April 2024

TECHNICAL NOTE

Drainage Calculations

109 Coldharbour Lane, Hayes

1.0 Introduction

1.1 Lanmor Consulting Ltd has been appointed to prepare detailed drainage calculations to discharge condition 3 for the approved development at Kings Arms Court, 109 Coldharbour Lane, Hayes under planning permission reference APP/2022/2495. The consented scheme is for the replacement of the existing dwelling on site. Condition 3 states that:

Prior to the commencement of the development hereby approved, a scheme for the provision of sustainable water management and water efficiency shall be submitted to and approved in writing by the Local Planning Authority. The scheme shall:

i. Provide information about the design storm period and intensity, the method employed to delay and control the surface water discharged from the site and the measures taken to prevent pollution of the receiving groundwater and/or surface waters;

ii. Include a timetable for its implementation; and

iii. Provide a management and maintenance plan for the lifetime of the development

The scheme shall also demonstrate the use of methods to minimise the use of potable water through water collection, reuse and recycling and will:

iv. Provide details of water collection facilities to capture excess rainwater;

v. Provide details of how rain and grey water will be recycled and reused in the development;

vi. Provide details of how the dwelling will achieve a water efficiency standard of no more than 110 litres per person per day maximum water consumption (to include a fixed factor of water for outdoor use of 5 litres per person per day in accordance with the optional requirement defined within Approved Document G of the Building Regulations).

Thereafter the development shall be implemented and retained/maintained in accordance with these details for as long as the development remains in existence..

2.0 Existing Site Conditions

2.1 The proposed site is located at 109 Coldharbour Lane, Hayes. The site obtained approval in 2023 for the upward extension to provide 9 new dwellings at 109 Coldharbour Lane, Hayes. The existing building contains 21 residential apartments, with commercial units at the ground floor with parking at lower ground floor.

2.2 The existing property for 21 residential units and ground floor commercial was approved in 2014, with conditions discharged between 2014 to 2016. The approved development has been completed and its operational.

3.0 Existing Drainage

3.1 The site is totally occupied by a single building, the entire site is 100% impermeable. As part of the approved 2014 consent a drainage system was installed for both foul and surface water discharges from the development. The foul drainage consisted of a network of pipework suspended under the ground floor slab, which connects to an underground drainage pipework to the south of the building.

3.2 The surface water strategy of the development consisted of greenroofs and underground attenuation beneath the lower ground floor slab. The rainwater pipes from the are collect by suspended pipework under the ground floor slab, which discharge to an underground network of pipe below the lower ground floor slab. The pipe work discharges to a buried attenuation tank, which is them pumped up to external manhole to the east of the building and connect to the adopted surface water sewer to the north of the in East Way.

3.3 An extract of the drainage installed is included in appendix A.

4.0 Proposed Drainage

Foul Water

4.1 The proposed development is for an upward extension, to the existing property. The foul discharges from the new residential dwellings will utilise the existing soil vent pipes for discharge of effluent to the adopted sewer network. Where necessary the existing soil vent pipes will be extended up though the proposed extension.

Surface Water

4.2 The SuDS strategy for the site was considered, however as the site is fully developed and the proposals are for an upward extension to the existing property the options are very limited.

4.3 The highest level in the SuDS hierarchy is to reuse runoff at source, greenroof have the ability to reuse, attenuate and treat the runoff from buildings, the building has a flat roof so green/blue roofs will be employed as part of these proposals to manage runoff from the roof.

4.4 Rainwater harvesting also falls in to this category, harvesting was considered but the green roofs to collect and retain up to the first 5mm of rainfall in every storm, therefore the volume of runoff reaching the harvesting facility will be limited. The volume runoff reaching the harvesting facility will not be sufficient to supply the demand for the 9 residential properties and has therefore been discounted.

4.5 Next in order of the hierarchy is the use of infiltration such as soakaways, the site is fully developed so there no opportunity to use soakaways so they were discounted. Next is discharge to watercourse, there are none in the area so they have also been discounted.

4.6 Next on the hierarchy is attenuation and discharge to surface water sewer. The existing property already includes an attenuation and discharge to adopted sewer so given these proposals will not increase the impermeable are it is proposed reuse the existing drainage provisions.

4.7 Hydraulic Calculations have been undertaken to confirm the size of the attenuation tank. The existing tank is 9m x 2m x 2m deep with a 9l/s pumped discharge, the revised calculations confirmed the tank was adequate to accommodate a 1 in 100 year storm event with a 40% allowance for climate change.

4.8 The proposed drainage strategy for the development of using green roofs with attenuation for extreme events is indicated on drawing 241800/DS/01 and is include in Appendix B together with the full drainage calculations for different return periods.

5.0 Surface Water Runoff Treatment

5.1 The CIRIA SuDS Manual C753, Section 26 provides guidance regarding the treatment and methods for managing pollution risks from surface water runoff. Part of the assessment is to determine which land use classification the proposed development falls under, Table 26.1 of the CIRIA Report C753 sets the approaches to water quality risk management. For this site the Simple Index Approach will be used.

5.2 Table 26.2 in C753 reproduced as Table 5.1, show the potential hazard associated with different land uses the hazard indices. The development will consist of residential houses, it is concluded that the site should be classed within the sections shown in Table 5.1 below.

5.3 The roofs of the residential buildings is considered to have a “very low” pollution hazard, generating 0.2 total suspended solids, 0.2 metals and 0.05 hydro-carbons.

TABLE 26.2 Pollution hazard indices for different land use classifications

Land use	Pollution hazard level	Total suspended solids (TSS)	Metals	Hydro-carbons
Residential roofs	Very low	0.2	0.2	0.05
Other roofs (typically commercial/ industrial roofs)	Low	0.3	0.2 (up to 0.8 where there is potential for metals to leach from the roof)	0.05
Individual property driveways, residential car parks, low traffic roads (eg cul de sacs, homezones and general access roads) and non-residential car parking with infrequent change (eg schools, offices) ie < 300 traffic movements/day	Low	0.5	0.4	0.4
Commercial yard and delivery areas, non-residential car parking with frequent change (eg hospitals, retail), all roads except low traffic roads and trunk roads/motorways[1]	Medium	0.7	0.6	0.7
Sites with heavy pollution (eg haulage yards, lorry parks, highly frequented lorry approaches to industrial estates, waste sites), sites where chemicals and fuels (other than domestic fuel oil) are to be delivered, handled, stored, used or manufactured; industrial sites; trunk roads and motorways[1]	High	0.8[2]	0.8[2]	0.9[2]

Table 5.1 – CIRIA SuDS Manual C753 (Land use classifications)

5.4 The proposed development will incorporate greenroofs for collections of runoff from the site. Suitable treatment measures offered by SuDS features are set out in CIRA report.

5.5 Table 26.3 of C753 reproduced below as Table 5.2 sets out the mitigation indices provided by SuDS features for discharge to surface waters.

TABLE 26.3 Indicative SuDS mitigation indices for discharges to surface waters

	Mitigation indices[1]		
Type of SuDS component	**TSS**	**Metals**	**Hydrocarbons**
Filter strip	0.4	0.4	0.5
Filter drain	0.4[2]	0.4	0.4
Swale	0.5	0.6	0.6
Bioretention system	0.8	0.8	0.8
Permeable pavement	0.7	0.6	0.7
Detention basin	0.5	0.5	0.6
Pond[4]	0.7[3]	0.7	0.5
Wetland	0.8[3]	0.8	0.8
Proprietary treatment systems[5,6]	These must demonstrate that they can address each of the contaminant types to acceptable levels for frequent events up to approximately the 1 in 1 year return period event, for inflow concentrations relevant to the contributing drainage area.		

