Stormwater Drainage Proposal

Applicant: Beckett Developments Ltd.

Site Location:

Palmyra, Whitechurch Road, Rathfarnham, Co. Dublin

Date of Report: 27th April 2023

Prepared By:

HYDROCARE
ENVIRONMENTAL LTD

Document Control Sheet

Project No.: 23-004

Project Title: Beckett Developments Ltd., Palmyra, Whitechurch Road, Rathfarnham, Dublin 16

Revision: A

Status: FINAL

Prepared By: Adrian Bacaoanu, *MSc. Sust. Energy Engineering, BSc. Applied Physics*

Checked By: Daniel Nolan, *BA BAI, Msc Environmental Engineering, FETAC Site Assessor, MIEI*

CONTENTS

1.1 Introduction

Hydrocare Environmental Ltd, has been retained by the applicant to revise and design a new surface water drainage proposal for a development site at Palmyra, Whitechurch Road, Rathfarnham, Dublin 16 in response to Items 7(a), 7(b), 7(c), 8(a), 8(b), 8(c) & 8(d) of the Conditions to Grant, Planning Ref. No. SD21A/0246.

The proposed development will consist of the construction of 8 houses comprising of 1 three-bedroom two storey detached, Type B1 (c. 122sq.m) Site 1, 1 four bedroom 2 storey detached type B2 (c.134sq.m) Site 2, 6 four bedroom 2 storey semidetached Type Al (c.148sq.m) Sites 3-8 inclusive, all associated on and off site development works, landscaping, boundary treatments, removal of existing street boundary screen wall and the provision of vehicular and pedestrian access to Grangebrook Avenue on infill site of circa 0.226Ha.

1.2 Stormwater Design Parameters & Considerations

At present the proposed development is a greenfield site which consists largely of trees and open grass areas.

Due to the constrained nature of the development, soakaways could not be designed to cater for the surface water runoff from the impermeable site areas and dispose it to the ground BRE Digest 365 due to the requirement for a 5m separation distance from foundations. Additionally, soil infiltration tests carried out by Ground Investigations Ireland Ltd. shows that *"At all locations the water level dropped too slowly to allow calculation of 'f' the soil infiltration rate. These locations are therefore not recommended as suitable for soakaway design and construction."* The ground investigation report has been attached herewith.

To cater for the surface water runoff from this proposed development, it is proposed to install individual surface water drainage systems sized to cater for the runoff from impermeable surfaces of each of the 8 no. dwellings. Each dwelling house system will have a separate controlled outfall to the public surface water drain available locally. The rationale for the individual controlled outfalls at each house was because there will be no common area within this development in which to locate a 'shared/common' surface water drainage

system and flow control device. There will be just the 8 individual private sites which will be accessed off a public estate road/ footpath, this is an infill site as such and therefore there is no other public open space or remaining common area.

The surface water network will outfall to the public stormwater sewer available locally. The outfall flow rate for each dwelling site will be controlled to 0.5l/s. Therefore the total outfall flow rate from this development will be 4l/s. The IH124 Greenfield Runoff Rate for this entire development site is 1.48l/s.

Item 7(c) of the Condition to Grant for this development, ref. no. SD21A/0246 states: *Show in a report and drawing what the maximum surface water discharge rate will be from the overall site. The report shall demonstrate that the discharge rate will not be more than 2 litres/sec/hectare or greenfield run off rate whichever is greater from the entire site.*

As the greenfield runoff rate for this development site is 1.48l/s, this would require that the outfall flow rate from each dwelling house be restricted to 0.185l/s in order to satisfy the criteria. However, it is not practical to restrict the individual outfall flow rates to less than 0.5l/s due to the increased risk of blockage. This is half of the outfall flow rate for each site compared to the surface water drainage system previously designed by others for this development under the ref. no. SD21A/0246.

1.3 Site Characteristics

1.3.1 Breakdown of Impermeable Surfaces

Dwelling Site 1:

- Total Site Area: 273m^2
- Total Roof Area: 79.2m^2
- Impermeable Footpath Area: 29.4m^2
- Permeable Paving Area: 89.1m^2
- Remaining Permeable Green Area: 75.3m^2

Dwelling Site 2:

- Total Site Area: 315.8m^2
- Total Roof Area: 99.3m^2
- Impermeable Footpath Area: 28.1m^2
- Permeable Paving Area: 62.5m^2
- Remaining Permeable Green Area: 125.9m^2

Dwelling Site 3:

- Total Site Area: 261.2m^2
- Total Roof Area: 92.8m^2
- Impermeable Footpath Area: 23.9m^2
- Permeable Paving Area: 67.4m^2
- Remaining Permeable Green Area: 77.1m^2

Dwelling Site 4:

- Total Site Area: 271.3m^2
- Total Roof Area: 92.8m^2
- Impermeable Footpath Area: 24m^2
- Permeable Paving Area: 74.1m^2
- Remaining Permeable Green Area: 80.4m^2

Dwelling Site 5:

- Total Site Area: 269.8m^2
- Total Roof Area: 93.3m^2
- Impermeable Footpath Area: 19.9m^2
- Permeable Paving Area: 56.6m^2
- Remaining Permeable Green Area: 100m^2

Dwelling Site 6:

- Total Site Area: 269.7m^2
- Total Roof Area: 92.2m^2
- Impermeable Footpath Area: 25.5m^2
- Permeable Paving Area: 53.1m^2
- Remaining Permeable Green Area: 98.9m^2

Dwelling Site 7:

- Total Site Area: 303.1m^2
- Total Roof Area: 80.2m^2
- Impermeable Footpath Area: 27.9m^2
- Permeable Paving Area: 77.7m^2
- Remaining Permeable Green Area: 117.3m^2

Dwelling Site 8:

- Total Site Area: 280.2m^2
- Total Roof Area: 80.6m^2
- Impermeable Footpath Area: 37.1m^2
- Permeable Paving Area: 60.4m^2
- Remaining Permeable Green Area: 102.1m^2

1.4 Design Proposal

As soakaways could not be designed to manage the surface water runoff from this development it is proposed to install permeable paving with an underlying gravel attenuation blanket at each proposed dwelling house. The permeable paving will be a Kilsaran Clima-Pave System A Load Category 2 or similar approved system. This system will have a 0.4m(D) underlying gravel bed with a permeable geotextile at the base allowing some infiltration to the ground during regular rainfall events. The permeable paving will

discharge to the public surface water drainage system at a controlled outfall flow rate restricted to 0.5l/s. The permeable paving attenuation underlying gravel attenuation blanket volume calculations assume that no surface water infiltrates to the ground through the base.

The proposed attenuation system will manage the surface water runoff which arises from this development during the peak rainfall event duration that arises during the 1 in 100-year return period. This includes a 20% allowance for climate change.

As a SuDS feature it is proposed to install a tree pit in the rear garden of each dwelling house except Dwelling No.3. For Dwelling House No.3 there is an existing tree to be retained and protected reducing available space for a new tree-pit. The tree-pit for each dwelling house will be sized so that it is 1m(W) x 1m(L) x 1m(D). This will cater for the surface water arising from the impermeable footpath areas of this development during regular rainfall events, thus limiting the outfall to the public storm drain during these events.

However, the gravel filled attenuation blanket underlying the permeable paving will be sized to cater for the surface water runoff from all impermeable surfaces during the peak rainfall event in during the 100-year return period. This includes the roof areas, footpaths and the permeable paving. The base of the underlying attenuation gravel blanket will be permeable, allowing for some infiltration to the ground within the site boundary thus also providing some source control.

1.5 Design Calculations

The surface water drainage is to include:

- Total attenuation of runoff waters will be for the critical 100-year rainfall return period with 20% allowance for climate change.
- The outfall flow control for each dwelling house will be restricted to 0.5l/s.
- Each dwelling is to include a 1m(W) x 1m(L) x 1m(D) tree pit for additional storage, drainage and source control not included in the calculations.
- Based on the CIRIA C753 SuDS Manual 2015, the following Runoff Coefficient will be applied.

- Pitched Roof with Tiles: 0.90
- Road Pavement: 0.75
- Permeable Pavement: 0.60

1.5.1 Greenfield Runoff Rate

IH124 Greenfield Runoff Rate Calculation

Friday 10 March 2023

Client: Beckett Developments Ltd.
Site Location: Palmyra, Whitechurch Road, Rathfarnham, Co. Dublin
Agent: Terry & O'Flanagan Ltd., F1, Centrepoint Business Park, Oak Road, Dublin 12

The IH124 method was specifically introduced as an update to the original Flood Studies Report (1975) to address the runoff from small catchments (CIRIA C697 and IH124)

$$Q_{BAR}\ RURAL\ (m^3/s) = 0.00108\ AREA^{0.89} \times SAAR^{1.17} \times SOIL^{2.17}$$

- Q_{BAR} RURAL is the mean annual flood flow from a rural catchment (43% AEP or 2.3 year return period).
- AREA is the area of the catchment (km^2)
- SAAR is the standard average annual rainfall
- SOIL is the Soil Index, SOIL - 0.1 SOIL1 + 0.3 Soil2 + 0.37 Soil3 + 0.47 Soil4 + 0.53 Soil5
- The soil type is selected based on the Flood Studies or the Wallingford Procedure WRAP maps.

Inputs

AREA:	0.2265	Ha	Site AREA is 0.2265Ha. As site is <50Ha, use 50Ha
SAAR:	907	mm	Grid Reference E:314473 N:226367 - Met Eireann Mean Annual Rainfall Data
Soil:	0.47		FSR SPR value for SOIL type 4 is 0.47

Outputs

Q_{BAR} RURAL (l/s/Ha)-	6.54
Site Area (Ha)-	0.2265
Q_{BAR} RURAL (l/s)-	1.48

	l/s
Q_1 =	1.26
Q_{30} =	3.11
Q_{100} =	3.86

Growth Curve Factors (GDSDS)	
Return Period (years)	Growth Curve Factor
1	0.85
Q_{BAR}	1
10	1.7
30	2.1
100	2.61
200	2.9

1.5.2 Dwelling Site 1 Calculations

Return Period (Years):	**100**
Impermeable Area (m^2):	**146.79**
Controlled Outflow (l/s):	**0.5**
Climate Change Increase Allowance:	**20%**

Dwelling Site 1

Required Attenuation Volume

Client: *Beckett Developments Ltd.*

Site Location: Palmyra, Whitechurch Road, Rathfarnham, Co. Dublin

Agent: *Terry & O'Flanagan Ltd., F1, Centrepoint Business Park, Oak Road, Dublin 12*

Duration (time)	Duration (secs)	Rainfall Depth (mm)	Rainfall Depth Incl. Climate Change (mm)	Rainfall Intensity (mm/s)	Inflow Rate (m^3/s)	Inflow Rate (l/s)	Overflow Flow Rate (l/s)	Storage Rate (l/s)	Storage Volume (Litres)	Storage Volume (m^3)
5 mins	300	19	22.8	0.07600	0.01116	11.16	0.5	10.66	3196.812	3.196812
10 mins	600	26.5	31.8	0.05300	0.00778	7.78	0.5	7.28	4367.922	4.367922
15 mins	900	31.1	37.32	0.04147	0.00609	6.09	0.5	5.59	5028.203	5.028203
30 mins	1,800	39	46.8	0.02600	0.00382	3.82	0.5	3.32	5969.772	5.969772
1 hours	3,600	48.9	58.68	0.01630	0.00239	2.39	0.5	1.89	6813.637	6.813637
2 hours	7,200	61.3	73.56	0.01022	0.00150	1.50	0.5	1.00	7197.872	7.197872
3 hours	10,800	69.9	83.88	0.00777	0.00114	1.14	0.5	0.64	6912.745	6.912745
4 hours	14,400	76.8	92.16	0.00640	0.00094	0.94	0.5	0.44	6328.166	6.328166
6 hours	21,600	87.6	105.12	0.00487	0.00071	0.71	0.5	0.21	4630.565	4.630565
9 hours	32,400	100	120	0.00370	0.00054	0.54	0.5	0.04	1414.8	1.4148
12 hours	43,200	109.8	131.76	0.00305	0.00045	0.45	0.5	-0.05	-2258.95	-2.25895
18 hours	64,800	125.4	150.48	0.00232	0.00034	0.34	0.5	-0.16	-10311	-10.311
24 hours	86,400	137.7	165.24	0.00191	0.00028	0.28	0.5	-0.22	-18944.4	-18.9444

