summer	2.571	0.0	442.6	1908
4320 min Summer	1.844	0.0	472.2	2728
5760 min Summer	1.455	0.0	492.2	3520
7200 min Summer	1.210	0.0	508.1	4320
8640 min Summer	1.040	0.0	519.5	5024
10080 min Summer	0.916	0.0	529.3	5752
15 min Winter	135.484	0.0	132.7	26

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

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	114.715	0.315	0.0	2.2	2.2	171.9	Flood Risk
60 min Winter	114.790	0.390	0.0	2.3	2.3	212.7	Flood Risk
120 min Winter	114.860	0.460	0.0	2.4	2.4	251.4	Flood Risk
180 min Winter	114.897	0.497	0.0	2.4	2.4	271.4	Flood Risk
240 min Winter	114.910	0.510	0.0	2.4	2.4	283.1	FLOOD
360 min Winter	114.922	0.522	0.0	2.4	2.4	295.2	FLOOD
480 min Winter	114.928	0.528	0.0	2.4	2.4	301.0	FLOOD
600 min Winter	114.930	0.530	0.0	2.4	2.4	303.0	FLOOD
720 min Winter	114.929	0.529	0.0	2.4	2.4	302.2	FLOOD
960 min Winter	114.923	0.523	0.0	2.4	2.4	295.8	FLOOD
1440 min Winter	114.901	0.501	0.0	2.4	2.4	274.5	FLOOD
2160 min Winter	114.856	0.456	0.0	2.4	2.4	248.9	Flood Risk
2880 min Winter	114.813	0.413	0.0	2.3	2.3	225.4	Flood Risk
4320 min Winter	114.731	0.331	0.0	2.2	2.2	180.7	Flood Risk
5760 min Winter	114.657	0.257	0.0	2.1	2.1	140.4	Flood Risk
7200 min Winter	114.592	0.192	0.0	2.1	2.1	104.8	O K
8640 min Winter	114.534	0.134	0.0	2.1	2.1	73.3	O K
10080 min Winter	114.482	0.082	0.0	2.1	2.1	44.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	88.169	0.0	173.7	40
60 min Winter	54.663	0.0	220.0	68
120 min Winter	32.785	0.0	265.4	126
180 min Winter	24.016	0.0	292.4	184
240 min Winter	19.157	10.1	311.5	242
360 min Winter	13.835	22.2	337.8	358
480 min Winter	10.992	28.0	358.1	474
600 min Winter	9.188	30.0	365.8	588
720 min Winter	7.934	29.2	366.0	700
960 min Winter	6.289	22.8	366.5	918
1440 min Winter	4.527	1.5	364.1	1168
2160 min Winter	3.253	0.0	474.4	1624
2880 min Winter	2.571	0.0	498.2	2076
4320 min Winter	1.844	0.0	531.9	2944
5760 min Winter	1.455	0.0	556.1	3800
7200 min Winter	1.210	0.0	573.1	4552
8640 min Winter	1.040	0.0	587.2	5352
10080 min Winter	0.916	0.0	599.0	6056

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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)	19.300	Shortest Storm (mins)	15
Ratio R	0.423	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.500

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.200	4	8	0.200	8	12	0.100

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Model Details

Storage is Online Cover Level (m) 114.900

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.00000
Membrane Percolation (mm/hr)	1000
Max Percolation (l/s)	505.6
Safety Factor	2.0
Porosity	0.30
Invert Level (m)	114.400
Width (m)	35.0
Length (m)	52.0
Slope (1:X)	0.0
Depression Storage (mm)	5
Evaporation (mm/day)	3
Membrane Depth (m)	0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0074-2300-0900-2300
Design Head (m)	0.900
Design Flow (l/s)	2.3
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	74
Invert Level (m)	113.900
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.900	2.3
Flush-Flo™	0.273	2.3
Kick-Flo®	0.565	1.9
Mean Flow over Head Range	-	2.0

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)
0.100	2.0	1.000	2.4	2.400	3.6
0.200	2.3	1.200	2.6	2.600	3.7
0.300	2.3	1.400	2.8	3.000	4.0
0.400	2.2	1.600	3.0	3.500	4.3
0.500	2.1	1.800	3.2	4.000	4.6
0.600	1.9	2.000	3.3	4.500	4.8
0.800	2.2	2.200	3.5	5.000	5.1

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Hydro-Brake® Optimum Outflow Control

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
5.500	5.3	7.000	6.0	8.500	6.5
6.000	5.5	7.500	6.2	9.000	6.7
6.500	5.8	8.000	6.3	9.500	6.9

Appendix E: Micro Drainage Calculations.