Table 5.2 – Extract from CIRIA SuDS Manual C753 (Mitigation Indices to Surface Water)

5.6 The greenroof will provide mitigation of 0.8 for total suspended solids, 0.8 for metals and 0.8 for hydrocarbons. These are all greater than the pollution hazard indices identified in table 5.1 above. The above assessment has demonstrated that the proposed SuDS features will provide a suitable level of treatment appropriate to the type of development proposed.

6.0 Surface Water Maintenance

6.1 The proposed surface water drainage network is to remain private, under the ownership of the freeholder, and it will be their responsibility to maintain the network and arrange any necessary repairs or maintenance as required. The following pages provide information on the actions to maintain the system and frequencies.

6.2 Regular inspection of the surface water drainage network for blockages and clearing unwanted debris/silt from the system should improve the performance of the surface water network and decrease the need for future repairs. In the event of blockages, high pressure water jets can be used to clear the gullies and pipes to ensure they are functioning correctly. This should be undertaken by certified trained professionals.

6.3 The level and frequency of maintenance required on site is dependent on the type of facility. The type of maintenance will fall into one of three categories “regular maintenance”, “occasional maintenance” and “remedial maintenance”.

6.4 Regular maintenance of the drainage and SuDS features will include inspections, removal of litter/debris and sweeping of the surfaces. Occasional maintenance will include removal of sediment etc. and remedial maintenance may include structural repairs and infiltration reconditioning if required.

6.5 The drainage and SuDS elements after an initial inspection following construction should be inspected on a monthly basis for the first 12 months and after large storms. Thereafter the following maintenance regime should be applied and adjusted if the 12-month monitoring process has identified any issues.

6.6 For specialist equipment, maintenance brochures will be provided by the manufacturers. These will set out the frequency of inspections and correct methods of cleaning etc. that should be followed. It is recommended that once installed the facility should be inspected monthly for the first three months and thereafter at six monthly intervals or as advised in the maintenance brochure.

Green Roofs

6.7 For Green roofs, the following maintenance is recommended.

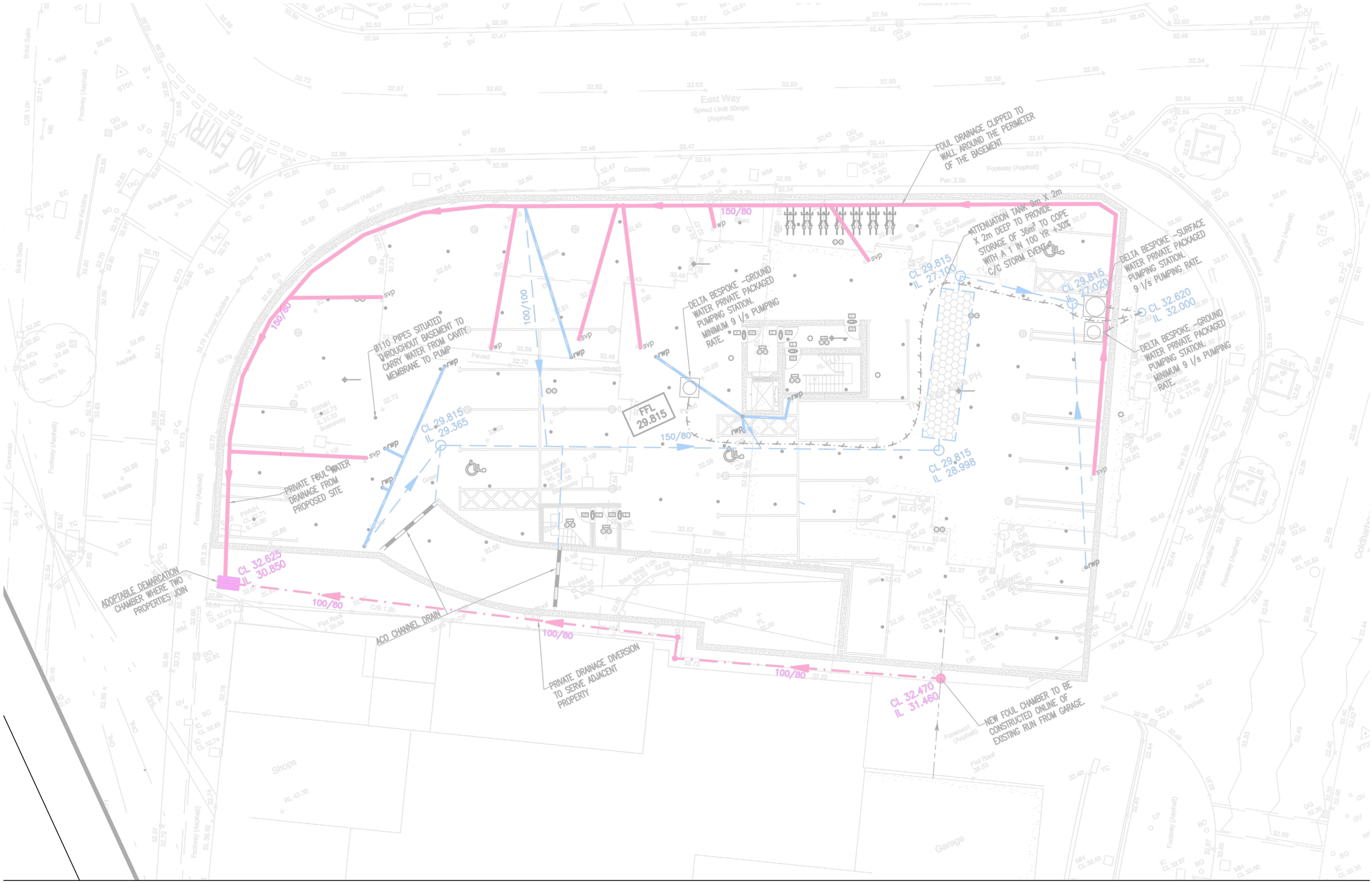
Green Roof Maintenance Schedule		
	Required Action	**Typical Frequency**
Regular inspections	Inspect all components including soil substrate, vegetation, drains, irrigation systems (if applicable), membranes and roof structure for proper operation, integrity of waterproofing and structural stability	Annually and after severe storms
	Inspect soil substrate for evidence of erosion channels and identify any sediment sources	Annually and after severe storms
	Inspect drain inlets to ensure unrestricted runoff from the drainage layer to the conveyance or roof drain system	Annually and after severe storms
	Inspect underside of roof for evidence of leakage	Annually and after severe storms
Regular maintenance	Remove debris and litter to prevent clogging of inlet drains and interference with plant growth	Six monthly and annually or as required
	During establishment (ie year one), replace dead plants as required	Monthly (but usually responsibility of manufacturer)
	Post establishment, replace dead plants as required (where > 5% of coverage)	Annually (in autumn)
	Remove fallen leaves and debris from deciduous plant foliage	Six monthly or as required
	Remove nuisance and invasive vegetation, including weeds	Six monthly or as required
	Mow grasses, prune shrubs and manage other planting (if appropriate) as required – clippings should be removed and not allowed to accumulate	Six monthly or as required
Remedial Actions	If erosion channels are evident, these should be stabilised with extra soil substrate similar to the original material, and sources of erosion damage should be identified and controlled	As required
	If drain inlet has settled, cracked or moved, investigate and repair as appropriate	As required

Table 1.8 – Blue Roof Maintenance

6.8 The above information is only intended as guidance in standard maintenance practise for surface water drainage and SuDS features. The above measures should be reviewed regularly and modified to suit the site conditions. Therefore, this part of the condition has been satisfied.