Dwelling Site 1

Required Storage for 1 in 100 year Peak Rainfall Event:

7.20 m^3 See Attenuation Volume Calculation Overleaf

Proposed Attenuation System

Gravel Filled Attenuation Blanket

Void Ratio:	**30%**
Permeable Paving	
Surface Area	**89.1 m^2**
Depth:	**0.4 m**

Total Volume: **10.69 m^3** **Proposed Storage Volume is Sufficient**

1.5.3 Dwelling Site 2 Calculations

Return Period (Years):	**100**
Impermeable Area (m^2):	**147.95**
Controlled Outflow (l/s):	**0.5**
Climate Change Increase Allowance:	**20%**

Dwelling Site 2

Required Attenuation Volume

Client: *Beckett Developments Ltd.*

Site Location: Palmyra, Whitechurch Road, Rathfarnham, Co. Dublin

Agent: *Terry & O'Flanagan Ltd., F1, Centrepoint Business Park, Oak Road, Dublin 12*

Duration (time)	Duration (secs)	Rainfall Depth (mm)	Rainfall Depth Incl. Climate Change (mm)	Rainfall Intensity (mm/s)	Inflow Rate (m^3/s)	Inflow Rate (l/s)	Overflow Flow Rate (l/s)	Storage Rate (l/s)	Storage Volume (Litres)	Storage Volume (m^3)
5 mins	300	19	22.8	0.07600	0.01124	11.24	0.5	10.74	3223.146	3.223146
10 mins	600	26.5	31.8	0.05300	0.00784	7.84	0.5	7.34	4404.651	4.404651
15 mins	900	31.1	37.32	0.04147	0.00613	6.13	0.5	5.63	5071.307	5.071307
30 mins	1,800	39	46.8	0.02600	0.00385	3.85	0.5	3.35	6023.826	6.023826
1 hours	3,600	48.9	58.68	0.01630	0.00241	2.41	0.5	1.91	6881.413	6.881413
2 hours	7,200	61.3	73.56	0.01022	0.00151	1.51	0.5	1.01	7282.834	7.282834
3 hours	10,800	69.9	83.88	0.00777	0.00115	1.15	0.5	0.65	7009.627	7.009627
4 hours	14,400	76.8	92.16	0.00640	0.00095	0.95	0.5	0.45	6434.611	6.434611
6 hours	21,600	87.6	105.12	0.00487	0.00072	0.72	0.5	0.22	4751.978	4.751978
9 hours	32,400	100	120	0.00370	0.00055	0.55	0.5	0.05	1553.4	1.5534
12 hours	43,200	109.8	131.76	0.00305	0.00045	0.45	0.5	-0.05	-2106.77	-2.10677
18 hours	64,800	125.4	150.48	0.00232	0.00034	0.34	0.5	-0.16	-10137.2	-10.1372
24 hours	86,400	137.7	165.24	0.00191	0.00028	0.28	0.5	-0.22	-18753.6	-18.7536

Dwelling Site 2

Required Storage for 1 in 100 year Peak Rainfall Event:

7.28 m^3 See Attenuation Volume Calculation Overleaf

Proposed Attenuation System

Gravel Filled Attenuation Blanket

Void Ratio:	30%
Permeable Paving	
Surface Area	62.5 m^2
Depth:	0.4 m
Total Volume:	7.50 m^3

Proposed Storage Volume is Sufficient

1.5.4 Dwelling Site 3 Calculations

Return Period (Years):	**100**
Impermeable Area (m^2):	**145.98**
Controlled Outflow (l/s):	**0.5**
Climate Change Increase Allowance:	**20%**

Dwelling Site 3

Required Attenuation Volume

Client: *Beckett Developments Ltd.*

Site Location: Palmyra, Whitechurch Road, Rathfarnham, Co. Dublin

Agent: *Terry & O'Flanagan Ltd., F1, Centrepoint Business Park, Oak Road, Dublin 12*

Duration (time)	Duration (secs)	Rainfall Depth (mm)	Rainfall Depth Incl. Climate Change (mm)	Rainfall Intensity (mm/s)	Inflow Rate (m^3/s)	Inflow Rate (l/s)	Overflow Flow Rate (l/s)	Storage Rate (l/s)	Storage Volume (Litres)	Storage Volume (m^3)
5 mins	300	19	22.8	0.07600	0.01109	11.09	0.5	10.59	3178.344	3.178344
10 mins	600	26.5	31.8	0.05300	0.00774	7.74	0.5	7.24	4342.164	4.342164
15 mins	900	31.1	37.32	0.04147	0.00605	6.05	0.5	5.55	4997.974	4.997974
30 mins	1,800	39	46.8	0.02600	0.00380	3.80	0.5	3.30	5931.864	5.931864
1 hours	3,600	48.9	58.68	0.01630	0.00238	2.38	0.5	1.88	6766.106	6.766106
2 hours	7,200	61.3	73.56	0.01022	0.00149	1.49	0.5	0.99	7138.289	7.138289
3 hours	10,800	69.9	83.88	0.00777	0.00113	1.13	0.5	0.63	6844.802	6.844802
4 hours	14,400	76.8	92.16	0.00640	0.00093	0.93	0.5	0.43	6253.517	6.253517
6 hours	21,600	87.6	105.12	0.00487	0.00071	0.71	0.5	0.21	4545.418	4.545418
9 hours	32,400	100	120	0.00370	0.00054	0.54	0.5	0.04	1317.6	1.3176
12 hours	43,200	109.8	131.76	0.00305	0.00045	0.45	0.5	-0.05	-2365.68	-2.36568
18 hours	64,800	125.4	150.48	0.00232	0.00034	0.34	0.5	-0.16	-10432.9	-10.4329
24 hours	86,400	137.7	165.24	0.00191	0.00028	0.28	0.5	-0.22	-19078.3	-19.0783

Dwelling Site 3

Required Storage for 1 in 100 year Peak Rainfall Event:

7.14 m^3 See Attenuation Volume Calculation Overleaf

Proposed Attenuation System

Gravel Filled Attenuation Blanket

Void Ratio:	**30%**	
Permeable Paving		
Surface Area	**74.1 m^2**	
Depth:	**0.4 m**	
Total Volume:	8.89 m^3	**Proposed Storage Volume is Sufficient**

1.5.5 Dwelling Site 4 Calculations

Return Period (Years):	**100**
Impermeable Area (m^2):	**145.98**
Controlled Outflow (l/s):	**0.5**
Climate Change Increase Allowance:	**20%**

Dwelling Site 4

Required Attenuation Volume

Client: *Beckett Developments Ltd.*

Site Location: Palmyra, Whitechurch Road, Rathfarnham, Co. Dublin

Agent: *Terry & O'Flanagan Ltd., F1, Centrepoint Business Park, Oak Road, Dublin 12*

Duration (time)	Duration (secs)	Rainfall Depth (mm)	Rainfall Depth Incl. Climate Change (mm)	Rainfall Intensity (mm/s)	Inflow Rate (m^3/s)	Inflow Rate (l/s)	Overflow Flow Rate (l/s)	Storage Rate (l/s)	Storage Volume (Litres)	Storage Volume (m^3)
5 mins	300	19	22.8	0.07600	0.01109	11.09	0.5	10.59	3178.344	3.178344
10 mins	600	26.5	31.8	0.05300	0.00774	7.74	0.5	7.24	4342.164	4.342164
15 mins	900	31.1	37.32	0.04147	0.00605	6.05	0.5	5.55	4997.974	4.997974
30 mins	1,800	39	46.8	0.02600	0.00380	3.80	0.5	3.30	5931.864	5.931864
1 hours	3,600	48.9	58.68	0.01630	0.00238	2.38	0.5	1.88	6766.106	6.766106
2 hours	7,200	61.3	73.56	0.01022	0.00149	1.49	0.5	0.99	7138.289	7.138289
3 hours	10,800	69.9	83.88	0.00777	0.00113	1.13	0.5	0.63	6844.802	6.844802
4 hours	14,400	76.8	92.16	0.00640	0.00093	0.93	0.5	0.43	6253.517	6.253517
6 hours	21,600	87.6	105.12	0.00487	0.00071	0.71	0.5	0.21	4545.418	4.545418
9 hours	32,400	100	120	0.00370	0.00054	0.54	0.5	0.04	1317.6	1.3176
12 hours	43,200	109.8	131.76	0.00305	0.00045	0.45	0.5	-0.05	-2365.68	-2.36568
18 hours	64,800	125.4	150.48	0.00232	0.00034	0.34	0.5	-0.16	-10432.9	-10.4329
24 hours	86,400	137.7	165.24	0.00191	0.00028	0.28	0.5	-0.22	-19078.3	-19.0783

Dwelling Site 4

Required Storage for 1 in 100 year Peak Rainfall Event:

7.14 m^3 See Attenuation Volume Calculation Overleaf

Proposed Attenuation System

Gravel Filled Attenuation Blanket

Void Ratio:	30%	
Permeable Paving		
Surface Area	74.1 m^2	
Depth:	0.4 m	
Total Volume:	8.89 m^3	**Proposed Storage Volume is Sufficient**

1.5.6 Dwelling Site 5 Calculations

Return Period (Years):	**100**
Impermeable Area (m^2):	**132.86**
Controlled Outflow (l/s):	**0.5**
Climate Change Increase Allowance:	**20%**

Dwelling Site 5

Required Attenuation Volume

Client: *Beckett Developments Ltd.*

Site Location: Palmyra, Whitechurch Road, Rathfarnham, Co. Dublin

Agent: *Terry & O'Flanagan Ltd., F1, Centrepoint Business Park, Oak Road, Dublin 12*

Duration (time)	Duration (secs)	Rainfall Depth (mm)	Rainfall Depth Incl. Climate Change (mm)	Rainfall Intensity (mm/s)	Inflow Rate (m^3/s)	Inflow Rate (l/s)	Overflow Flow Rate (l/s)	Storage Rate (l/s)	Storage Volume (Litres)	Storage Volume (m^3)
5 mins	300	19	22.8	0.07600	0.01010	10.10	0.5	9.60	2879.094	2.879094
10 mins	600	26.5	31.8	0.05300	0.00704	7.04	0.5	6.54	3924.789	3.924789
15 mins	900	31.1	37.32	0.04147	0.00551	5.51	0.5	5.01	4508.149	4.508149
30 mins	1,800	39	46.8	0.02600	0.00345	3.45	0.5	2.95	5317.614	5.317614
1 hours	3,600	48.9	58.68	0.01630	0.00217	2.17	0.5	1.67	5995.931	5.995931
2 hours	7,200	61.3	73.56	0.01022	0.00136	1.36	0.5	0.86	6172.814	6.172814
3 hours	10,800	69.9	83.88	0.00777	0.00103	1.03	0.5	0.53	5743.877	5.743877
4 hours	14,400	76.8	92.16	0.00640	0.00085	0.85	0.5	0.35	5043.917	5.043917
6 hours	21,600	87.6	105.12	0.00487	0.00065	0.65	0.5	0.15	3165.718	3.165718
9 hours	32,400	100	120	0.00370	0.00049	0.49	0.5	-0.01	-257.4	-0.2574
12 hours	43,200	109.8	131.76	0.00305	0.00041	0.41	0.5	-0.09	-4095.03	-4.09503
18 hours	64,800	125.4	150.48	0.00232	0.00031	0.31	0.5	-0.19	-12408	-12.408
24 hours	86,400	137.7	165.24	0.00191	0.00025	0.25	0.5	-0.25	-21247	-21.247

