mechanical and electrical consulting engineers

TECHNICAL REPORT

SURFACE WATER DISPOSAL STRATEGY FOR COMPLIANCE WITH SUDS (SUSTAINABLE DRAINAGE SYSTEMS)

Project No: 1640
Revision: 01
Date: September 2017

STEPHENSON HOUSE, HAMPSTEAD ROAD, LONDON

Lazari Investments Ltd

TECHNICAL REPORT

mechanical and electrical consulting engineers

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Stephenson House

Surface Water Disposal Strategy

Revision 01

September 2017

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Stephenson House

Surface Water Disposal Strategy

Introduction

This study has been commissioned by GLP in order review the strategy for the disposal of surface water from the redevelopment of Stephenson House.

This reviews the information provided within the earlier SUDS (SUstainable Drainage Systems) report produced by others and issued as part of the planning application and the responses received from the statutory sewerage undertaker (Thames Water) and the Lead Local Flood Authority (Camden Council).

The report will go on to explore how the extensive provision of living roof areas may contribute toward a tangible attenuation of rainwater flows and how this principle of rooftop attenuation may be exploited to reduce or remove basement rainwater attenuation tanks from which water would need to be pumped into the public sewer.

Executive Summary

There is the requirement for the flows from the development to be significantly restricted resulting in the need to temporarily hold water within the building. The outline proposal given within the SuDS report is to use storage tanks at basement level. The discharge from the tanks into the public sewer will be restricted to an agreed rate by flow control devices.

This will most likely require the water to be moved from the tanks via pumps. This unfortunately has the adverse impacts of lifetime electricity consumption, maintenance and potential for failure. It is recommended therefore that wherever possible, measures which allow controlled gravity discharges to the sewer or at least minimise the volume of storage required should be explored and exploited wherever possible.

The original SUDS report appears contradictory in terms of the maximum outflow rate. Additionally it appeared not to take account of the requirement to add an allowance for climate change of 30%. The estimated tank volume of 135m3 has been recalculated to include the climate change allowance required by the local authority. This has increased the volume of storage potentially required to 172m3 based upon an assumed acceptable outflow rate of 5 l/s; this flow rate will require confirmation by the planning authority.

A storage volume of 172,000 litres equates to a tank almost 25m long x 4m wide x 1.8m high, so the importance of minimising this volume and its impact on valuable floorspace is clear.

On submission of the SuDS report for planning, Camden (Lead Local Flood Authority – London Borough of Camden) advised an action to "provide details on feasibility for SuDS higher up in the SuDS hierarchy" and this report is the response on the feasibility of the practical application of roof attenuation, to meet the planning requirements.

At this early stage of the design it is not possible to determine the exact details, as this will be subject to the further development of the roofscape and structure and the building. However, by working with the Architect

A work in progress view of a similar roofscape where attenuation has been blended with increased amenity value and undertaking a series of Microdrainage and blue roof calculations we believe that an alternative approach can be offered which provides a better long term sustainable option to the unnecessary pumping of rainwater for the lifetime of the building.

Our proposal is for all rainwater to be routed from the building via gravity. To achieve this, a series of blue and green roof areas will be provided to control and slow the flow of rainwater collected. However, using this option it is not possible to achieve the very strict flow rate of 5 l/s from the development.

The proposal is therefore to request a relaxation of this flow rate for a higher one which we will enable the removal from the design of the burden of lifetime pumping and the negative sustainability issues that go with this.

The details and outline calculations are appended to and discussed later in this report, however, we believe it is possible to still reduce the peak surface water flow from the building by at least 50% whilst achieving a gravity connection to the sewer. This we believe is the best compromise of stormwater flow control versus ongoing energy consumption and risk.

In order to prevent any delay in the approval process, we have included other less preferred options so these can be considered and selected if necessary during the planning review.

A simple topping to a void former can provide an effective hidden attenuation volume whilst maintaining a fully utilisable roofscape

Blue Roof Principles

There is no fixed definition for a Blue Roof. At the more elaborate end of the spectrum, they share similar characteristics with an Intensive Green Roof system but with deeper substrate, containing more organic matter and retaining more water, thus allowing establishment of a marshy habitat.

Blue Roofs in this guise can significantly improve thermal performance of a building, acting as a thermal store, reducing fluctuations in temperature and providing a cooling effect in summer, with additional insulation in winter; particularly beneficial in mitigating Urban Heat Island effect. Incorporation of an attenuation zone results in a reduction in the rate of run-off slowing rainfall to entry into watercourses and sewers.

Systems which release the entire volume of the design storm within 24-48 hours are however more common and will be the only ones considered in this report.

Any system which purposely retains water on the roof to minimise the impact upon downstream infrastructure can be classified a blue roof. These can broadly be considered under the following categories;

- Exposed

  Where the water is retained directly on top of the roof finish. A layer of aggregate may be used which will help aesthetically.

- Enclosed

  Where the water is stored within a void formed beneath paving for example or within similar void former

- Combined

  Where a void former is used to create a calculable void beneath a green roof for example.

Project Examples

The following are some of the projects where rooftop rainwater attenuation has been successfully incorporated.