APPENDIX A

Existing Installed Drainage Network



109 Coldharbour Lane
Existing Drainage Layout

Sacle 1:200

APPENDIX B

241800/500/01 – Drainage Layout

109 Coldharbour Lane
Hayes

Proposed Drainage
Hayes

SCALE	DRAWN BY	PRJ No.	DWG No.
1:200	OR	241800	241800/DS/01

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Microdrainage Calculations

Summary of Results for 1 year Return Period

Half Drain Time : 2 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	27.238	0.038	0.0	3.4	3.4	0.6	O K
30 min Summer	27.235	0.035	0.0	3.2	3.2	0.6	O K
60 min Summer	27.235	0.035	0.0	3.1	3.1	0.6	O K
120 min Summer	27.242	0.042	0.0	3.8	3.8	0.7	O K
180 min Summer	27.243	0.043	0.0	3.8	3.8	0.7	O K
240 min Summer	27.241	0.041	0.0	3.7	3.7	0.7	O K
360 min Summer	27.235	0.035	0.0	3.1	3.1	0.6	O K
480 min Summer	27.230	0.030	0.0	2.7	2.7	0.5	O K
600 min Summer	27.226	0.026	0.0	2.4	2.4	0.4	O K
720 min Summer	27.223	0.023	0.0	2.1	2.1	0.4	O K
960 min Summer	27.219	0.019	0.0	1.7	1.7	0.3	O K
1440 min Summer	27.215	0.015	0.0	1.3	1.3	0.2	O K
2160 min Summer	27.211	0.011	0.0	1.0	1.0	0.2	O K
2880 min Summer	27.209	0.009	0.0	0.8	0.8	0.1	O K
4320 min Summer	27.207	0.007	0.0	0.6	0.6	0.1	O K
5760 min Summer	27.205	0.005	0.0	0.5	0.5	0.1	O K
7200 min Summer	27.205	0.005	0.0	0.4	0.4	0.1	O K
8640 min Summer	27.204	0.004	0.0	0.3	0.3	0.1	O K
10080 min Summer	27.203	0.003	0.0	0.3	0.3	0.1	O K
15 min Winter	27.240	0.040	0.0	3.6	3.6	0.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	33.273	0.0	2.9	11
30 min Summer	21.466	0.0	5.3	19
60 min Summer	13.379	0.0	8.0	54
120 min Summer	8.159	0.0	10.8	78
180 min Summer	6.077	0.0	12.7	106
240 min Summer	4.924	0.0	14.0	134
360 min Summer	3.637	0.0	15.9	192
480 min Summer	2.927	0.0	17.3	250
600 min Summer	2.472	0.0	18.4	314
720 min Summer	2.154	0.0	19.2	374
960 min Summer	1.732	0.0	20.6	492
1440 min Summer	1.275	0.0	22.5	730
2160 min Summer	0.939	0.0	24.2	1096
2880 min Summer	0.756	0.0	25.1	1436
4320 min Summer	0.556	0.0	25.8	2200
5760 min Summer	0.447	0.0	25.8	2904
7200 min Summer	0.378	0.0	25.9	3640
8640 min Summer	0.329	0.0	25.9	4288
10080 min Summer	0.293	0.0	25.9	5048
15 min Winter	33.273	0.0	3.9	11

Summary of Results for 1 year Return Period

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	27.234	0.034	0.0	3.0	3.0	0.6	O K
60 min Winter	27.243	0.043	0.0	3.9	3.9	0.7	O K
120 min Winter	27.249	0.049	0.0	4.4	4.4	0.8	O K
180 min Winter	27.243	0.043	0.0	3.9	3.9	0.7	O K
240 min Winter	27.238	0.038	0.0	3.4	3.4	0.6	O K
360 min Winter	27.229	0.029	0.0	2.6	2.6	0.5	O K
480 min Winter	27.224	0.024	0.0	2.2	2.2	0.4	O K
600 min Winter	27.221	0.021	0.0	1.9	1.9	0.4	O K
720 min Winter	27.218	0.018	0.0	1.6	1.6	0.3	O K
960 min Winter	27.215	0.015	0.0	1.3	1.3	0.3	O K
1440 min Winter	27.211	0.011	0.0	1.0	1.0	0.2	O K
2160 min Winter	27.208	0.008	0.0	0.7	0.7	0.1	O K
2880 min Winter	27.206	0.006	0.0	0.6	0.6	0.1	O K
4320 min Winter	27.205	0.005	0.0	0.4	0.4	0.1	O K
5760 min Winter	27.204	0.004	0.0	0.3	0.3	0.1	O K
7200 min Winter	27.203	0.003	0.0	0.3	0.3	0.1	O K
8640 min Winter	27.203	0.003	0.0	0.2	0.2	0.0	O K
10080 min Winter	27.202	0.002	0.0	0.2	0.2	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	21.466	0.0	6.6	19
60 min Winter	13.379	0.0	9.6	50
120 min Winter	8.159	0.0	12.8	78
180 min Winter	6.077	0.0	14.9	106
240 min Winter	4.924	0.0	16.4	134
360 min Winter	3.637	0.0	18.6	198
480 min Winter	2.927	0.0	20.2	252
600 min Winter	2.472	0.0	21.4	308
720 min Winter	2.154	0.0	22.4	372
960 min Winter	1.732	0.0	24.1	494
1440 min Winter	1.275	0.0	26.3	748
2160 min Winter	0.939	0.0	28.4	1096
2880 min Winter	0.756	0.0	29.7	1472
4320 min Winter	0.556	0.0	31.0	2184
5760 min Winter	0.447	0.0	31.4	2880
7200 min Winter	0.378	0.0	31.3	3352
8640 min Winter	0.329	0.0	31.0	4400
10080 min Winter	0.293	0.0	30.9	4984

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	1	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.800	Shortest Storm (mins)	15
Ratio R	0.438	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Green Roof

Area (m^3)	1050	Evaporation (mm/day)	3
Depression Storage (mm)	5	Decay Coefficient	0.050

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.019081	32	36	0.003852	64	68	0.000778	96	100	0.000157
4	8	0.015622	36	40	0.003154	68	72	0.000637	100	104	0.000129
8	12	0.012790	40	44	0.002582	72	76	0.000521	104	108	0.000105
12	16	0.010472	44	48	0.002114	76	80	0.000427	108	112	0.000086
16	20	0.008573	48	52	0.001731	80	84	0.000349	112	116	0.000071
20	24	0.007019	52	56	0.001417	84	88	0.000286	116	120	0.000058
24	28	0.005747	56	60	0.001160	88	92	0.000234			
28	32	0.004705	60	64	0.000950	92	96	0.000192			