Dwelling Site 5

Required Storage for 1 in 100 year Peak Rainfall Event:

6.17 m^3 See Attenuation Volume Calculation Overleaf

Proposed Attenuation System

Gravel Filled Attenuation Blanket

Void Ratio:	30%
Permeable Paving	
Surface Area	56.6 m^2
Depth:	0.4 m
Total Volume:	6.79 m^3

Proposed Storage Volume is Sufficient

1.5.7 Dwelling Site 6 Calculations

Return Period (Years):	100
Impermeable Area (m^2):	133.97
Controlled Outflow (l/s):	0.5
Climate Change Increase Allowance:	20%

Dwelling Site 6

Required Attenuation Volume

Client: *Beckett Developments Ltd.*

Site Location: Palmyra, Whitechurch Road, Rathfarnham, Co. Dublin

Agent: *Terry & O'Flanagan Ltd., F1, Centrepoint Business Park, Oak Road, Dublin 12*

Duration (time)	Duration (secs)	Rainfall Depth (mm)	Rainfall Depth Incl. Climate Change (mm)	Rainfall Intensity (mm/s)	Inflow Rate (m^3/s)	Inflow Rate (l/s)	Overflow Flow Rate (l/s)	Storage Rate (l/s)	Storage Volume (Litres)	Storage Volume (m^3)
5 mins	300	19	22.8	0.07600	0.01018	10.18	0.5	9.68	2904.402	2.904402
10 mins	600	26.5	31.8	0.05300	0.00710	7.10	0.5	6.60	3960.087	3.960087
15 mins	900	31.1	37.32	0.04147	0.00556	5.56	0.5	5.06	4549.574	4.549574
30 mins	1,800	39	46.8	0.02600	0.00348	3.48	0.5	2.98	5369.562	5.369562
1 hours	3,600	48.9	58.68	0.01630	0.00218	2.18	0.5	1.68	6061.066	6.061066
2 hours	7,200	61.3	73.56	0.01022	0.00137	1.37	0.5	0.87	6254.465	6.254465
3 hours	10,800	69.9	83.88	0.00777	0.00104	1.04	0.5	0.54	5836.984	5.836984
4 hours	14,400	76.8	92.16	0.00640	0.00086	0.86	0.5	0.36	5146.214	5.146214
6 hours	21,600	87.6	105.12	0.00487	0.00065	0.65	0.5	0.15	3282.401	3.282401
9 hours	32,400	100	120	0.00370	0.00050	0.50	0.5	0.00	-124.2	-0.1242
12 hours	43,200	109.8	131.76	0.00305	0.00041	0.41	0.5	-0.09	-3948.77	-3.94877
18 hours	64,800	125.4	150.48	0.00232	0.00031	0.31	0.5	-0.19	-12240.9	-12.2409
24 hours	86,400	137.7	165.24	0.00191	0.00026	0.26	0.5	-0.24	-21063.6	-21.0636

Dwelling Site 6

Required Storage for 1 in 100 year Peak Rainfall Event:

6.25 m^3 See Attenuation Volume Calculation Overleaf

Proposed Attenuation System

Gravel Filled Attenuation Blanket

Void Ratio:	30%
Permeable Paving Surface Area	53.1 m^2
Depth:	0.4 m
Total Volume:	6.37 m^3

Proposed Storage Volume is Sufficient

1.5.8 Dwelling Site 7 Calculations

Return Period (Years):	**100**
Impermeable Area (m^2):	**139.73**
Controlled Outflow (l/s):	**0.5**
Climate Change Increase Allowance:	**20%**

Dwelling Site 7

Required Attenuation Volume

Client: *Beckett Developments Ltd.*

Site Location: Palmyra, Whitechurch Road, Rathfarnham, Co. Dublin

Agent: *Terry & O'Flanagan Ltd., F1, Centrepoint Business Park, Oak Road, Dublin 12*

Duration (time)	Duration (secs)	Rainfall Depth (mm)	Rainfall Depth Incl. Climate Change (mm)	Rainfall Intensity (mm/s)	Inflow Rate (m^3/s)	Inflow Rate (l/s)	Overflow Flow Rate (l/s)	Storage Rate (l/s)	Storage Volume (Litres)	Storage Volume (m^3)
5 mins	300	19	22.8	0.07600	0.01062	10.62	0.5	10.12	3035.73	3.03573
10 mins	600	26.5	31.8	0.05300	0.00741	7.41	0.5	6.91	4143.255	4.143255
15 mins	900	31.1	37.32	0.04147	0.00579	5.79	0.5	5.29	4764.537	4.764537
30 mins	1,800	39	46.8	0.02600	0.00363	3.63	0.5	3.13	5639.13	5.63913
1 hours	3,600	48.9	58.68	0.01630	0.00228	2.28	0.5	1.78	6399.063	6.399063
2 hours	7,200	61.3	73.56	0.01022	0.00143	1.43	0.5	0.93	6678.171	6.678171
3 hours	10,800	69.9	83.88	0.00777	0.00109	1.09	0.5	0.59	6320.133	6.320133
4 hours	14,400	76.8	92.16	0.00640	0.00089	0.89	0.5	0.39	5677.056	5.677056
6 hours	21,600	87.6	105.12	0.00487	0.00068	0.68	0.5	0.18	3887.892	3.887892
9 hours	32,400	100	120	0.00370	0.00052	0.52	0.5	0.02	567	0.567
12 hours	43,200	109.8	131.76	0.00305	0.00043	0.43	0.5	-0.07	-3189.83	-3.18983
18 hours	64,800	125.4	150.48	0.00232	0.00032	0.32	0.5	-0.18	-11374.2	-11.3742
24 hours	86,400	137.7	165.24	0.00191	0.00027	0.27	0.5	-0.23	-20111.8	-20.1118

Dwelling Site 7

Required Storage for 1 in 100 year Peak Rainfall Event:

6.68 m^3 See Attenuation Volume Calculation Overleaf

Proposed Attenuation System

Gravel Filled Attenuation Blanket

Void Ratio:	30%
Permeable Paving	
Surface Area	77.7 m^2
Depth:	0.4 m
Total Volume:	9.32 m^3

Proposed Storage Volume is Sufficient

1.5.9 Dwelling Site 8 Calculations

Return Period (Years):	**100**
Impermeable Area (m^2):	**145.88**
Controlled Outflow (l/s):	**0.5**
Climate Change Increase Allowance:	**20%**

Dwelling Site 8

Required Attenuation Volume

Client: *Beckett Developments Ltd.*

Site Location: Palmyra, Whitechurch Road, Rathfarnham, Co. Dublin

Agent: *Terry & O'Flanagan Ltd., F1, Centrepoint Business Park, Oak Road, Dublin 12*

Duration (time)	Duration (secs)	Rainfall Depth (mm)	Rainfall Depth Incl. Climate Change (mm)	Rainfall Intensity (mm/s)	Inflow Rate (m^3/s)	Inflow Rate (l/s)	Overflow Flow Rate (l/s)	Storage Rate (l/s)	Storage Volume (Litres)	Storage Volume (m^3)
5 mins	300	19	22.8	0.07600	0.01109	11.09	0.5	10.59	3176.064	3.176064
10 mins	600	26.5	31.8	0.05300	0.00773	7.73	0.5	7.23	4338.984	4.338984
15 mins	900	31.1	37.32	0.04147	0.00605	6.05	0.5	5.55	4994.242	4.994242
30 mins	1,800	39	46.8	0.02600	0.00379	3.79	0.5	3.29	5927.184	5.927184
1 hours	3,600	48.9	58.68	0.01630	0.00238	2.38	0.5	1.88	6760.238	6.760238
2 hours	7,200	61.3	73.56	0.01022	0.00149	1.49	0.5	0.99	7130.933	7.130933
3 hours	10,800	69.9	83.88	0.00777	0.00113	1.13	0.5	0.63	6836.414	6.836414
4 hours	14,400	76.8	92.16	0.00640	0.00093	0.93	0.5	0.43	6244.301	6.244301
6 hours	21,600	87.6	105.12	0.00487	0.00071	0.71	0.5	0.21	4534.906	4.534906
9 hours	32,400	100	120	0.00370	0.00054	0.54	0.5	0.04	1305.6	1.3056
12 hours	43,200	109.8	131.76	0.00305	0.00044	0.44	0.5	-0.06	-2378.85	-2.37885
18 hours	64,800	125.4	150.48	0.00232	0.00034	0.34	0.5	-0.16	-10448	-10.448
24 hours	86,400	137.7	165.24	0.00191	0.00028	0.28	0.5	-0.22	-19094.8	-19.0948

Dwelling Site 8

Required Storage for 1 in 100 year Peak Rainfall Event:

7.13 m^3 See Attenuation Volume Calculation Overleaf

Proposed Attenuation System

Gravel Filled Attenuation Blanket

Void Ratio:	30%
Permeable Paving	
Surface Area	60.4 m^2
Depth:	0.4 m
Total Volume:	7.25 m^3

Proposed Storage Volume is Sufficient

1.6 Attenuation & Outfall Flow Control

The flow control device limiting flows to the from the underlying gravel attenuation blankets to the public storm drain must be an easily accessible Orifice Plate, Hydrobrake, Controflow or similar approved device which can be easily cleaned and maintained.

Please see attached herewith the proposed site layout drawing detailing the surface water drainage systems.

1.7 Maintenance Plan

A separate surface water drainage system has been designed for each of the 8 no. proposed dwellings. This will ensure that maintenance of each system is the responsibility of the homeowner or occupant of that respective dwelling.

- The systems have been designed to promote infiltration within the boundary of each site.
- Attenuation storage has been provided in excess of the 100-year peak rainfall event including a 20% allowance for climate change with a controlled outfall flow rate to the public storm drain.
- Each system will contain a 1m(W) x 1m(L) x 1m(D) tree-pit. This will capture surface water runoff during regular rainfall events allowing for infiltration to the ground at the rear of each dwelling.
- In excess rainfall events, this will overflow from the tree-pits via a high-level overflow to the gravel attenuation blankets underlying the permeable paving systems.
- Each underlying gravel attenuation blanket will be lined with a permeable geo-textile along the base allowing further infiltration to the ground within the site boundary.
- Each underlying gravel attenuation blanket will also have a controlled outfall to the public storm drain restricted to 0.5l/s.

Each dwelling house will have the same SUDS, varying only in the size of the underlying gravel attenuation blankets as required. This system is designed for easy maintenance which must include.

- Regular inspection and day to day care – collecting leaves and vegetation from inlets and outlets particularly around the tree-pits and visually inspecting the permeable paving to ensure there is no ponding.
- Occasional maintenance – the gullys, downpipes and flow control device must occasionally be inspected to ensure they are not silted up or blocked and must be cleared as needed. The permeable paving must also be inspected and maintained as set out in the maintenance schedule below.