Project Name	Date Installed	Comments
Mixed Use Devt. Greenwich Reach	2012	Mixed use
Blackburn Youth Zone	2012	Education
Bristol University	2014	Education - Auditorium
Unite Stratford	2014	Education
Rooftop MUGA at MUFC Supporters Trust Hotel	2015	Commercial
New rooftop MUGA at Media City	2015	Commercial
Creek Road, Greenwich	2016	Residential
Taylor Wimpy Homes Kew Podium	2016	Residential
Project Dylon, Sydenham, Kent	2017	Residential
White Collar Factory, London	2016	Mixed including IT & Software
Seacole House, London	2016	Transformer building for London financial quarter
Euston HS2 , Camden	In Design	Transport / Commercial / Retail

University of Bristol void former installation and completed blue / green roof

A typical Blue / Green attenuated roof build up and outlet

Loadings

The potential loads from a blue roof need to be considered by the structural engineer. The loadings from a basic blue roof can often fall within the standard tolerances meaning no upgrade of the design is necessary. However, as with all flat roofs, the maximum loadings will need to consider the potential for snow build up and the potential for blockage or failure of the rainwater system leading to overflow.

The following outline figures will assist in giving some background and context to the likely loads;

- General maximum operating depth = 0.65 kN/m^2
- Heavy duty void former = 0.09kN/m^2
- Additional possible water depth in event of blockage (will depend on roof detailing tbc) = 0.58 kN/m^2 approx
- Structural designs will normally already have a factor for snow loading, typically in the region of 0.60 kN/m^2 and should have an allowance for blockage of rainwater outlets causing accidental flooding
- A Blue Roof at zero gradient does not require a screed to be laid to falls. Such screeds can impose loads of between 1.2 and 4.8 kN/m2 and hence this allowance can be removed

It can be seen therefore, typically, the additional loads imposed by Blue Roofs will be relatively small and structural requirements are unlikely to differ significantly from a conventional flat roof.

Void formers can be specified with sufficient strength to allow the roof to be used for a roof terrace with raised planters, plant and equipment zones.

Loads from the proposed green roof areas will also need to be added and considered.

Potential Benefits

When compared to a traditional rainwater collection system and central attenuation reservoir located underground or at ground level it is believed that attenuation at roof level can potentially offer the following benefits.

- An above ground tank uses expensive floor area, yet it will probably only be fully utilized several times in the entire lifespan of the building. Storage at roof level however (assuming a void former is adopted) maintains or improves the ability for the area to still be fully utilized for plant space or a valuable roof terrace or external office break out space.
- Underground tanks may require pumped discharges which are subject to failure and are not a sustainable solution.
- Tanks situated below ground level may expose the building to sewer surcharge
- A zero gradient blue roof allows greater flexibility in outlet positioning.
- When compared to a traditional system for the building it is believed that the investment of a void former, some careful detailing and increased waterproofing specification could yield the following savings
    - A reduction of rainwater outlets and downpipes together with the associated underground drainage works
    - The removal / reduction in size of the central storage tank and control device
    - The removal of screed or tapered insulation associated with 1:60 falls afforded to normal 'flat' roofs.


Public health Rainwater

Blue-roof thinking

The custom has been to remove storm water from a building as quickly as possible, but there is a different way of managing rainwater, says Carl Harrop

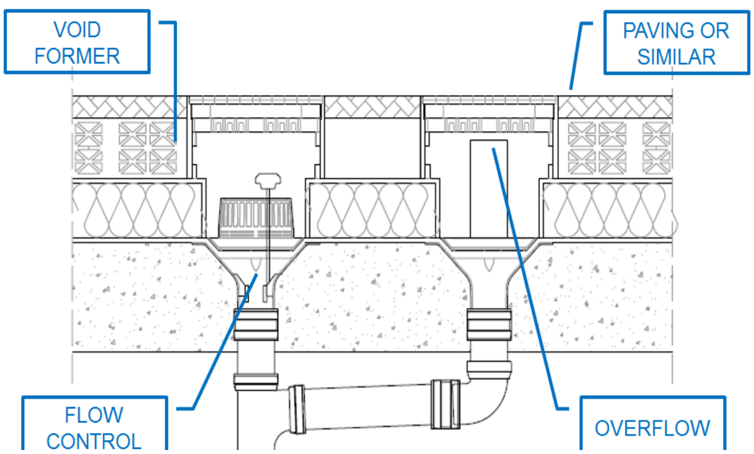
The authors early thoughts on blue roof technology was published in the industry journal

Design Considerations

A completed blue roof installation may well be invisible and require far less maintenance than a system incorporating pumps for example; however, failure through design or maintenance still has the potential to cause significant damage to the building below and hence the design should be undertaken in detail across the whole design team.

The detailed design of a system will vary upon the type of system selected and the building form but the following bullets give an indication of some of the key elements of a good design.

- Probably the most important is a well-considered overspill strategy. The engineer and architect should work together to map the safe route of water should there be a blockage or storm event that exceeds the storm condition.



- The outlets should be located in a position that is readily accessible to allow safe inspection and maintenance.

- A high quality roof waterproofing system should be specified. The manufacturer should be aware and warranty the waterproofing system in the context of a blue roof system.

Structural loadings and slab deflection should be reviewed by the structural engineer.

Overflows should not be unique to Blue Roofs.