Time Area Diagram

Total Area (ha) 0.030

Time From:	(mins) To:	Area (ha)
0	4	0.030

Model Details

Storage is Online Cover Level (m) 29.815

Cellular Storage Structure

Invert Level (m) 27.200 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

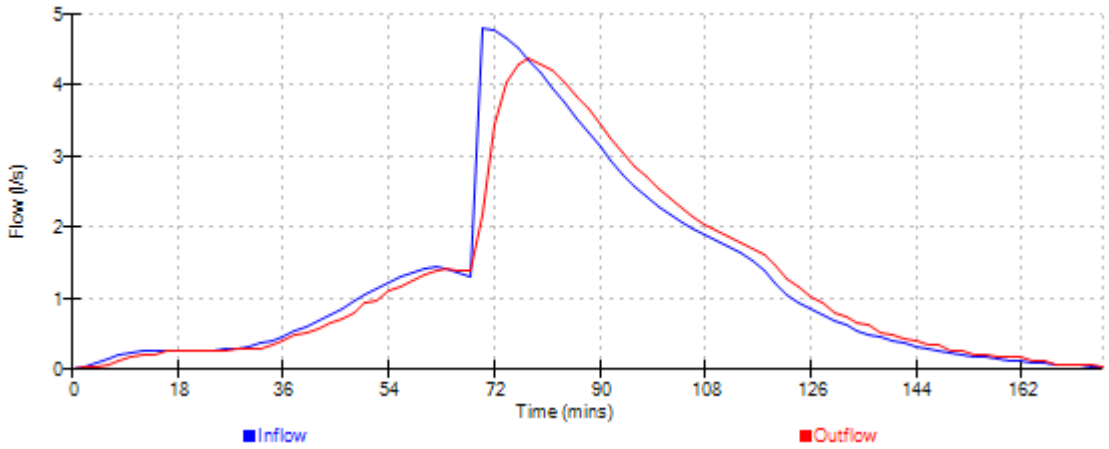
Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	18.0	18.0	2.001	0.0	62.0
2.000	18.0	62.0			

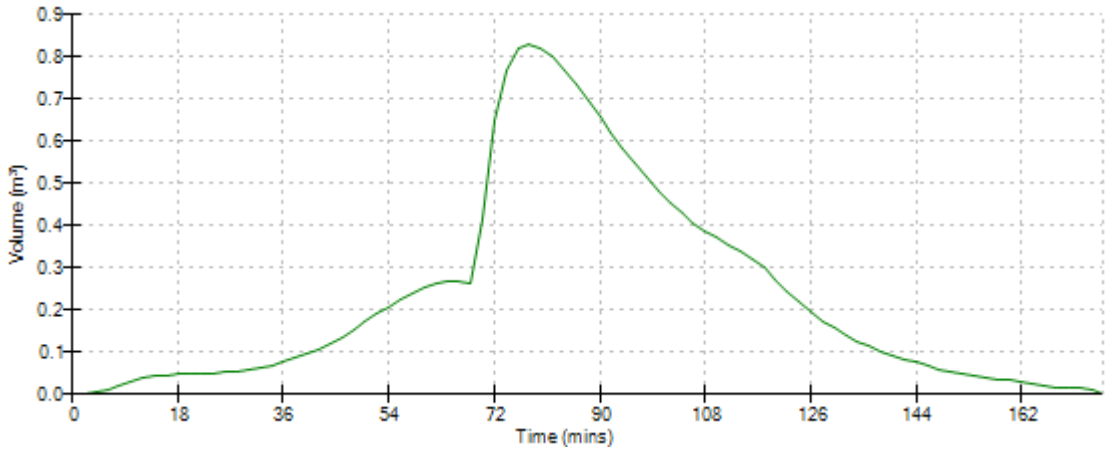
Pump Outflow Control

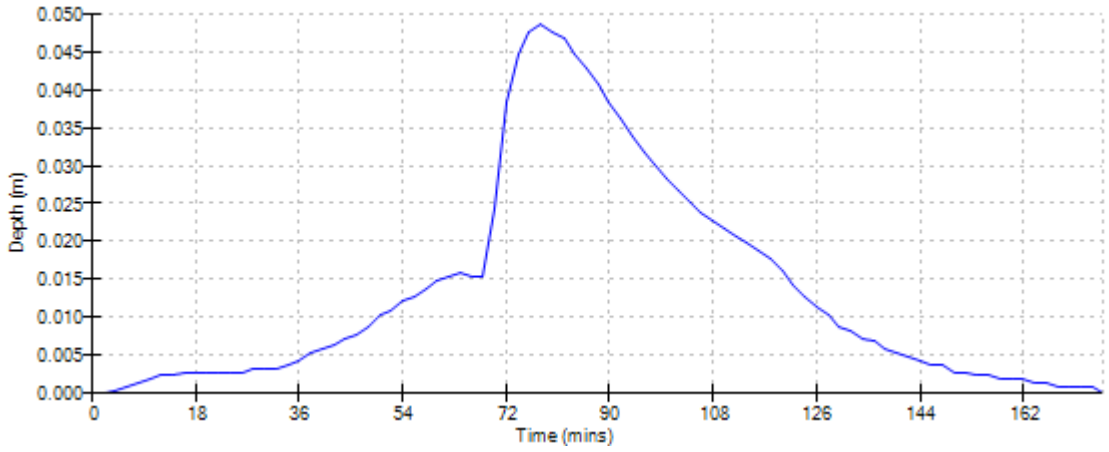
Invert Level (m) 27.200

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	9.0000	0.900	9.0000	1.700	9.0000	2.500	9.0000
0.200	9.0000	1.000	9.0000	1.800	9.0000	2.600	9.0000
0.300	9.0000	1.100	9.0000	1.900	9.0000	2.700	9.0000
0.400	9.0000	1.200	9.0000	2.000	9.0000	2.800	9.0000
0.500	9.0000	1.300	9.0000	2.100	9.0000	2.900	9.0000
0.600	9.0000	1.400	9.0000	2.200	9.0000	3.000	9.0000
0.700	9.0000	1.500	9.0000	2.300	9.0000		
0.800	9.0000	1.600	9.0000	2.400	9.0000		

Event: 120 min Winter







Summary of Results for 30 year Return Period

Half Drain Time : 6 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	27.293	0.093	0.0	8.3	8.3	1.6	O K
30 min Summer	27.355	0.155	0.0	9.0	9.0	2.7	O K
60 min Summer	27.439	0.239	0.0	9.0	9.0	4.1	O K
120 min Summer	27.430	0.230	0.0	9.0	9.0	3.9	O K
180 min Summer	27.342	0.142	0.0	9.0	9.0	2.4	O K
240 min Summer	27.297	0.097	0.0	8.8	8.8	1.7	O K
360 min Summer	27.278	0.078	0.0	7.0	7.0	1.3	O K
480 min Summer	27.266	0.066	0.0	5.9	5.9	1.1	O K
600 min Summer	27.257	0.057	0.0	5.1	5.1	1.0	O K
720 min Summer	27.250	0.050	0.0	4.5	4.5	0.9	O K
960 min Summer	27.241	0.041	0.0	3.7	3.7	0.7	O K
1440 min Summer	27.231	0.031	0.0	2.8	2.8	0.5	O K
2160 min Summer	27.223	0.023	0.0	2.0	2.0	0.4	O K
2880 min Summer	27.218	0.018	0.0	1.6	1.6	0.3	O K
4320 min Summer	27.213	0.013	0.0	1.2	1.2	0.2	O K
5760 min Summer	27.210	0.010	0.0	0.9	0.9	0.2	O K
7200 min Summer	27.209	0.009	0.0	0.8	0.8	0.1	O K
8640 min Summer	27.207	0.007	0.0	0.7	0.7	0.1	O K
10080 min Summer	27.206	0.006	0.0	0.6	0.6	0.1	O K
15 min Winter	27.302	0.102	0.0	9.0	9.0	1.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	81.719	0.0	15.2	11
30 min Summer	52.383	0.0	21.0	31
60 min Summer	32.061	0.0	26.9	48
120 min Summer	19.041	0.0	32.8	78
180 min Summer	13.895	0.0	36.4	106
240 min Summer	11.067	0.0	38.9	130
360 min Summer	8.018	0.0	42.5	190
480 min Summer	6.376	0.0	45.2	252
600 min Summer	5.334	0.0	47.3	312
720 min Summer	4.609	0.0	49.0	374
960 min Summer	3.659	0.0	51.8	492
1440 min Summer	2.640	0.0	55.6	736
2160 min Summer	1.903	0.0	59.3	1096
2880 min Summer	1.507	0.0	61.6	1456
4320 min Summer	1.085	0.0	64.3	2204
5760 min Summer	0.858	0.0	65.6	2928
7200 min Summer	0.716	0.0	66.0	3664
8640 min Summer	0.617	0.0	65.9	4320
10080 min Summer	0.544	0.0	65.3	5136
15 min Winter	81.719	0.0	17.6	18