1.8 Maintenance Schedule

Schedule	Action	Frequency
Paving Visual Inspection	Visually inspect the permeable paving for ponding during or following a heavy rainfall event.	Once a Year
Paving Maintenance	Brush, vacuum, or power wash the joints of the permeable paving if ponding is observed.	As Required
Paving Weed Control	Treat with weedkiller or manually remove weeds.	As Required
Paving Structural Maintenance	Remove and replace damaged blocks.	As Required
Flow Control Device Inspection	Flow control chamber and unit should be visually inspected, and any debris or silt should be removed.	Once a Year
Flow Control Device Maintenance	The flow control device does not require routine maintenance. In the event of a suspected blockage the system shall be inspected, and the source of blockage removed until unit becomes operational.	As Required
Gullys and Downpipes	Visually inspect and remove any debris and check there is no physical damage.	Monthly
High Level Overflow Maintenance	Jet pipes from the tree-pit high level overflow and check by running water through the overflow.	Once a Year
Tree Pit Visual Inspection	Remove rubbish, leaves, and debris. Check health of plant and water.	As Required
Tree Pit Maintenance	Check for damage of the tree pit and repair if needed. Ensure soil is not compacted and is free draining to the gravels.	Once a Year

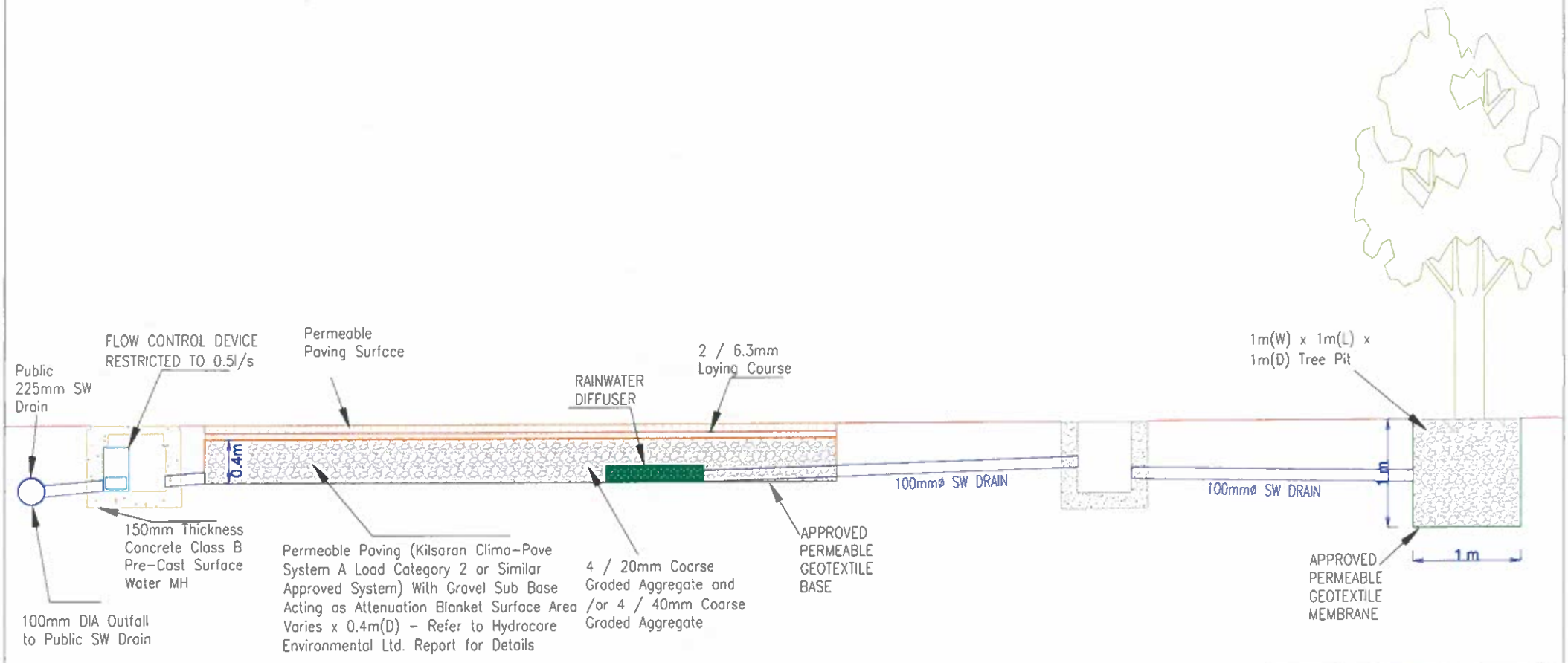
Met Eireann
Return Period Rainfall Depths for sliding Durations
Irish Grid: Easting: 320597, Northing: 237733,

	Interval		Years												
DURATION	6months,	1year,	2,	3,	4,	5,	10,	20,	30,	50,	75,	100,	150,	200,	250,	500,
5 mins	2.5,	3.5,	4.1,	4.9,	5.4,	5.8,	7.2,	8.7,	9.8,	11.2,	12.4,	13.4,	14.9,	16.1,	17.0,	N/A ,
10 mins	3.5,	4.9,	5.7,	6.8,	7.6,	8.1,	10.0,	12.2,	13.6,	15.6,	17.3,	18.7,	20.8,	22.4,	23.7,	N/A ,
15 mins	4.2,	5.8,	6.7,	8.0,	8.9,	9.6,	11.8,	14.3,	16.0,	18.3,	20.4,	22.0,	24.4,	26.4,	27.9,	N/A ,
30 mins	5.5,	7.6,	8.7,	10.3,	11.4,	12.2,	15.0,	18.0,	20.0,	22.8,	25.3,	27.2,	30.1,	32.3,	34.2,	N/A ,
1 hours	7.3,	9.9,	11.2,	13.3,	14.6,	15.7,	19.0,	22.7,	25.1,	28.4,	31.4,	33.6,	37.1,	39.7,	41.9,	N/A ,
2 hours	9.6,	12.9,	14.6,	17.1,	18.7,	20.0,	24.1,	28.5,	31.4,	35.4,	38.9,	41.6,	45.6,	48.7,	51.3,	N/A ,
3 hours	11.3,	15.1,	17.0,	19.8,	21.7,	23.1,	27.6,	32.6,	35.8,	40.3,	44.1,	47.1,	51.5,	54.9,	57.7,	N/A ,
4 hours	12.7,	16.8,	18.9,	22.0,	24.0,	25.6,	30.5,	35.9,	39.3,	44.1,	48.2,	51.4,	56.2,	59.8,	62.8,	N/A ,
6 hours	15.0,	19.6,	22.0,	25.5,	27.8,	29.5,	35.0,	41.0,	44.9,	50.1,	54.7,	58.2,	63.4,	67.4,	70.7,	N/A ,
9 hours	17.6,	22.9,	25.6,	29.6,	32.1,	34.1,	40.3,	46.9,	51.2,	57.0,	62.0,	65.9,	71.6,	76.0,	79.6,	N/A ,
12 hours	19.8,	25.6,	28.6,	32.8,	35.6,	37.7,	44.4,	51.6,	56.2,	62.4,	67.8,	71.9,	78.1,	82.8,	86.6,	N/A ,
18 hours	23.3,	29.9,	33.3,	38.1,	41.2,	43.6,	51.0,	59.0,	64.1,	71.0,	76.9,	81.4,	88.2,	93.3,	97.5,	N/A ,
24 hours	26.1,	33.4,	37.0,	42.3,	45.7,	48.2,	56.3,	64.9,	70.4,	77.8,	84.1,	88.9,	96.1,	101.6,	106.0,	121.0,
2 days	32.2,	40.3,	44.3,	50.1,	53.8,	56.5,	65.2,	74.3,	80.0,	87.7,	94.3,	99.2,	106.6,	112.1,	116.6,	131.7,
3 days	37.0,	45.9,	50.2,	56.4,	60.3,	63.3,	72.4,	82.0,	87.9,	95.9,	102.7,	107.8,	115.4,	121.1,	125.7,	141.1,
4 days	41.3,	50.7,	55.4,	61.9,	66.0,	69.1,	78.7,	88.6,	94.8,	103.1,	110.2,	115.4,	123.2,	129.1,	133.8,	149.5,
6 days	48.8,	59.2,	64.3,	71.4,	75.9,	79.2,	89.6,	100.2,	106.9,	115.7,	123.1,	128.6,	136.8,	142.9,	147.8,	164.2,
8 days	55.3,	66.6,	72.1,	79.7,	84.5,	88.1,	99.1,	110.3,	117.3,	126.5,	134.3,	140.1,	148.6,	155.0,	160.1,	177.0,
10 days	61.3,	73.4,	79.2,	87.3,	92.3,	96.1,	107.6,	119.5,	126.7,	136.4,	144.5,	150.4,	159.3,	165.8,	171.1,	188.6,
12 days	66.9,	79.7,	85.8,	94.3,	99.6,	103.5,	115.6,	127.9,	135.5,	145.4,	153.8,	160.0,	169.1,	175.9,	181.3,	199.2,
16 days	77.3,	91.3,	97.9,	107.1,	112.9,	117.1,	130.1,	143.3,	151.3,	161.9,	170.8,	177.3,	187.0,	194.1,	199.8,	218.6,
20 days	86.8,	101.9,	109.1,	118.9,	125.0,	129.6,	143.3,	157.2,	165.7,	176.9,	186.2,	193.0,	203.1,	210.5,	216.5,	236.0,
25 days	98.0,	114.3,	122.0,	132.5,	139.1,	143.9,	158.5,	173.3,	182.3,	194.1,	203.9,	211.1,	221.6,	229.4,	235.6,	256.0,

NOTES:
N/A Data not available
These values are derived from a Depth Duration Frequency (DDF) Model
For details refer to:
'Fitzgerald D. L. (2007), Estimates of Point Rainfall Frequencies, Technical Note No. 61, Met Eireann, Dublin',
Available for download at www.met.ie/climate/dataproducts/Estimation-of-Point-Rainfall-Frequencies_TN61.pdf

FOR PLANNING PURPOSES ONLY
NOT CONSTRUCTION ISSUE

SURFACE WATER DRAINAGE LONG SECTION



HYDROCARE ENVIRONMENTAL LTD
Tel: 0419842378 / 0877905155
E-mail: info@hydrocareenvironmental.ie

ATTENUATION SYSTEM SW LONG SECTION

BECKETT DEVELOPMENTS LTD.
PALMYRA, WHITECHURCH ROAD,
RATHFARNHAM, CO. DUBLIN

SCALE 1:50 DATE: 27/04/2023

Permavoid Rainwater Diffuser Unit

Data Sheet

PRODUCT INFORMATION P1 ISSUE 3 - JUNE 2018

Run-off from building roofs is collected into downpipes and flows into a back inlet gully incorporating an internal filter or catchpit inspection chambers. The back inlet gully or chamber discharges the filtered stormwater into the permeable sub-base via Permavoid Rainwater Diffuser Unit encapsulated in a 2mm mesh fabric. The run-off will then diffuse out of the Permavoid Rainwater Diffuser Unit and into the modified granular sub-base layer. The Permavoid unit is a 150mm deep modular interlocking plastic unit storage system designed for use as a combined drainage component and sub-base replacement system, ideal for shallow infiltration/attenuation.

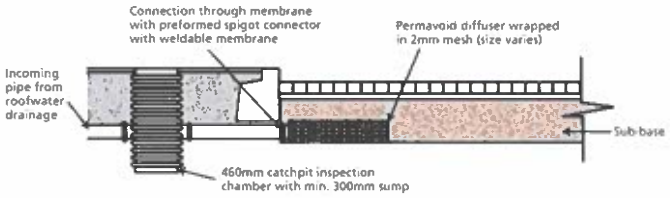
Permavoid Rainwater Diffuser Unit - Configuration Options

Length \ Width	354mm	708mm	1062mm	1416mm	2124mm
708mm	✓	✓	✓	✓	✓
1062mm	✗	✓	✓*	✓	✓
1416mm	✓	✓	✓	✓	✓
2124mm	✓	✓	✓	✓	✓

*1062 x 1062mm diffuser unit has a 354 x 354mm central opening.
Depths available are either 150mm or 300mm.
Connections available are either Ø110mm or Ø160mm.