BSEN 12056 states:

'Overflows or emergency outlets should be provided on flat roofs with parapets and in non-eaves gutters in order to reduce the risk of overspilling of rainwater into a building or structural overloading'

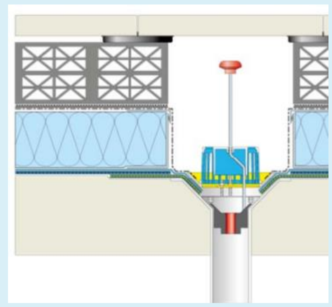
Design Parameters

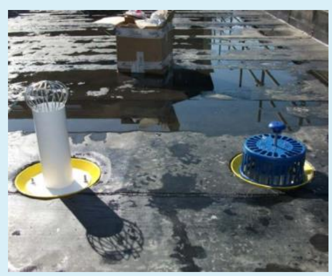
Building rainwater disposal systems are generally designed in accordance with BS EN 12O56. The following key information is applicable to this building in terms of the rainwater disposal systems;

- Assumed building life = 40 years
- Design storm duration = 2 minutes
- Risk category = 3
- Design rainfall intensity = 255 mm/hr

In terms of the attenuation systems, the following parameters have been employed;

- Return Period = 100 years
- Climate Change allowance = 30%
- Base existing flow comparison = 50mm/hr
- Design Storm duration= 6 hours





Analysis

General

In preparing our outline calculations we have our used unique software specially developed for the design of Blue Roofs. This allows a choice of flow restriction methods; in this instance we have assumed one of the commercially available rainwater outlets with integral flow control device will be used.

Due to the complex nature of the roofs on this project it will additionally be necessary to build a MicroDrainage simulation model to fully assess the characteristic of the rainwater flowing through the different roof types for various winter and summer storm durations.

The basis for our calculations is that the attenuation system will be capable of containing the rainwater resulting from a storm with a return period of 100 years. A climate change allowance of 30% has also been added to this figure and the performance checked against a 6 hour storm duration.

Table 1 on the following page looks at the estimated existing flow from the site using an intensity of 50mm/hr, suggesting and existing flow rate of **52 litres per second.**

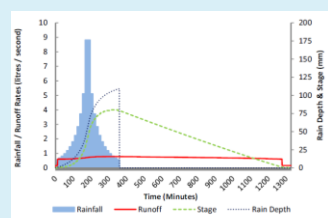
Table 2 examines the various options that could be employed at the site together with the resultant tank sizes where applicable based upon a restricted outfall rate of **5 l/s.**

Option 3 is the preferred option and the one we are seeking approval for through the planning and statutory consultation process. The flow into the receiving sewer is estimated to be reduced by over 50% from **52 l/s** to **28 l/s.** Although this has a higher flow rate than the original SuDS report this includes the climate change allowance and designs out the requirement for lifetime pumping of rainwater.

Return Period (years): 100

Percentage Increase: 30

D	M100-D mm	intensity mm/h
5 min	14.0	168.5
10 min	20.8	125.0
15 min	25.1	100.4
30 min	32.7	65.4
45 min	37.2	49.6
60 min	40.5	40.5
2 hours	48.5	24.3
4 hours	56.6	14.1



An illustration of how the flow from a blue roof (red line) decreases the peak rainwater flow (blue area)

The table below gives the baseline conditions for the design.

Ref	Approx. Attenuation Tank Size	Approx. Discharge to Sewer	Description	Commentary
B1	-	52 l/s	Existing flow from development	Based upon the same 100% impermeable area as the existing site – based upon a rainfall intensity of 50mm/hr
B2	172 m3	5 l/s	No Blue or Green Roof provision	Baseline condition for reference purposes only using full attenuation and 5 l/s discharge to sewer

Table 1

Table 2 below outlines the various options that we have explored in order to establish the best balance of reduced peak flows, reduced total discharge volume and the adverse implications of running and maintain the different systems.

Ref	Approximate Attenuation Tank Size	Approximate Discharge to Sewer	Description	Commentary
1	60 m3	5 l/s	**Rooftop + Pumps** Combination of blue and green roofs introduced wherever feasible	Pumping rainwater from the basement introduces a risk of flooding in event of failure. From a sustainability viewpoint the lifetime carbon of running / maintaining pumps has questionable sustainability impacts
2a	60 m3	5 l/s	**Rooftop + Pumps + RWH**	The introduction of rainwater harvesting will have the benefit in reducing the total volume of water discharged to the sewer and will reduce potable water consumption. The disadvantages associated with pumping rainwater from the basement remain however.
2b	?	5 l/s	**Rooftop + Pumps + RWH inc Blue**	This option will increase the efficiency of the rainwater harvesting by increase the contributing area by inclosing the blue roof discharges. Increased pump running costs and tank size may result however.
3	0	24 l/s	**Rooftop + Gravity Discharge**	This option will maximise the use of rooftop storage and remove the provision of a basement tank and associated pumps. Although this will result in a higher peak flow to the sewer than the pumped option it will still yield a reduction in excess 50% on the current condition. It is believed that this is the better overall proposition in terms of sustainability as it removes the need to pump rainwater for the life of the building. It also removes the risk of flooding the property in the event of pump failure.

Table 2

Rainwater Harvesting

Background

As discussed elsewhere in this report, the most sustainable approach for this building is considered to be the implementation of maximum rooftop attenuation using a gravity connection to the sewer. In such a system rainwater harvesting would not be appropriate.

This proposal requires the approval of a higher peak discharge to the sewer than discussed in the original SuDS submission however. As such, we have also included options which satisfy a 5 l/s sewer discharge and as some of these include the use of rainwater harvesting we have included a brief overview of the potential for use.