Summary of Results for 30 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	27.449	0.249	0.0	9.0	9.0	4.3	O K
60 min Winter	27.536	0.336	0.0	9.0	9.0	5.7	O K
120 min Winter	27.438	0.238	0.0	9.0	9.0	4.1	O K
180 min Winter	27.302	0.102	0.0	9.0	9.0	1.8	O K
240 min Winter	27.285	0.085	0.0	7.7	7.7	1.5	O K
360 min Winter	27.265	0.065	0.0	5.9	5.9	1.1	O K
480 min Winter	27.253	0.053	0.0	4.8	4.8	0.9	O K
600 min Winter	27.245	0.045	0.0	4.1	4.1	0.8	O K
720 min Winter	27.239	0.039	0.0	3.5	3.5	0.7	O K
960 min Winter	27.232	0.032	0.0	2.9	2.9	0.5	O K
1440 min Winter	27.223	0.023	0.0	2.0	2.0	0.4	O K
2160 min Winter	27.217	0.017	0.0	1.5	1.5	0.3	O K
2880 min Winter	27.213	0.013	0.0	1.2	1.2	0.2	O K
4320 min Winter	27.209	0.009	0.0	0.8	0.8	0.2	O K
5760 min Winter	27.207	0.007	0.0	0.7	0.7	0.1	O K
7200 min Winter	27.206	0.006	0.0	0.6	0.6	0.1	O K
8640 min Winter	27.205	0.005	0.0	0.5	0.5	0.1	O K
10080 min Winter	27.205	0.005	0.0	0.4	0.4	0.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	52.383	0.0	24.1	32
60 min Winter	32.061	0.0	30.8	52
120 min Winter	19.041	0.0	37.5	84
180 min Winter	13.895	0.0	41.4	106
240 min Winter	11.067	0.0	44.3	134
360 min Winter	8.018	0.0	48.4	194
480 min Winter	6.376	0.0	51.4	254
600 min Winter	5.334	0.0	53.8	316
720 min Winter	4.609	0.0	55.8	378
960 min Winter	3.659	0.0	59.0	504
1440 min Winter	2.640	0.0	63.4	738
2160 min Winter	1.903	0.0	67.7	1084
2880 min Winter	1.507	0.0	70.5	1464
4320 min Winter	1.085	0.0	74.0	2204
5760 min Winter	0.858	0.0	75.9	2904
7200 min Winter	0.716	0.0	76.8	3584
8640 min Winter	0.617	0.0	77.2	4320
10080 min Winter	0.544	0.0	77.1	5144

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	30	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.800	Shortest Storm (mins)	15
Ratio R	0.438	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Green Roof

Area (m^3)	1050	Evaporation (mm/day)	3
Depression Storage (mm)	5	Decay Coefficient	0.050

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.019081	32	36	0.003852	64	68	0.000778	96	100	0.000157
4	8	0.015622	36	40	0.003154	68	72	0.000637	100	104	0.000129
8	12	0.012790	40	44	0.002582	72	76	0.000521	104	108	0.000105
12	16	0.010472	44	48	0.002114	76	80	0.000427	108	112	0.000086
16	20	0.008573	48	52	0.001731	80	84	0.000349	112	116	0.000071
20	24	0.007019	52	56	0.001417	84	88	0.000286	116	120	0.000058
24	28	0.005747	56	60	0.001160	88	92	0.000234			
28	32	0.004705	60	64	0.000950	92	96	0.000192			

Time Area Diagram

Total Area (ha) 0.030

Time From:	(mins) To:	Area (ha)
0	4	0.030

Model Details

Storage is Online Cover Level (m) 29.815

Cellular Storage Structure

Invert Level (m) 27.200 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

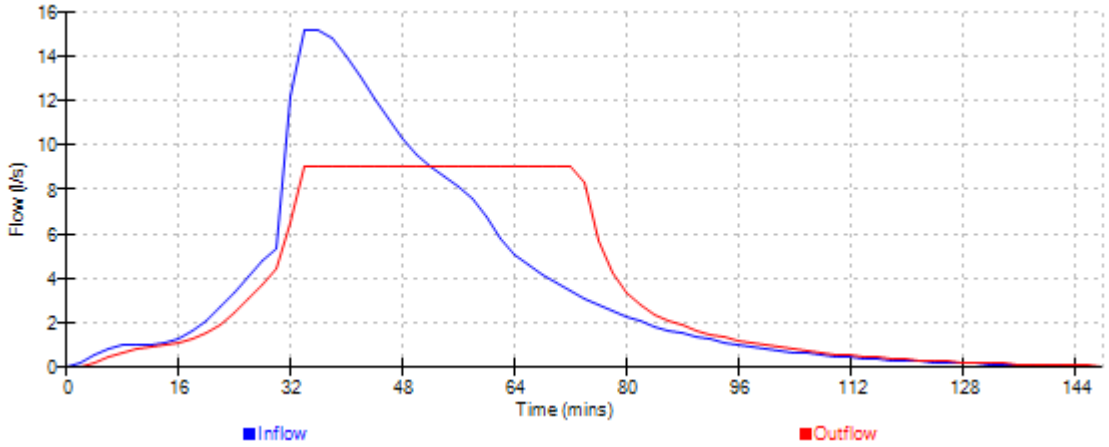
Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	18.0	18.0	2.001	0.0	62.0
2.000	18.0	62.0			