Catchpit: 460mm diameter catchpit with 160mm inlet - PSMST 160
460mm diameter catchpit with 110mm inlet - PSMST 110

Typical Layout - Rainwater downpipe drainage into sub-base reservoir



Technical Support

Detailed guidance and assistance is available.
For further information, please contact our Technical Team on **+44 (0) 1509 615 100** or email **civils@polypipe.com** or visit **www.polypipe.com/civils-technical-hub**

ELEMENT	VALUE
PHYSICAL PROPERTIES	
Weight per unit	3kg
Length	708mm
Width	354mm
Depth	150mm
SHORT TERM COMPRESSIVE STRENGTH	
Vertical	715kN/m²
Lateral	156kN/m²
SHORT TERM DEFLECTION	
Vertical	1mm per 126kN/m²
Lateral	1mm per 15kN/m²
TENSILE STRENGTH	
Of a single joint	42.4kN/m²
Of a single joint at (1% secant modulus)	18.8kN/m²
Bending resistance of unit	0.71kN/m
Bending resistance of single joint	0.16kN/m
OTHER PROPERTIES	
Volumetric void ratio	95%
Average effective perforated surface area	52%
Intrinsic permeability (k)	Minimum 1.0×10^{-5}
Ancillary	Permavoid Permatie Permavoid Shear Connector
Material	Polypropylene (PP)

HYDRAULIC PERFORMANCE						
3 units wide, 1 unit deep (1.06m x 0.15m)						
FREE DISCHARGE						
Gradient (%)	0	1	2	3	4	5
Flow rate (l/m/s)	8	13	15	17	19	21

Polypipe Civils,
Charnwood Business Park, Loughborough, Leicestershire LE11 1LE
Tel: +44 (0) 1509 615100 Fax: +44 (0) 1509 610215 Email: civils@polypipe.com
www.polypipe.com/wms

Polypipe

Permavoid Rainwater Diffuser Unit

Data Sheet

Permavoid Rainwater Diffuser Unit can be utilised in these SuDS techniques

TECHNIQUES													
Blue Green roofs	Podium Decks	Trees	Sports Pitches	Cycle Paths	Permeable Paving (sub base & podium)	Bioretention & Rain Gardens	Attenuation Storage Tanks	Infiltration	Swales	Filter Drains	Detention Basins	Ponds & Wetlands	Filter Strips
			✓		✓		✓						

Visit **www.polypipe.com/greeninfrastructure**

Polypipe Civils,
Charnwood Business Park, Loughborough, Leicestershire LE11 1LE
Tel: +44 (0) 1509 615100 Fax: +44 (0) 1509 610215 Email: civils@polypipe.com
www.polypipe.com/wms

Polypipe

Design Data

Hydro-Brake® Optimum

Vortex Flow Control

Inspired by nature and engineered to deliver the perfect curve, the Hydro-Brake® Optimum is the most advanced vortex flow control available. There is no equivalent to the Hydro-Brake® Optimum when it comes to delivering the best possible hydraulic performance with a passive flow control.

With a wide range of configurations and options available, the Hydro-Brake® Optimum is able to provide precision flow control to suit the vast majority of applications.

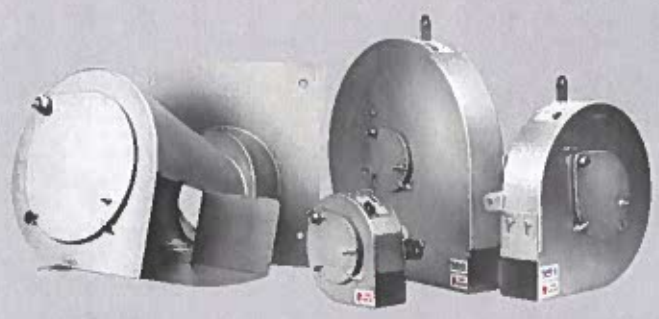


Figure 1 - The Hydro-Brake® Optimum is designed and manufactured to deliver precise, repeatable flow control.

Precision Engineered Vortex Flow Controls

Each Hydro-Brake® Optimum is custom configured to suit the application and is manufactured under strict quality assurance procedures to deliver precise flow control to exacting requirements.

Every unit is backed by significant R&D investment to fine-tune the performance, meaning that the Hydro-Brake® Optimum is the only vortex flow control to have been independently certified by the BBA and WRc.

BBA APPROVAL INSPECTION TESTING CERTIFICATION CERTIFICATE 08/4598

wrc approved PT/409/0417

Benefits

- Manufactured from high grade stainless steel.
- Future proof – adjustable or replaceable inlet plates available to alter flow rates post-installation.
- Configurations available to suit a wide variety of installations.
- Large cross sectional area at all heads.
- Simple installation.
- Self-activating.
- No moving parts or external power requirement.

Versatile and Flexible

At Hydro International, we pride ourselves on providing solutions that meet your requirements, rather than providing a standard solution and asking you to compromise on your project needs.

The Hydro-Brake® Optimum offers designers options to precision-engineer a vortex flow control to:

- Minimise upstream storage volumes.
- Maximise internal (inlet & outlet) cross sectional areas to prevent blockages.
- Build-in a climate change factor to allow for future changes in flow rate.

Furthermore, if you need to retrofit a flow control, our dedicated team of engineers can assist with providing a customised Hydro-Brake® Optimum suitable for installation into existing drainage infrastructure.

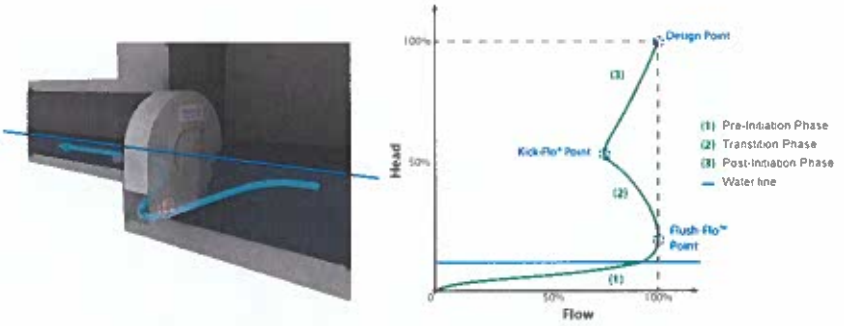
Design Data
Hydro-Brake® Optimum
Vortex Flow Control

Operating Principles

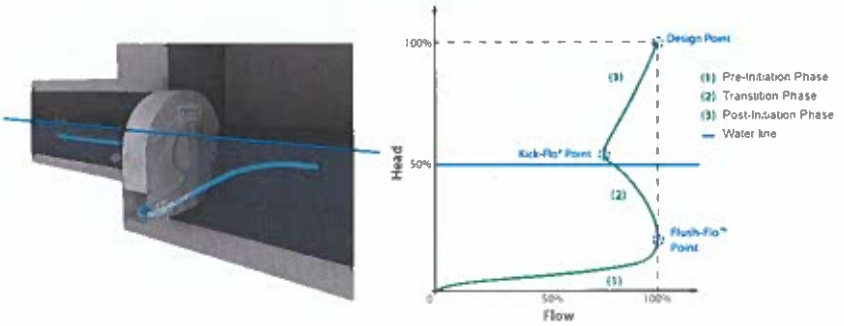
The hydraulic behaviour of the Hydro-Brake® Optimum is described by its hydraulic characteristic curve, which relates the discharge flow from the unit to the hydraulic head acting upon that unit.

The hydraulic characteristic curve consists of three distinct sections, each corresponding to a different governing flow control regime:

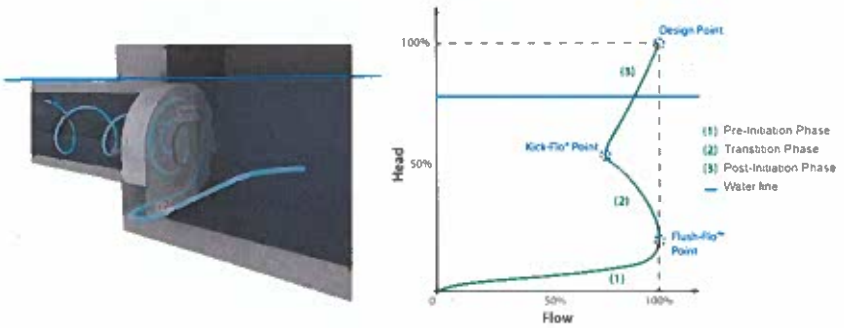
1. The pre-initiation phase – governed by orifice flow and defined on the characteristic curve as the region between the origin and the point at which the vortex begins to have a throttling effect (Flush-Flo™ point). In this region, the depth of water is below the soffit of the outlet orifice of the Hydro-Brake® Optimum.



2. The transition phase – governed by vortex formation and defined on the characteristic curve as the region between the Flush-Flo™ and the point at which the vortex has fully initiated (Kick-Flo® point). In this region the vortex will continually form and collapse. A trapped volume of air inside the Hydro-Brake® Optimum will exert a backpressure and cause the discharge rate to reduce even though the hydraulic head continues to increase.



3. The post-initiation phase – governed by stable vortex flow and defined on the characteristic curve as the region above the Kick-Flo® point. A stable vortex is formed and sustained. An air filled core at the centre of the vortex acts as a pseudo-physical flow restriction by reducing the cross sectional area available for the passage of water.



Design Flexibility

It is possible for the Design Point to be achieved using a number of different flow control configurations, each with a different hydraulic response or characteristic curve.

An in-depth understanding of the flow regimes and interactions at each stage of the hydraulic characteristic curve allows custom configuration of the Hydro-Brake® Optimum to achieve the hydraulic profile best suited to the site requirements.

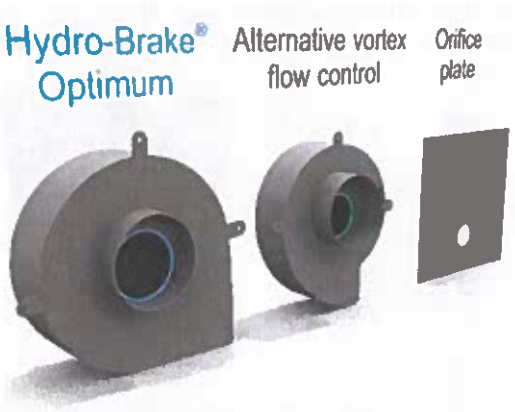
Hydro-Brake® Flow Control Series
Hydro-Brake® Hotline: 01275 337937
hydrobrake@hydro-int.com

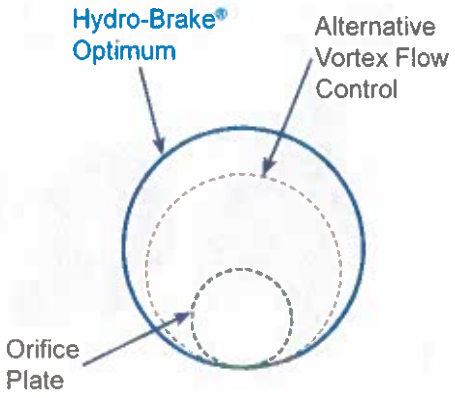
Design Data
Hydro-Brake® Optimum
Vortex Flow Control

Resilience by Design

Hydro-Brake® Optimum has outlets (clearances) up to 20% larger than competitor products to minimise the risk of blockages. All units are fitted with a pivoting bypass door to enable full access to the internal chamber and the outlet structure in the event that a blockage does occur.