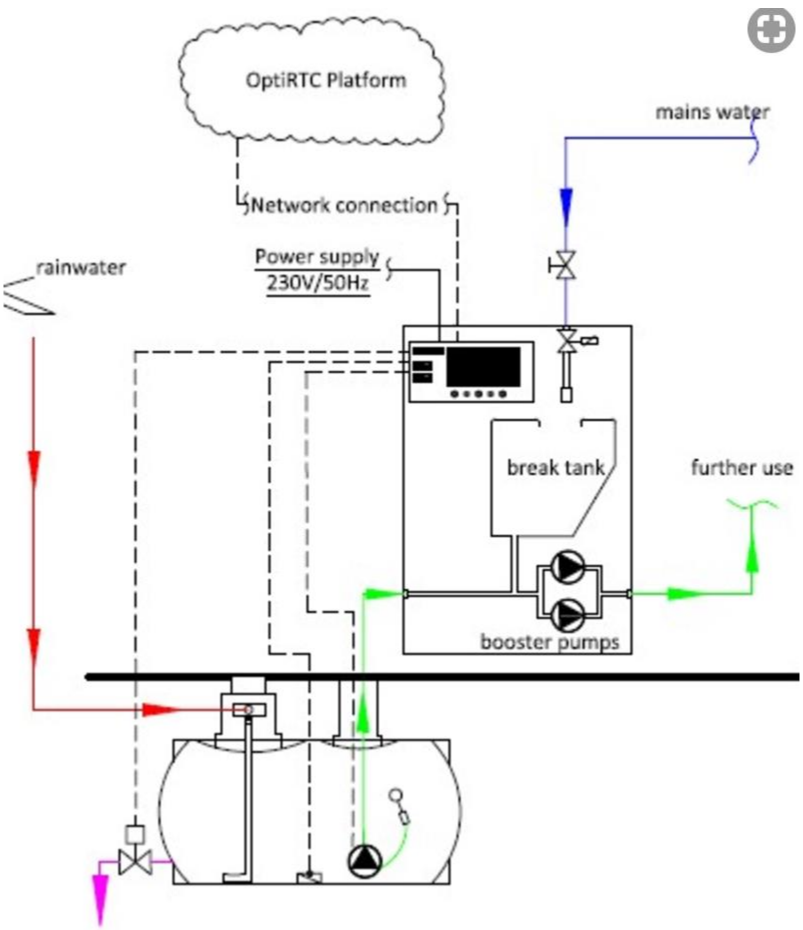
Discussion

One issue to overcome should rainwater harvesting be included in the scheme is the discolouration that can occur from water derived from green roof areas. This may limit the potential uses of the reclaimed water depending upon the client's perception.

Should the project develop in a direction where rainwater harvesting is incorporated, we would look to propose a system that made best use of the infrastructure already required for the attenuation of stormwater by combining the attenuation and rainwater harvesting tanks.

Traditionally, when these systems are combined, there is no saving in the total volume as it needs to be assured that the full attenuation volume is available at the time of a storm. This means that the tank may well lay close to empty for decades before it is called into action. A recent alternative approach however is to use a system based on a cloud technology platform that uses sensor data, weather forecast information and modelling to actively control, maintain and monitor the system to maximise its dual use.

In basic terms, during periods where no / limited rainfall is forecast the system closes the outflow and retains the collected water for re-use. When rain is forecast, the system proportionately empties the tank to ensure adequate attenuation volume is available. This provides excellent efficiencies where attenuation would otherwise only be fully utilised once or twice in a buildings life.



Operation and Maintenance

The purpose of a SuDS Maintenance Plan is to ensure that those involved in the maintenance and ongoing operation of the SuDS system understand its functionality and maintenance requirements in supporting the long-term performance to the criteria to which it was designed.

The completed SuDS Maintenance Plan should cover the following;

- A description of the site, describing how the drainage system works and what it is trying to achieve. It should also explain the biodiversity aspects of a scheme as these can easily be compromised by inappropriate maintenance.
- A plan that identifies runoff sub-catchments, SuDS components, critical water levels, control structures, flow routes (including exceedance routing) and outfalls.
- A plan for the safe and sustainable removal and disposal of silt and waste periodically arising from the drainage system.
- A maintenance schedule of work, listing the tasks to be undertaken and the frequency at which they should be performed so that an acceptable long-term performance standard is secured. The schedule should be a living document as it may change, where inspections advise changes to the scheme maintenance requirements.
- Contact sheet and emergency action plan for dealing with incidents or pollution accidents.

Although detailed operating and maintenance plans will be developed as the design progresses, the following reviews some of the primary operating and maintenance functions for the different SuDS components proposed within this report.

<u>Blue Roof Areas</u>
The level and type of maintenance of blue roof areas is dependent upon the configuration adopted. The following elements are however common and will form the basis of the management plan;

- Regularly inspect to ensure that there have been no changes to the use of the roof area that reduce the storage volume available or impede the (potentially subsurface) flow of water.

- Regularly inspect waterproofing membrane for mechanical damage
- Periodic inspections & removal of debris or other items that represent blockage risks particularly in vicinity of the outlet
- After significant storm events, visually inspect the roof to confirm that the orifice of the outlet is not blocked

<u>Green Roof Areas</u>

General maintenance is normally carried out annually during springtime. However, certain tasks which will be dependent upon the location of the roof, such as the removal of weeds, seedlings and accumulated leaf litter may also need to be done during other times of the year. Much of the green roof areas proposed for this project are planters within accessible areas so will be regularly tended.

Health and safety is a prime concern and although the outline designs currently indicate all planted roofs are safely accessible this must be monitored as the design develops.