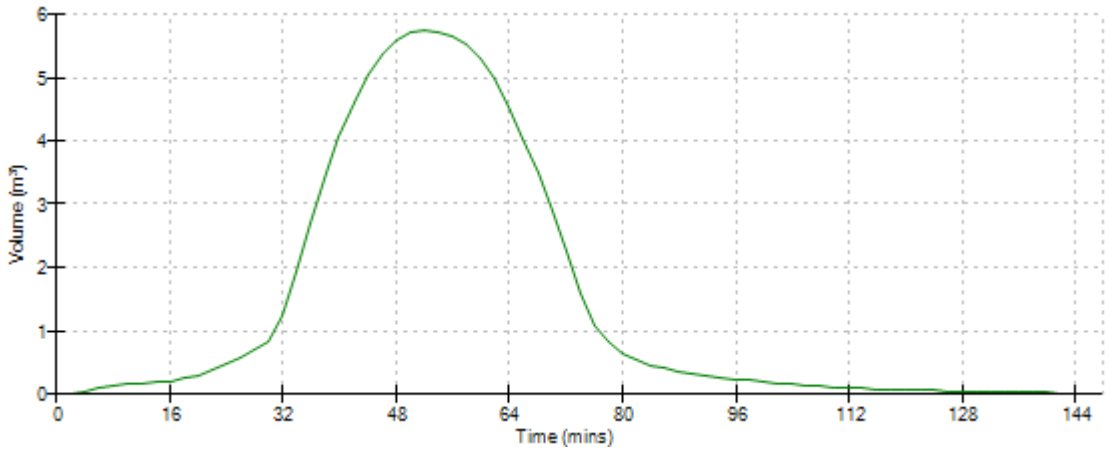
Pump Outflow Control

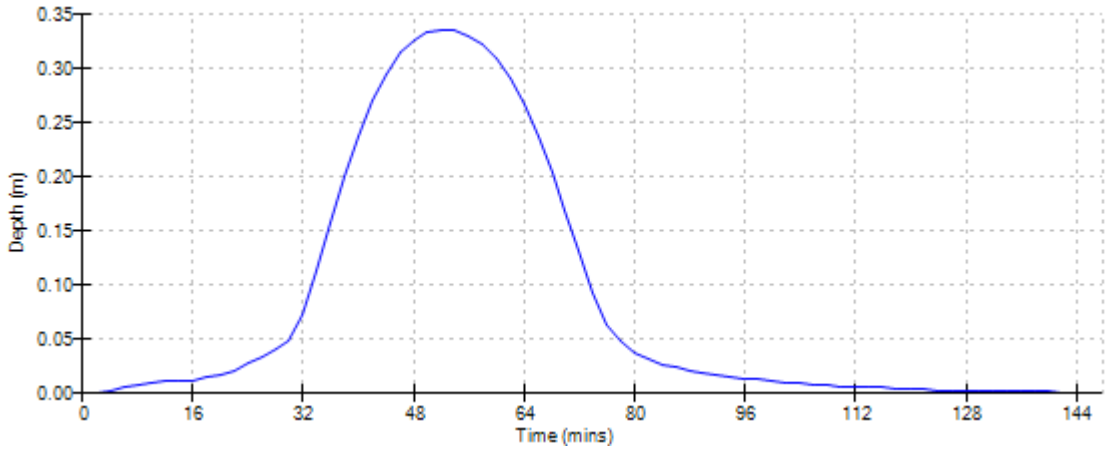
Invert Level (m) 27.200

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	9.0000	0.900	9.0000	1.700	9.0000	2.500	9.0000
0.200	9.0000	1.000	9.0000	1.800	9.0000	2.600	9.0000
0.300	9.0000	1.100	9.0000	1.900	9.0000	2.700	9.0000
0.400	9.0000	1.200	9.0000	2.000	9.0000	2.800	9.0000
0.500	9.0000	1.300	9.0000	2.100	9.0000	2.900	9.0000
0.600	9.0000	1.400	9.0000	2.200	9.0000	3.000	9.0000
0.700	9.0000	1.500	9.0000	2.300	9.0000		
0.800	9.0000	1.600	9.0000	2.400	9.0000		

Event: 60 min Winter







Summary of Results for 100 year Return Period

Half Drain Time : 14 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	27.394	0.194	0.0	9.0	9.0	3.3	O K
30 min Summer	27.618	0.418	0.0	9.0	9.0	7.1	O K
60 min Summer	27.779	0.579	0.0	9.0	9.0	9.9	O K
120 min Summer	27.746	0.546	0.0	9.0	9.0	9.3	O K
180 min Summer	27.600	0.400	0.0	9.0	9.0	6.8	O K
240 min Summer	27.463	0.263	0.0	9.0	9.0	4.5	O K
360 min Summer	27.302	0.102	0.0	9.0	9.0	1.8	O K
480 min Summer	27.285	0.085	0.0	7.6	7.6	1.5	O K
600 min Summer	27.273	0.073	0.0	6.6	6.6	1.3	O K
720 min Summer	27.265	0.065	0.0	5.8	5.8	1.1	O K
960 min Summer	27.253	0.053	0.0	4.8	4.8	0.9	O K
1440 min Summer	27.239	0.039	0.0	3.5	3.5	0.7	O K
2160 min Summer	27.229	0.029	0.0	2.6	2.6	0.5	O K
2880 min Summer	27.223	0.023	0.0	2.0	2.0	0.4	O K
4320 min Summer	27.216	0.016	0.0	1.5	1.5	0.3	O K
5760 min Summer	27.213	0.013	0.0	1.1	1.1	0.2	O K
7200 min Summer	27.211	0.011	0.0	1.0	1.0	0.2	O K
8640 min Summer	27.209	0.009	0.0	0.8	0.8	0.2	O K
10080 min Summer	27.208	0.008	0.0	0.7	0.7	0.1	O K
15 min Winter	27.497	0.297	0.0	9.0	9.0	5.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	106.323	0.0	21.4	21
30 min Summer	68.666	0.0	29.2	34
60 min Summer	42.167	0.0	37.1	56
120 min Summer	25.009	0.0	44.9	86
180 min Summer	18.187	0.0	49.4	116
240 min Summer	14.428	0.0	52.5	146
360 min Summer	10.398	0.0	57.0	192
480 min Summer	8.238	0.0	60.3	252
600 min Summer	6.873	0.0	62.9	312
720 min Summer	5.924	0.0	65.0	372
960 min Summer	4.684	0.0	68.4	490
1440 min Summer	3.359	0.0	73.1	736
2160 min Summer	2.405	0.0	77.6	1096
2880 min Summer	1.896	0.0	80.5	1456
4320 min Summer	1.355	0.0	84.0	2180
5760 min Summer	1.067	0.0	85.8	2872
7200 min Summer	0.885	0.0	86.6	3632
8640 min Summer	0.760	0.0	86.7	4400
10080 min Summer	0.668	0.0	86.5	5144
15 min Winter	106.323	0.0	24.6	23

Summary of Results for 100 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	27.762	0.562	0.0	9.0	9.0	9.6	O K
60 min Winter	27.953	0.753	0.0	9.0	9.0	12.9	O K
120 min Winter	27.828	0.628	0.0	9.0	9.0	10.7	O K
180 min Winter	27.581	0.381	0.0	9.0	9.0	6.5	O K
240 min Winter	27.376	0.176	0.0	9.0	9.0	3.0	O K
360 min Winter	27.285	0.085	0.0	7.6	7.6	1.4	O K
480 min Winter	27.269	0.069	0.0	6.2	6.2	1.2	O K
600 min Winter	27.258	0.058	0.0	5.2	5.2	1.0	O K
720 min Winter	27.251	0.051	0.0	4.6	4.6	0.9	O K
960 min Winter	27.240	0.040	0.0	3.6	3.6	0.7	O K
1440 min Winter	27.229	0.029	0.0	2.6	2.6	0.5	O K
2160 min Winter	27.221	0.021	0.0	1.9	1.9	0.4	O K
2880 min Winter	27.217	0.017	0.0	1.5	1.5	0.3	O K
4320 min Winter	27.212	0.012	0.0	1.1	1.1	0.2	O K
5760 min Winter	27.209	0.009	0.0	0.8	0.8	0.2	O K
7200 min Winter	27.208	0.008	0.0	0.7	0.7	0.1	O K
8640 min Winter	27.207	0.007	0.0	0.6	0.6	0.1	O K
10080 min Winter	27.206	0.006	0.0	0.5	0.5	0.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	68.666	0.0	33.4	37
60 min Winter	42.167	0.0	42.2	60
120 min Winter	25.009	0.0	51.0	92
180 min Winter	18.187	0.0	56.0	122
240 min Winter	14.428	0.0	59.5	148
360 min Winter	10.398	0.0	64.6	194
480 min Winter	8.238	0.0	68.3	256
600 min Winter	6.873	0.0	71.2	314
720 min Winter	5.924	0.0	73.7	374
960 min Winter	4.684	0.0	77.5	502
1440 min Winter	3.359	0.0	83.0	734
2160 min Winter	2.405	0.0	88.2	1104
2880 min Winter	1.896	0.0	91.7	1440
4320 min Winter	1.355	0.0	96.0	2152
5760 min Winter	1.067	0.0	98.5	2936
7200 min Winter	0.885	0.0	99.9	3608
8640 min Winter	0.760	0.0	100.5	4488
10080 min Winter	0.668	0.0	100.7	5048