All Hydro-Brake® Optimum units can also be supplied with an adjustable or replaceable inlet to future-proof the device, allowing flows to be altered post-installation, to account for site expansion or climate change.





Expert Design Support Services

Hydro International's professional engineers work with you to provide expert technical and aftersales support to ensure your projects meet exacting design requirements and deliver the very best hydraulic controls for your site.

With over 35 years' experience of flow control knowledge and experience, Hydro International's design support team is available to advise on any aspect of water flow management, including detailed modelling of vortex flow controls and composite outlet structures.

Call the Hydro-Brake® Hotline on: 01275 337937 or email hydrobrake@hydro-int.com

Hydro-Brake® Optimum Design Tool

Engineers have the flexibility to try out any number of flow control iterations and explore their impact on hydraulic performance.

The Hydro-Brake® Optimum Design Tool allows you to quickly and easily compare a number of different flow control options for your site to develop the most robust and sustainable drainage solution possible.

In just 3 simple steps you can obtain:

- Detailed dimensional drawings
- Hydraulic modelling data for direct import or copy/ paste into commercial hydraulic modelling software

www.hydrobrakeoptimum.com

Full MicroDrainage® Compatibility

Engineers can carry out sizing and flow rate calculations and conduct hydraulic modelling of drainage networks containing Hydro-Brake® Optimum units using the industry-standard MicroDrainage® modelling software.

XP Solutions

Micro Drainage

Guides to modelling the Hydro-Brake® Optimum using the Hydro-Brake® Optimum Design Tool and MicroDrainage® are available for download at: www.hydrobrakeoptimum.com

Design Data
Hydro-Brake® Optimum
Vortex Flow Control

Easy to Install

Hydro-Brake® Optimum has a range of mounting options for ease of installation or can be supplied ready fitted into a manhole chamber (with or without a weir wall) for simple plug-and-play installation. There are no set-up or commissioning requirements.

The Hydro-Brake® Flow Control Series

As a brand leader for vortex flow controls for more than 30 years, Hydro International continues to set the standard in flow control management technologies.

At Hydro International, we pride ourselves on our engineering excellence and in developing a range of flow control solutions, we have invested in significant research & development to validate their performance.

Hydro-Brake® Orifice

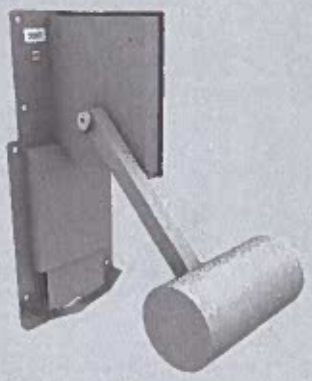
The low-cost option for unconstrainted sites (shown with optional screen).

Hydro-Brake® Optimum

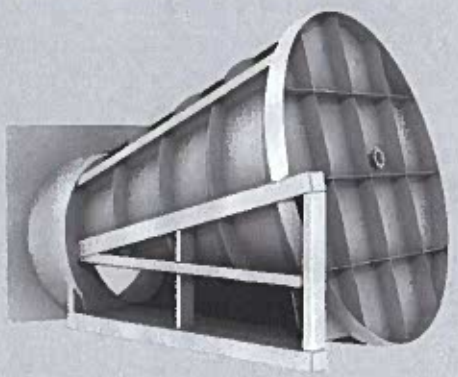
The vortex flow control with no equvalent, delivering Nature's Perfect Cuve with no moving parts and independently verified by the BBA and WRc.

Hydro-Brake® Agile

Precision engineered flow control for highly constrained applications.



Hydro-Brake® Flood Alleviation



The vortex controlled solution to watercourse flooding.

Hydro International
Shearwater House, Clevedon Hall Estate, Victoria Road, Clevedon, BS21 7RD
Hydro-Brake® Optimum Flow Control Design Data Sheet C/0118

Hydro-Brake® Flow Control Series
Hydro-Brake® Hotline: 01275 337937
hydrobrake@hydro-int.com

Clima-Pave™

Permeable Paving Solutions

Kilsaran

ideas taking shape

Selection of Pavement Type

The type of permeable pavement system to be adapted is based primarily on site ground conditions, site suitability and the permeability values of the sub-grade encountered on site from infiltration soak-pit testing. Table 1 gives guidance on the suitability of the three types of permeable pavement system.

Table 1: Guidance on selection of a pavement system

		System A - total infiltration	System B - partial infiltration	System C - no infiltration
Permeability of subgrade defined by coefficient of permeability, k (m/s)	10^{-6} to 10^{-3}	✓	✓	✓
	10^{-8} to 10^{-6}	✗	✓	✓
	10^{-10} to 10^{-6}	✗	✗	✓
Highest recorded water table within 1000mm of formation level		✗	✗	✓
Pollutants present in subgrade		✗	✗	✓

Selection of Pavement Sub-Base Thickness

The design of the sub-base for the permeable pavement should take into account the traffic loadings likely to use the pavement. It is essential to take into account any future increase in traffic volume and any HGV traffic which may use the pavement irrespective of how frequent. The correct loading category should be then selected from Table 2 taking into account the above considerations. It should be noted that no layers of the permeable pavement are designed for site traffic to use them and when finished the permeable pavement surface should not be trafficked by site traffic vehicles which are heavier than that for which the pavement was designed. It is advisable to complete paving works after all other work in the vicinity has been completed.

Typical build up details for each traffic category are illustrated on page 20 and 21 for guidance purposes.

Table 2: Loading Categories

1 DOMESTIC PARKING	2 CAR	3 PEDESTRIAN	4 SHOPPING	5 COMMERCIAL	6 HEAVY TRAFFIC
No Large Goods Vehicles	Emergency Large Goods Vehicles only	One Large Goods Vehicles per week	Ten Large Goods Vehicles per week	100 Large Goods Vehicles per week	1000 Large Goods Vehicles per week
Zero standard axles	100 standard axles	0.015msa	0.15msa	1.5msa	15msa
Patio	Car Parking Bays and Aisles	Town/city Pedestrian Street	Retail development delivery access route	Industrial Premises	Main road
Private Drive	Railway Station platform	Nursery Access	School/college access road	Lightly Trafficked Public Road	Distribution Centre
Decorative feature	External Car Showroom	Parking area to residential development	Office block delivery route	Light Industrial development	Bus Station (bus every 5 minutes)
Enclosed Playground	Sports Stadium Pedestrian route	Garden centre external display area	Deliveries to small residential development	Mixed retail/ industrial development	Motorway Truck Stop
Footway with zero vehicle overrun	Footway with occasional overrun	Cemetery Crematorium	Garden centre delivery route	Town Square	Bus Stop
	Private drive/ footway crossover	Hotel Parking	Fire Station Yard	Footway with regular overrun	Roundabout
		Airport Car Park with no bus pickup	Airport Car Park with bus to terminal	Airport landside roads	Bus Lane
		Sports Centre	Sports Stadium access route/ forecourt		

msa = millions of standard 8,000 kg axles

Sub-Base Thickness For Water Storage

The sub base depth must also take into consideration the water storage requirements for the site. The depth of sub-base may have to be adjusted to allow for increased site specific water storage. Further guidance on hydraulic factors can be found in BS 7533-13:2009 section 5.4.

Adjustment To Pavement Design For Low CBR Sub-Grade

In the case of CBR values below 5%, either ground improvement work will be required for the site, or the thickness of the coarse graded aggregate sub-base will have to be adjusted in accordance with 5.6.3 and table 9 of BS 7533-13:2009

Permeable Paving Aggregates

All materials used as permeable paving aggregate must comply to the grading and physical requirements below, as well at the general requirements of BS EN 12620 and BS EN 13242. Sub-base laying course materials should be clean, sound, non-friable and sound crushed rock material. Rounded gravel materials are not recommended for sub-base layers. The jointing material may be either clean crushed material or clean gravel material. The materials should be tested to confirm that it meets the requirements below.

The contractor shall also ensure that on-going deliveries to site are checked frequently for grading, shape and inspected to ensure cleanliness.

During installation on site, great care and attention must be paid to ensure that the aggregates are kept free of contamination and deleterious matter. Construction traffic cannot be allowed to traverse the layers of permeable paving aggregates during installation.

4/40mm Coarse Graded Permeable Paving Aggregate

Sieve Size (mm)	Percentage Passing
80	100
63	98-100
40	90-99
31,5	-
20	25-70
10	-
4	0-15
2	0-5

4/20mm Coarse Graded Permeable Paving Aggregate

Sieve Size (mm)	Percentage Passing
40	100
31,5	98-100
20	90-99
10	25-70
4	0-15
2	0-5

2/6.3mm Laying Course Paving Aggregate

Sieve Size (mm)	Percentage Passing
14	100
10	98-100
6.3	80-99
2	0-20
1	0-5

3mm Jointing Grit

Sieve Size (mm)	Percentage Passing
40	100
8	100
6.3	95-100
4	85-99
2	15-35
1	0-10
0.063	0.0-1.5

Property	Category to BS EN 13242 or BS EN 12620
Grading	4/20 (preferred) or 4/40 as per table above
Fines Content	F4
Shape	FI20
Resistance to Fragmentation	LA30
Water Absorption to BS EN 1097-6:2000	WA2
For water absorption > 2% Magnesium Sulfate Soundness	MS18
Resistance to Wear	MDE20
Acid Soluble Sulfate Content	AS0.2
Total Sulfur	≤1% by mass
Recycled Aggregates	Seek guidance from Kilsaran Technical Department

Typical Design Diagrams

Below are typical build-up details for permeable pavement systems based on BS 7533-13:2009. These diagrams are based on ideal site conditions for drainage and CBR values of 5% or greater. The diagrams are for project appraisal purposes only and in all cases a site specific design in accordance with BS 7533-13:2009 will be required.

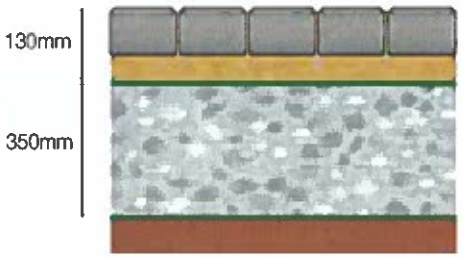
Key:

- 2 / 6.3mm Laying Course
- Hydraulically-Bound Coarse Graded Aggregate or 80mm of DBM Macadam
- 4 / 20mm Coarse Graded Aggregate and /or 4/40mm Coarse Graded Aggregate
- Capping Material
- Approved Geotextile
- Approved Impermeable Membrane

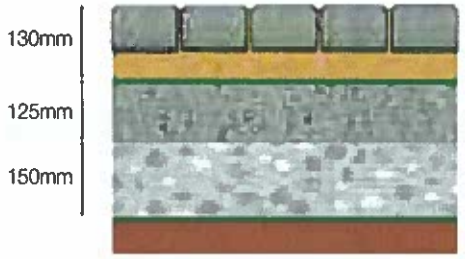
System A & B (Infiltrating & Partial Infiltration Systems)

LOAD CATEGORY 1

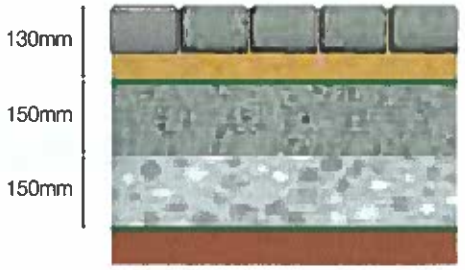
LOAD CATEGORY 2



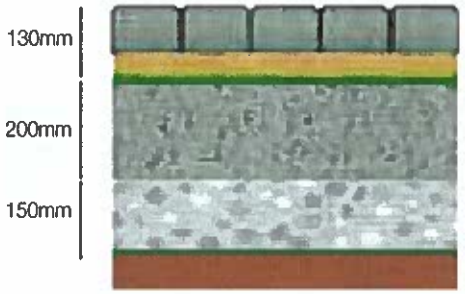
LOAD CATEGORY 3



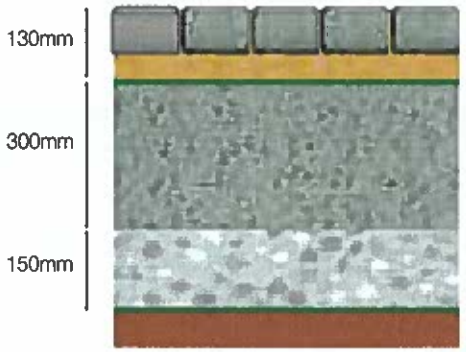
LOAD CATEGORY 4



LOAD CATEGORY 5



LOAD CATEGORY 6



Alternative build up / materials may be used depending on project specific details.