Debris and silt will be prevented from entering the water storage zone by the use of geotextile membranes. All rainwater outlets will be installed so as to be readily accessible for routine inspection and maintenance.

<u>Attenuation Tanks</u>

Some options for the building include the use of basement attenuation tanks.

- Tanks to be externally flanged to ease inspection and cleaning provided should the flow control device require removal.
- The tanks shall come complete with level probes linked to the building management system to also provide an audible warning should there be a tank surcharge event taking place that requires further investigation by the building maintenance team.
- Visual inspection by maintenance staff will be provided for whilst specialist confined space teams will be required for periodic cleaning.

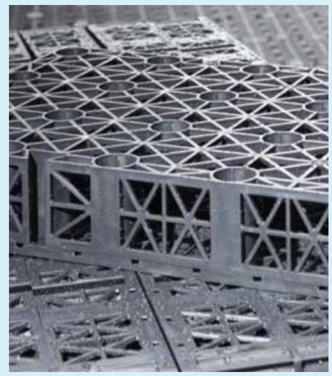
<u>Pumps</u>

The pumps will form part of the building services systems maintenance but will be dry well to facilitate safer maintenance and inspection.

Assumed Configuration

There are different ways in which rooftop stormwater attenuation systems can be configured. For the purposes of this initial study we have assumed the following;

- A zero gradient roof
- Water contained with a void former with a void ratio of 94% or greater
- It has been assumed that the entire flat roof areas surrounding the rooflights can be utilised to store water. We have used the following areas in our calculations. It should be noted that any intrusion into this either at design or during the life of the building will result in greater water depths than discussed in this study.
- Availability of adequate overflow / exceedance paths



Should it be preferred, roofs with gradients can be used, however the more concentrated loads and the low points would need to be discussed in detail with the structural engineer.

Roof waterproofing details are to be provided by the architect. However, if required, there are suppliers of blue roof systems that can provide the outlets, the roof waterproofing and the green roof elements whilst providing a single warranty for the system which is often considered a benefit. An example of one such company can be found using the following link;

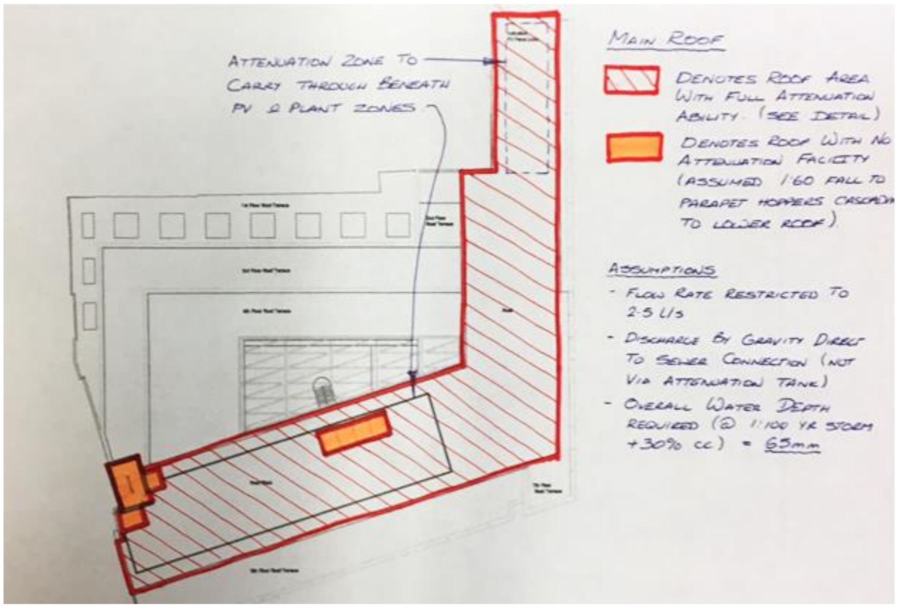
http://www.alumascroofing.co.uk/products/waterproofing/sustainable-roofing-systems/bluroof-stormwater-management/

The sketches within Appendix 1 at the individual roof areas at Stephenson House, illustrating the current assumptions and giving the basis for design development by the combined design team.

Appendix 1

Detailed review of Roofscape

Main Roof



Summary

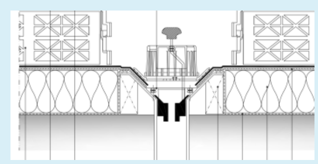
The current architectural proposals are for an inverted roof covered with ballast; the primary purpose of the ballast being to hold the insulation slabs in place.

In this instance, the attenuated water could only fill the gaps in-between the ballast (a loss of around 70%) before in extreme events ponding above the ballast. The overall water depth of this approach would be deeper than a roof configuration where the waterproofing sat above the insulation allowing.

For options 1, 2 and 3 it is proposed that this roof should discharge directly to the sewer bypassing the attenuation tank.

Design Water Depth and Overspill Strategy

On the assumption that an exposed roof or high volume void former is used, the proposed design water depth in the 100 year (+30% CC) is 65mm. Overspill points are to be through the parapets to the lower terrace on the perimeter of the building



A potential detail with the insulation below the waterproofing. Water can be contained in a void former or allowed to build up over the surface

7th Floor Terrace

Summary

The fact that this roof is small and narrow makes it difficult to effectively incorporate attenuation within its build up as the outlets would need to deal with such small flows that they would be too susceptible to blockage.