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)	20.800	Shortest Storm (mins)	15
Ratio R	0.438	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Green Roof

Area (m^3)	1050	Evaporation (mm/day)	3
Depression Storage (mm)	5	Decay Coefficient	0.050

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.019081	32	36	0.003852	64	68	0.000778	96	100	0.000157
4	8	0.015622	36	40	0.003154	68	72	0.000637	100	104	0.000129
8	12	0.012790	40	44	0.002582	72	76	0.000521	104	108	0.000105
12	16	0.010472	44	48	0.002114	76	80	0.000427	108	112	0.000086
16	20	0.008573	48	52	0.001731	80	84	0.000349	112	116	0.000071
20	24	0.007019	52	56	0.001417	84	88	0.000286	116	120	0.000058
24	28	0.005747	56	60	0.001160	88	92	0.000234			
28	32	0.004705	60	64	0.000950	92	96	0.000192			

Time Area Diagram

Total Area (ha) 0.030

Time From:	(mins) To:	Area (ha)
0	4	0.030

Model Details

Storage is Online Cover Level (m) 29.815

Cellular Storage Structure

Invert Level (m) 27.200 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

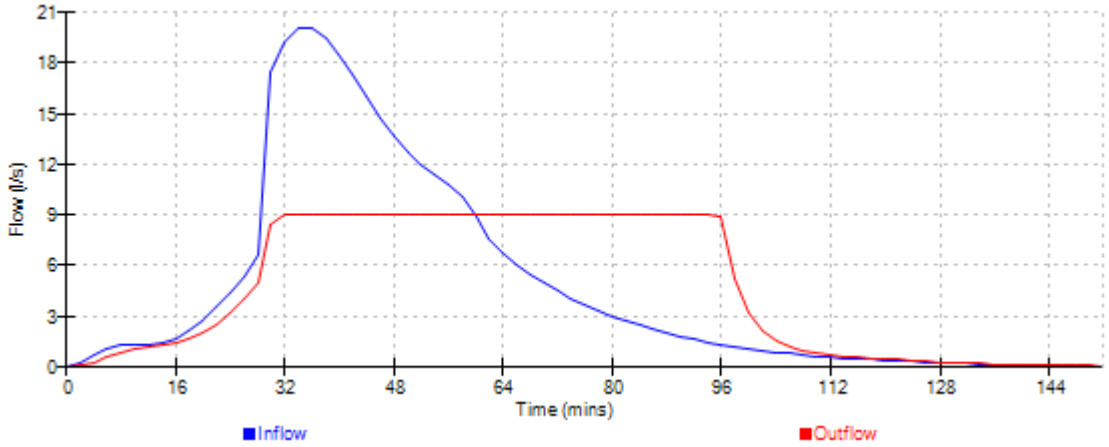
Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	18.0	18.0	2.001	0.0	62.0
2.000	18.0	62.0			

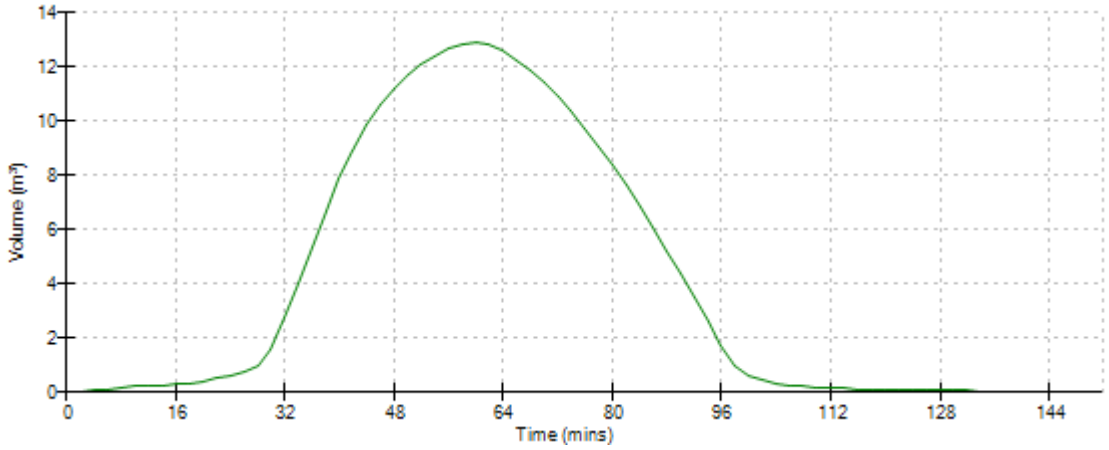
Pump Outflow Control

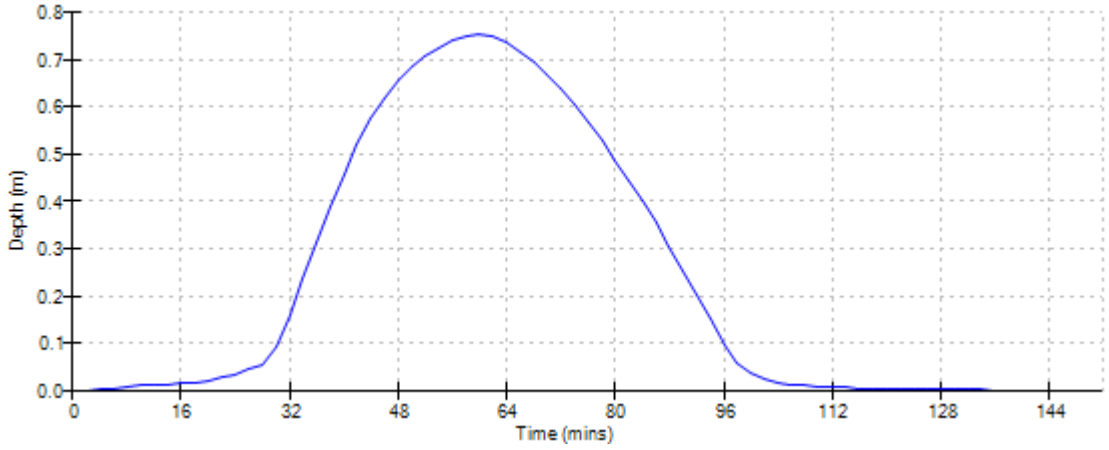
Invert Level (m) 27.200

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	9.0000	0.900	9.0000	1.700	9.0000	2.500	9.0000
0.200	9.0000	1.000	9.0000	1.800	9.0000	2.600	9.0000
0.300	9.0000	1.100	9.0000	1.900	9.0000	2.700	9.0000
0.400	9.0000	1.200	9.0000	2.000	9.0000	2.800	9.0000
0.500	9.0000	1.300	9.0000	2.100	9.0000	2.900	9.0000
0.600	9.0000	1.400	9.0000	2.200	9.0000	3.000	9.0000
0.700	9.0000	1.500	9.0000	2.300	9.0000		
0.800	9.0000	1.600	9.0000	2.400	9.0000		