For load categories 3-6 the hydraulically-bound coarse graded aggregate (porous no fines concrete) layer may be replaced with 80mm depth of DBM Macadam to act as a stiffening layer. The macadam layer should be punctured at 750mm centres on grid. Further details on the DBM macadam layer are given on page 19.

Where the depth of aggregate sub-base is in excess of 350mm for the given loading category, it may be possible to reduce the depth of aggregate required and provide a more cost effective design with the use of an appropriate and approved geo-grid. This can be appraised at design stage.

GROUND INVESTIGATIONS IRELAND
Geotechnical & Environmental

Catherinestown House,
Hazelhatch Road,
Newcastle,
Co. Dublin.
D22 YD52

Tel: 01 601 5175 / 5176
Email: info@gii.ie
Web: www.gii.ie

Ground Investigations Ireland

Grangebrook Avenue

Terry & O'Flanagan Ltd

Ground Investigation Report

January 2022

GROUND INVESTIGATIONS IRELAND
Geotechnical & Environmental

Catherinestown House,
Hazelhatch Road,
Newcastle,
Co. Dublin.
D22 YD52

Tel: 01 601 5175 / 5176
Email: info@gii.ie
Web: www.gii.ie

DOCUMENT CONTROL SHEET

Project Title	Grangebrook Avenue
Engineer	Terry & O'Flanagan Ltd
Client	Beckett Developments Ltd.
Project No	11264-11-21
Document Title	Ground Investigation Report

Rev.	Status	Author(s)	Reviewed By	Approved By	Office of Origin	Issue Date
A	Final	A Browne	J Cashen	B Sexton	Dublin	18 January 2022

GROUND INVESTIGATIONS IRELAND
Geotechnical & Environmental

Catherinestown House,
Hazelhatch Road,
Newcastle,
Co. Dublin.
D22 YD52

Tel: 01 601 5175 / 5176
Email: info@gii.ie
Web: www.gii.ie

CONTENTS

APPENDICES

1.0 Preamble

On the instructions of Terry & O'Flanagan Consulting Engineers, a site investigation was carried out by Ground Investigations Ireland Ltd., in December 2021 at the site of the proposed housing development at Grangebrook Avenue, Rathfarnham.

2.0 Overview

2.1. Background

It is proposed to construct a new residential development with associated services, access roads and car parking at the proposed site. The site is located within the gardens of a residential property and is predominantly greenfield. The proposed construction is envisaged to consist of conventional foundations and pavement make up with some local excavations for services and plant.

2.2. Purpose and Scope

The purpose of the site investigation was to investigate subsurface conditions utilising a variety of investigative methods in accordance with the project specification. The scope of the work undertaken for this project included the following:

- Visit project site to observe existing conditions
- Carry out 4 No. Soakaways to determine a soil infiltration value to BRE digest 365
- Report with recommendations

3.0 Subsurface Exploration

3.1. General

During the ground investigation a programme of intrusive investigation specified by the Consulting Engineer was undertaken to determine the sub surface conditions at the proposed site. Regular sampling and in-situ testing was undertaken in the exploratory holes to facilitate the geotechnical descriptions and to enable laboratory testing to be carried out on the soil samples recovered during excavation and drilling.
The procedures used in this site investigation are in accordance with Eurocode 7 Part 2: Ground Investigation and testing (ISEN 1997 – 2:2007) and B.S. 5930:2015.

3.2. Soakaway Testing

The soakaway testing was carried out in selected trial pits at the locations shown in the exploratory hole location plan in Appendix 1. These pits were carefully excavated and filled with water to assess the infiltration characteristics of the proposed site. The pits were allowed to drain and the drop in water level was recorded over time as required by BRE Digest 365. The pits were logged prior to completing the

soakaway test and were backfilled with arising's upon completion. The soakaway test results are provided in Appendix 2 of this Report.

4.0 Ground Conditions

4.1. General

The ground conditions encountered during the investigation are summarised below with reference to insitu and laboratory test results. The full details of the strata encountered during the ground investigation are provided in the exploratory hole logs included in the appendices of this report.

The sequence of strata encountered were consistent across the site and are generally comprised;

- Topsoil
- Made Ground
- Cohesive Deposits

TOPSOIL: Topsoil was encountered in all the exploratory holes and was present to a maximum depth of 0.2m BGL.

MADE GROUND: Made Ground deposits was encountered beneath the Topsoil at SA04 and was present to a depth 0.50m BGL. This deposit was described as *dark brown slightly sandy slightly gravelly CLAY with occasional fragments of plastic, tin, ceramic, and metal.*

COHESIVE DEPOSITS: Cohesive deposits were encountered beneath the Topsoil and were described typically as *brown slightly sandy slightly gravelly CLAY*. The secondary sand and gravel constituents varied across the site and with depth, with granular lenses occasionally present in the glacial till matrix.

4.2. Groundwater

No groundwater was noted during the investigation however we would point out that these exploratory holes did not remain open for sufficiently long periods of time to establish the hydrogeological regime and groundwater levels would be expected to vary with the time of year, rainfall, nearby construction and other factors.

5.0 Recommendations & Conclusions

5.1. General

The recommendations given and opinions expressed in this report are based on the findings as detailed in the exploratory hole records. Where an opinion is expressed on the material between exploratory hole locations, this is for guidance only and no liability can be accepted for its accuracy. No responsibility can be accepted for conditions which have not been revealed by the exploratory holes. Limited information has

been provided at the ground investigation stage and any designs based on the recommendations or conclusions should be completed in accordance with the current design codes, taking into account the variation and the specific details contained within the exploratory hole logs.

5.2. Soakaway Design

At all locations the water level dropped too slowly to allow calculation of 'f' the soil infiltration rate. These locations are therefore not recommended as suitable for soakaway design and construction.

The recommendations provided in this report should be verified in the design of the proposed buildings, using the full details of the loading conditions and taking into consideration the allowable tolerable settlements/movements that the building can accommodate. The founding strata should be inspected and verified by a suitably qualified engineer prior to construction of the building foundations.

APPENDIX 1 - Site Location Plan

Soakaway Pit

Client:

T&OF

Project Code:
11264-11-21

Project Title:
Grangebrook Avenue

Drawing Title:
Figure 1 Site Location

GII
GROUND INVESTIGATIONS IRELAND
Ground Investigations Ireland Ltd.
Catherinstown House,
Hazelhatch Road,
Newcastle, Co. Dublin
www.gii.ie 01-6015175/5176

Drawn By:	Date:
JC	17/01/2022

APPENDIX 2 – Soakaway Testing Records

Ground Investigations Ireland Ltd
www.gii.ie

Site Grangebrook Avenue			**Trial Pit Number** SA01
Machine : 3.5 tonne tracked excavator **Method** : Trial Pit	**Dimensions** 2.00m x 0.45m x 1.40m (L x W x D)	**Ground Level (mOD)**	**Client**	**Job Number** 11264-11-21
	Location	**Dates** 14/12/2021	**Engineer** Terry & O'Flanagan Ltd	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					(0.20) 0.20	TOPSOIL		
					(0.90)	Firm brown slightly sandy slightly gravelly CLAY with occasional cobbles		
					1.10 (0.30) 1.40	Firm to stiff brown slightly sandy slightly gravelly CLAY with some cobbles and boulders		
						Complete at 1.40m		

Plan

Remarks

No groundwater encountered
Trial pit stable
Complete at 1.40m BGL
Soakaway test carried out in trial pit according to BRE Digest 365
Trial pit backfilled upon completion

Scale (approx)	Logged By	Figure No.
1:25	CMP	11264-11-21.SA01

Ground Investigations Ireland Ltd
www.gii.ie

Site Grangebrook Avenue			**Trial Pit Number** SA02
Machine : 3.5 tonne tracked excavator **Method :** Trial Pit	**Dimensions** 1.50m x 0.45m x 1.20m (L x W x D)	**Ground Level (mOD)**	**Client**	**Job Number** 11264-11-21
	Location	**Dates** 14/12/2021	**Engineer** Terry & O'Flanagan Ltd	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					(0.20) 0.20	TOPSOIL		
					(0.60) 0.80	Firm greyish brown slightly sandy slightly gravelly CLAY with occasional cobbles		
					(0.40) 1.20	Firm brown slightly sandy slightly gravelly CLAY with some cobbles		
						Complete at 1.20m		

Plan

Remarks

No groundwater encountered
Trial pit stable
Complete at 1.20m BGL
Soakaway test carried out in trial pit according to BRE Digest 365
Trial pit backfilled upon completion

Scale (approx)	Logged By	Figure No.
1:25	CMP	11264-11-21.SA02

Ground Investigations Ireland Ltd
www.gii.ie

Site Grangebrook Avenue			**Trial Pit Number** SA03
Machine : 3.5 tonne tracked excavator **Method :** Trial Pit	**Dimensions** 1.60m x 0.45m x 1.00m (L x W x D)	**Ground Level (mOD)**	**Client**	**Job Number** 11264-11-21
	Location	**Dates** 14/12/2021	**Engineer** Terry & O'Flanagan Ltd	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					(0.20) 0.20	TOPSOIL		
					(0.50) 0.70	Firm brown slightly sandy slightly gravelly CLAY with occasional cobbles		
					(0.30) 1.00	Firm to stiff brown slightly sandy slightly gravelly CLAY with some cobbles and boulders OBSTRUCTION: presumed boulder Terminated at 1.00m		

Plan

Remarks

No groundwater encountered
Trial pit stable
Refusal at 1.00m BGL
Soakaway test carried out in trial pit according to BRE Digest 365
Trial pit backfilled upon completion

Scale (approx)	Logged By	Figure No.
1:25	CMP	11264-11-21.SA03

Ground Investigations Ireland Ltd
www.gii.ie

Site Grangebrook Avenue			**Trial Pit Number** SA04
Machine : 3.5 tonne tracked excavator **Method** : Trial Pit	**Dimensions** 1.40m x 0.45m x 1.20m (L x W x D)	**Ground Level (mOD)**	**Client**
	Location	**Dates** 14/12/2021	**Engineer** Terry & O'Flanagan Ltd
Job Number 11264-11-21			**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					(0.20) 0.20	TOPSOIL		
					(0.30) 0.50	MADE GROUND: Dark brown slightly sandy slightly gravelly Clay with a metal crowbar and occasional fragments of plastic wires, tin cans, ceramics and rootlets		
					(0.70) 1.20	Firm brown slightly sandy slightly gravelly CLAY		
						Complete at 1.20m		