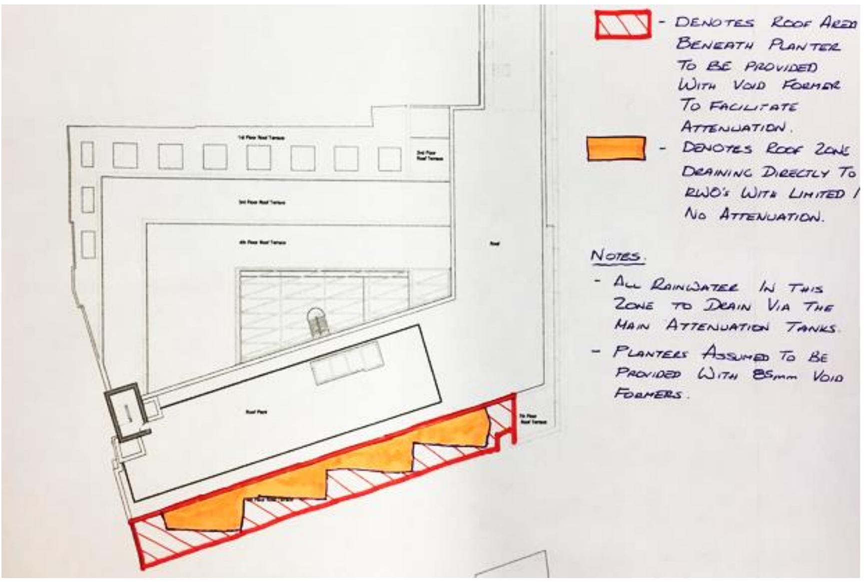
This area would therefore discharge to the main attenuation tank to reduce / control the flow rate under options 1 and 2.

Design Water Depth and Overspill Strategy

Standard rainwater outlets assume a head over outlet (water depth) of 35mm at the low point to achieve the flow rates given in the manufacturer's literature.

Overspill points are to be provided through the parapet. These will be sized to cater from potential overspill from the main roof.

6th Floor Terrace



Summary

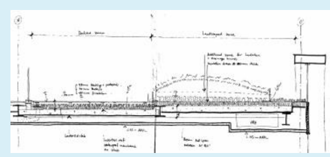
This roof area has two distinct zones. The planted zone has the ability to hold water for attenuation, whilst the zone closest to the level threshold into the building is of insufficient depth to facilitate this. The introduction of a dropped slab closest to the level threshold inboard to the building provides a significant risk of water ingress. A secondary system of overflow outlets and pipework is therefore proposed to protect this area.

The zone beneath the planter will be provided with a void former containing a semi-permeable weir device to slow the release of the water into the adjacent sub-paving zone containing the rainwater outlet and overflow.

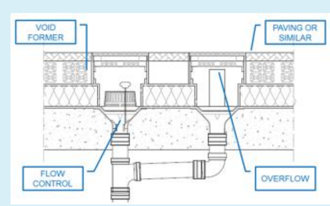
Design Water Depth and Overspill Strategy

The maximum water depth beneath the planter is to be 85mm (although this can be reduced if necessary). Water will not be stored within the lowered slab area.

Overflow capacity will be required via a dual outlet system to protect the level threshold into the building.

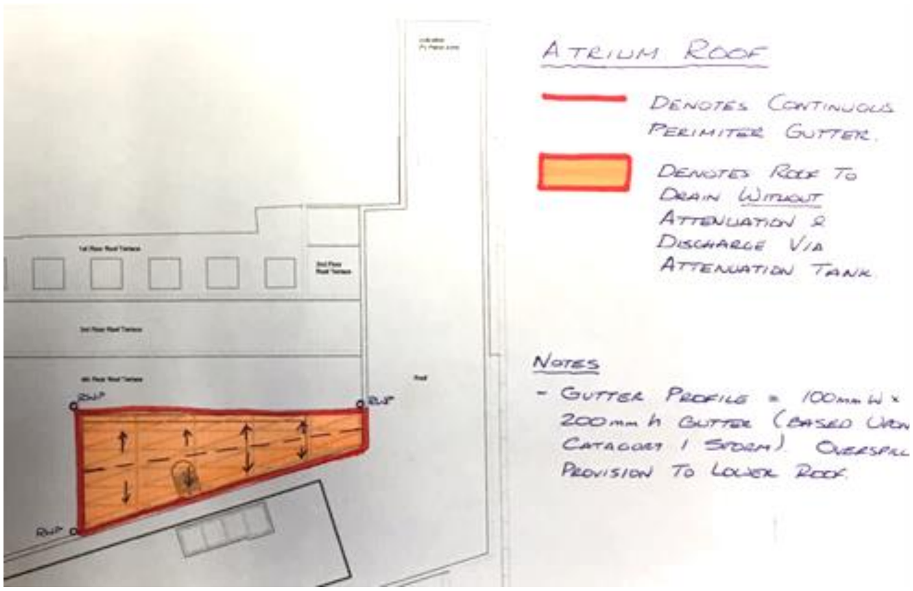


The current architectural sketch section



A possible dual outlet overflow configuration

Atrium Roof

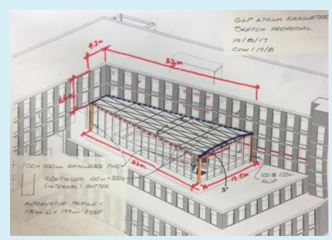


Summary

This glazed roof has no potential for attenuation. The roof will be provided with a continuous perimeter gutter 200mm deep and 100mm wide. 3 No. rainwater pipes will collect the water and route it into the main attenuation tank uncontrolled.