Event: 60 min Winter







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

Half Drain Time : 26 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	27.786	0.586	0.0	9.0	9.0	10.0	O K
30 min Summer	28.173	0.973	0.0	9.0	9.0	16.6	O K
60 min Summer	28.492	1.292	0.0	9.0	9.0	22.1	O K
120 min Summer	28.446	1.246	0.0	9.0	9.0	21.3	O K
180 min Summer	28.246	1.046	0.0	9.0	9.0	17.9	O K
240 min Summer	28.043	0.843	0.0	9.0	9.0	14.4	O K
360 min Summer	27.696	0.496	0.0	9.0	9.0	8.5	O K
480 min Summer	27.447	0.247	0.0	9.0	9.0	4.2	O K
600 min Summer	27.311	0.111	0.0	9.0	9.0	1.9	O K
720 min Summer	27.291	0.091	0.0	8.2	8.2	1.6	O K
960 min Summer	27.275	0.075	0.0	6.7	6.7	1.3	O K
1440 min Summer	27.255	0.055	0.0	5.0	5.0	0.9	O K
2160 min Summer	27.240	0.040	0.0	3.6	3.6	0.7	O K
2880 min Summer	27.232	0.032	0.0	2.9	2.9	0.5	O K
4320 min Summer	27.223	0.023	0.0	2.1	2.1	0.4	O K
5760 min Summer	27.218	0.018	0.0	1.6	1.6	0.3	O K
7200 min Summer	27.215	0.015	0.0	1.3	1.3	0.3	O K
8640 min Summer	27.213	0.013	0.0	1.1	1.1	0.2	O K
10080 min Summer	27.211	0.011	0.0	1.0	1.0	0.2	O K
15 min Winter	27.964	0.764	0.0	9.0	9.0	13.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	148.852	0.0	32.1	28
30 min Summer	96.133	0.0	43.1	41
60 min Summer	59.033	0.0	54.2	64
120 min Summer	35.012	0.0	65.2	98
180 min Summer	25.462	0.0	71.5	128
240 min Summer	20.200	0.0	75.8	158
360 min Summer	14.557	0.0	82.2	218
480 min Summer	11.534	0.0	87.0	272
600 min Summer	9.622	0.0	90.7	318
720 min Summer	8.294	0.0	93.8	372
960 min Summer	6.557	0.0	98.7	492
1440 min Summer	4.702	0.0	105.7	736
2160 min Summer	3.368	0.0	112.7	1100
2880 min Summer	2.655	0.0	117.4	1464
4320 min Summer	1.897	0.0	123.5	2196
5760 min Summer	1.493	0.0	127.3	2880
7200 min Summer	1.240	0.0	129.7	3672
8640 min Summer	1.064	0.0	131.1	4352
10080 min Summer	0.936	0.0	131.8	5088
15 min Winter	148.852	0.0	36.7	30

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 Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	28.409	1.209	0.0	9.0	9.0	20.7	O K
60 min Winter	28.767	1.567	0.0	9.0	9.0	26.8	O K
120 min Winter	28.689	1.489	0.0	9.0	9.0	25.5	O K
180 min Winter	28.377	1.177	0.0	9.0	9.0	20.1	O K
240 min Winter	28.049	0.849	0.0	9.0	9.0	14.5	O K
360 min Winter	27.518	0.318	0.0	9.0	9.0	5.4	O K
480 min Winter	27.297	0.097	0.0	8.7	8.7	1.7	O K
600 min Winter	27.282	0.082	0.0	7.4	7.4	1.4	O K
720 min Winter	27.271	0.071	0.0	6.4	6.4	1.2	O K
960 min Winter	27.257	0.057	0.0	5.1	5.1	1.0	O K
1440 min Winter	27.241	0.041	0.0	3.7	3.7	0.7	O K
2160 min Winter	27.229	0.029	0.0	2.6	2.6	0.5	O K
2880 min Winter	27.223	0.023	0.0	2.1	2.1	0.4	O K
4320 min Winter	27.217	0.017	0.0	1.5	1.5	0.3	O K
5760 min Winter	27.213	0.013	0.0	1.2	1.2	0.2	O K
7200 min Winter	27.211	0.011	0.0	1.0	1.0	0.2	O K
8640 min Winter	27.209	0.009	0.0	0.8	0.8	0.2	O K
10080 min Winter	27.208	0.008	0.0	0.7	0.7	0.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	96.133	0.0	49.0	43
60 min Winter	59.033	0.0	61.3	64
120 min Winter	35.012	0.0	73.7	104
180 min Winter	25.462	0.0	80.8	136
240 min Winter	20.200	0.0	85.7	168
360 min Winter	14.557	0.0	92.8	222
480 min Winter	11.534	0.0	98.2	256
600 min Winter	9.622	0.0	102.4	314
720 min Winter	8.294	0.0	105.9	376
960 min Winter	6.557	0.0	111.5	498
1440 min Winter	4.702	0.0	119.5	734
2160 min Winter	3.368	0.0	127.5	1104
2880 min Winter	2.655	0.0	133.0	1472
4320 min Winter	1.897	0.0	140.3	2216
5760 min Winter	1.493	0.0	144.9	2896
7200 min Winter	1.240	0.0	147.9	3624
8640 min Winter	1.064	0.0	150.1	4408
10080 min Winter	0.936	0.0	151.5	4920

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)	20.800	Shortest Storm (mins)	15
Ratio R	0.438	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Green Roof

Area (m^3)	1050	Evaporation (mm/day)	3
Depression Storage (mm)	5	Decay Coefficient	0.050

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.019081	32	36	0.003852	64	68	0.000778	96	100	0.000157
4	8	0.015622	36	40	0.003154	68	72	0.000637	100	104	0.000129
8	12	0.012790	40	44	0.002582	72	76	0.000521	104	108	0.000105
12	16	0.010472	44	48	0.002114	76	80	0.000427	108	112	0.000086
16	20	0.008573	48	52	0.001731	80	84	0.000349	112	116	0.000071
20	24	0.007019	52	56	0.001417	84	88	0.000286	116	120	0.000058
24	28	0.005747	56	60	0.001160	88	92	0.000234			
28	32	0.004705	60	64	0.000950	92	96	0.000192			

Time Area Diagram

Total Area (ha) 0.030

Time From:	(mins) To:	Area (ha)
0	4	0.030

Model Details

Storage is Online Cover Level (m) 29.815

Cellular Storage Structure

Invert Level (m) 27.200 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	18.0	18.0	2.001	0.0	62.0
2.000	18.0	62.0			

Pump Outflow Control

Invert Level (m) 27.200

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	9.0000	0.900	9.0000	1.700	9.0000	2.500	9.0000
0.200	9.0000	1.000	9.0000	1.800	9.0000	2.600	9.0000
0.300	9.0000	1.100	9.0000	1.900	9.0000	2.700	9.0000
0.400	9.0000	1.200	9.0000	2.000	9.0000	2.800	9.0000
0.500	9.0000	1.300	9.0000	2.100	9.0000	2.900	9.0000
0.600	9.0000	1.400	9.0000	2.200	9.0000	3.000	9.0000
0.700	9.0000	1.500	9.0000	2.300	9.0000		
0.800	9.0000	1.600	9.0000	2.400	9.0000		

Event: 60 min Winter