Plan

Remarks

No groundwater encountered
Trial pit stable
Complete at 1.20m BGL
Soakaway test carried out in trial pit according to BRE Digest 365
Trial pit backfilled upon completion

Scale (approx)	Logged By	Figure No.
1:25	CMP	11264-11-21.SA04

GROUND INVESTIGATIONS IRELAND
Geotechnical & Environmental

Catherinestown House,
Hazelhatch Road,
Newcastle,
Co. Dublin,
D22 YD52

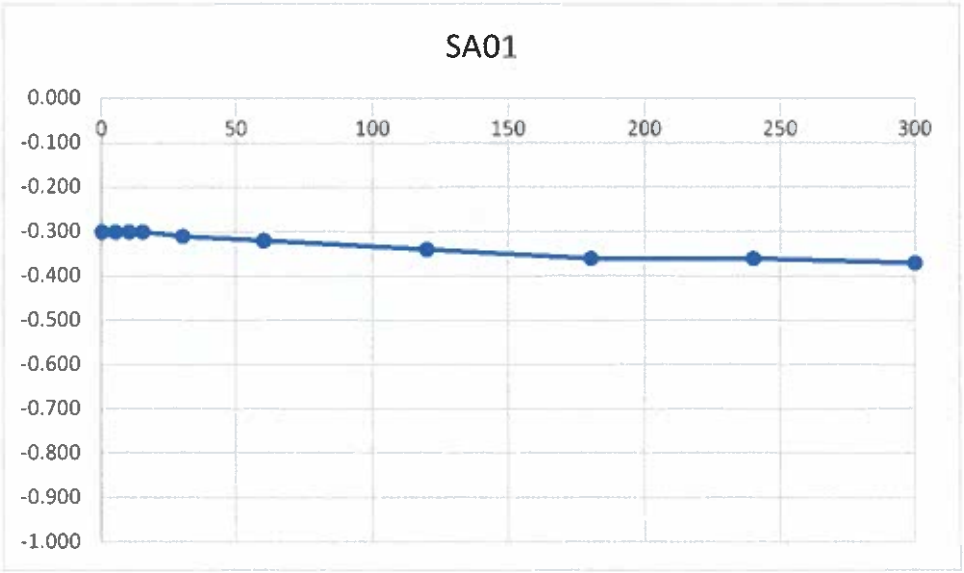
Tel: 01 601 5175 / 5176
Email: info@gii.ie
Web: www.gii.ie

SA01
Soakaway Test to BRE Digest 365
Trial Pit Dimensions: 2.00m x 0.45m x 1.40m (L x W x D)

Date	Time	Water level (m bgl)
14/12/2021	0	-0.300
14/12/2021	5	-0.300
14/12/2021	10	-0.300
14/12/2021	15	-0.300
14/12/2021	30	-0.310
14/12/2021	60	-0.320
14/12/2021	120	-0.340
14/12/2021	180	-0.360
14/12/2021	240	-0.360
14/12/2021	300	-0.370

***Soakaway Failed - Pit Backfilled**

Start Depth	Depth of Pit	Difference	75% Full	25% Full
0.300	1.400	1.100	0.575	0.731



GROUND INVESTIGATIONS IRELAND
Geotechnical & Environmental

Catherinestown House,
Hazelhatch Road,
Newcastle,
Co. Dublin.
D22 YD52

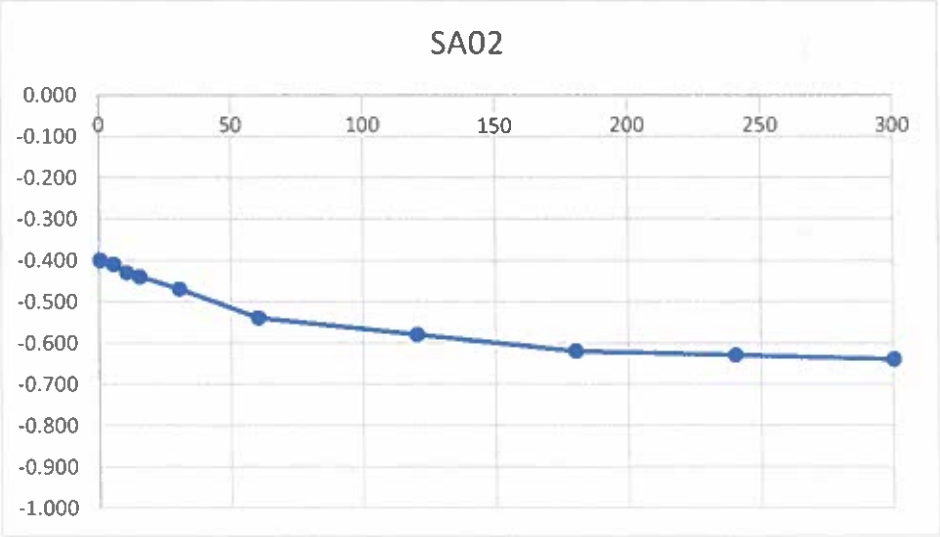
Tel: 01 601 5175 / 5176
Email: info@gii.ie
Web: www.gii.ie

SA02
Soakaway Test to BRE Digest 365
Trial Pit Dimensions: 1.50m x 0.45m x 1.20m (L x W x D)

Date	Time	Water level (m bgl)
14/12/2021	0	-0.400
14/12/2021	5	-0.410
14/12/2021	10	-0.430
14/12/2021	15	-0.440
14/12/2021	30	-0.470
14/12/2021	60	-0.540
14/12/2021	120	-0.580
14/12/2021	180	-0.620
14/12/2021	240	-0.630
14/12/2021	300	-0.640

***Soakaway Failed - Pit Backfilled**

Start Depth	Depth of Pit	Difference	75% Full	25% Full
0.400	1.200	0.800	0.600	0.850



GROUND INVESTIGATIONS IRELAND
Geotechnical & Environmental

Catherinestown House,
Hazelhatch Road,
Newcastle,
Co. Dublin.
D22 YD52

Tel: 01 601 5175 / 5176
Email: info@gii.ie
Web: www.gii.ie

SA03

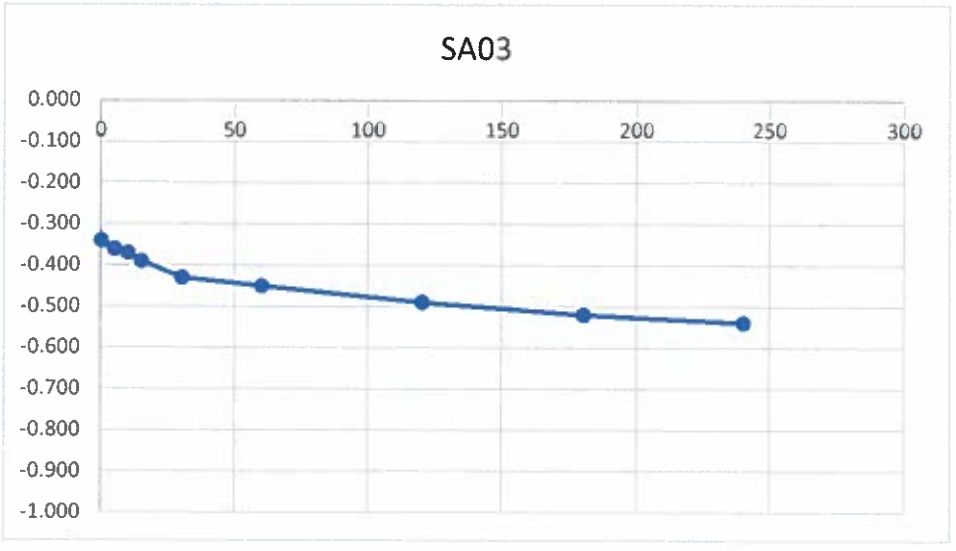
Soakaway Test to BRE Digest 365

Trial Pit Dimensions: 1.60m x 0.45m x 1.00m (L x W x D)

Date	Time	Water level (m bgl)
14/12/2021	0	-0.340
14/12/2021	5	-0.360
14/12/2021	10	-0.370
14/12/2021	15	-0.390
14/12/2021	30	-0.430
14/12/2021	60	-0.450
14/12/2021	120	-0.490
14/12/2021	180	-0.520
14/12/2021	240	-0.540

***Soakaway Failed - Pit Backfilled**

Start Depth	Depth of Pit	Difference	75% Full	25% Full
0.340	1.000	0.660	0.505	0.719



GROUND INVESTIGATIONS IRELAND
Geotechnical & Environmental

Catherinestown House,
Hazelhatch Road,
Newcastle,
Co. Dublin.
D22 YD52

Tel: 01 601 5175 / 5176
Email: info@gii.ie
Web: www.gii.ie

SA04

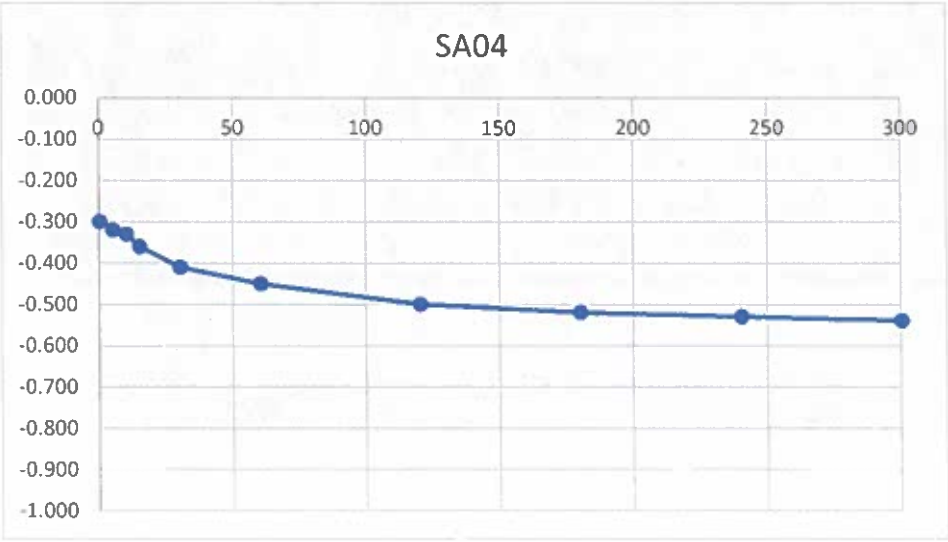
Soakaway Test to BRE Digest 365

Trial Pit Dimensions: 1.40m x 0.45m x 1.20m (L x W x D)

Date	Time	Water level (m bgl)
14/12/2021	0	-0.300
14/12/2021	5	-0.320
14/12/2021	10	-0.330
14/12/2021	15	-0.360
14/12/2021	30	-0.410
14/12/2021	60	-0.450
14/12/2021	120	-0.500
14/12/2021	180	-0.520
14/12/2021	240	-0.530
14/12/2021	300	-0.540

***Soakaway Failed - Pit Backfilled**

Start Depth	Depth of Pit	Difference	75% Full	25% Full
0.300	1.200	0.900	0.525	0.694



Grangebrook Avenue – Soakaway Photographs

SA01

SA01

Grangebrook Avenue – Soakaway Photographs

SA01

SA01

Grangebrook Avenue – Soakaway Photographs

SA02

SA02

Grangebrook Avenue – Soakaway Photographs

SA02

SA02

Grangebrook Avenue – Soakaway Photographs

SA03

SA03

Grangebrook Avenue – Soakaway Photographs

SA03

SA03

Grangebrook Avenue – Soakaway Photographs

SA04

SA04

Grangebrook Avenue – Soakaway Photographs

SA04

SA04