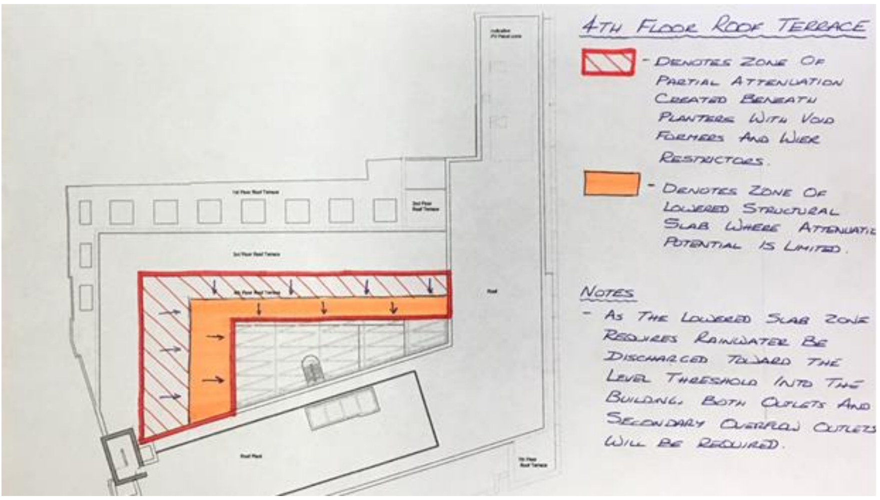
Design Water Depth and Overspill Strategy

This gutter has been sized at BS12056 category and the overspill strategy is onto the lower surrounding roof area.



Gutter sizing sketch

4th Floor Terrace



Summary

This area is characterised by its split slab level. Unfortunately, the lower slab sits closest to the level threshold into the building increasing the risk of water ingress should there be a blockage or storm the exceeds the design limitations. For this reason, a system of secondary outlets are recommended.

The upstand beams split the roof into numerous sections so this detail will be repeated in each structural bay. This detail limits the potential for rooftop attenuation.

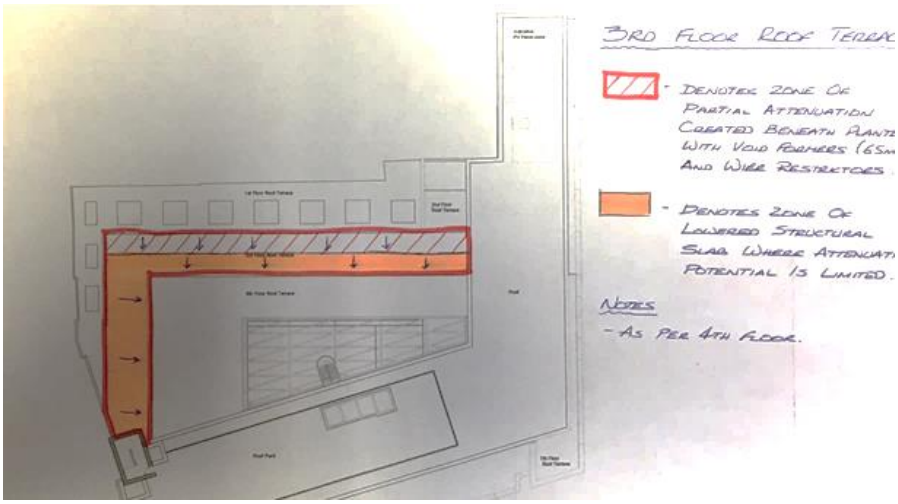
Beneath the planter zone however there is the opportunity for some beneficial slowing of rainwater flows through a void former with integral semi permeable weir. This area will discharge to the attenuation tank.

Design Water Depth and Overspill Strategy

The maximum water depth beneath the planter is to be 85mm (although this can be reduced if necessary). Water will not be stored within the lowered slab area.

Overflow capacity will be required via a dual outlet system to protect the level threshold into the building.

3rd Floor Terrace



Summary

As with the 4th Floor, this area is characterised by its split slab level. Unfortunately, the lower slab sits closest to the level threshold into the building increasing the risk of water ingress should there be a blockage or storm the exceeds the design limitations. For this reason, a system of secondary outlets are recommended.

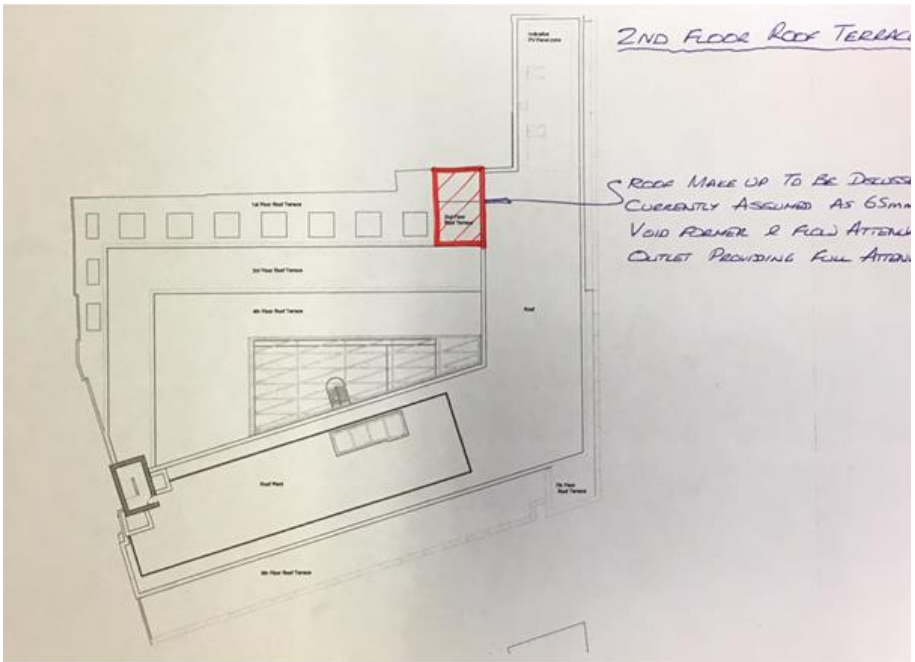
The upstand beams split the roof into numerous sections so this detail will be repeated in each structural bay. This detail limits the potential for rooftop attenuation.

Beneath the planter zone however there is the opportunity for some beneficial slowing of rainwater flows through a void former with integral semi permeable weir. This area will discharge to the attenuation tank under options 1 and 2.

Design Water Depth and Overspill Strategy

The maximum water depth beneath the planter is to be 85mm (although this can be reduced if necessary). Water will not be stored within the lowered slab area. Overflow capacity will be required via a dual outlet system to protect the level threshold into the building.

2nd Floor Roof Terrace



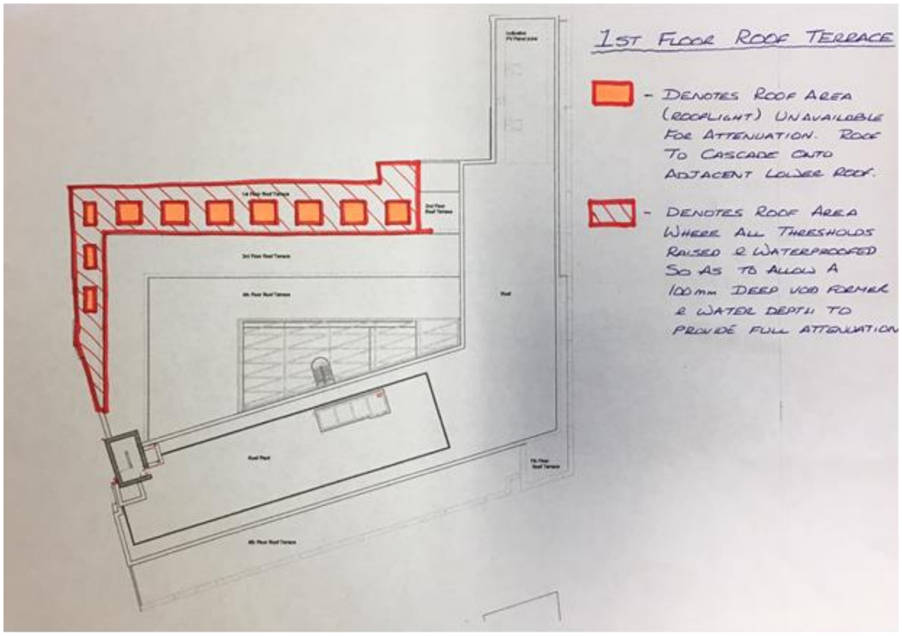
Summary

This area has been assumed to be available for the introduction of void formers 85mm in depth using 75mm water depth and flow restrictor outlets. This would allow the area to discharge to the building gravity outfall.

Design Water Depth and Overspill Strategy

Design water depth is 75mm, although if necessary this can be adjusted.
Ovespill provision is to be through the parapet and possible via secondary outlet.

1st Floor Roof Terrace



Summary

The roof lights in this area can not provide any attenuation, however, discussions with the architect reveals that it is possible to increase the waterproofing depth of the surrounding roof areas in order to allow an increased depth to compensate for this.

It is therefore proposed to utilise a 100mm deep void former to control the release of the water into the gravity outfall of the building allowing the attenuation tank to be by-passed under options 1 and 2.

Design Water Depth and Overspill Strategy

Design water depth is 85mm, although if necessary this can be adjusted. Ovespill provision is to be through the parapet and possible via secondary outlet.

Appendix 2

Microdraiange Calculations – No Rooftop Attenuation

The following calculations have been undertaken to provide a corrected baseline condition from the original SuDS report. These calculations assume no rooftop attenuation or green roof areas and a return period of 100 years and a climate change allowance of 30%.

The result indicates that the total attenuation volume required is 173m3.

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Date 30/08/2017 14:19	Designed by UKRXM014	Micro Drainage
File 170830 Stephenson	Checked by	
XP Solutions	Source Control 2015.1	

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	0.924	0.924	5.0	0.0	5.0	92.4	O K
30 min Summer	1.167	1.167	5.0	0.0	5.0	116.7	O K
60 min Summer	1.366	1.366	5.0	0.0	5.0	136.6	O K
120 min Summer	1.480	1.480	5.0	0.0	5.0	148.0	O K
180 min Summer	1.469	1.469	5.0	0.0	5.0	146.9	O K
240 min Summer	1.410	1.410	5.0	0.0	5.0	141.0	O K
360 min Summer	1.306	1.306	5.0	0.0	5.0	130.6	O K
480 min Summer	1.229	1.229	5.0	0.0	5.0	122.9	O K
600 min Summer	1.160	1.160	5.0	0.0	5.0	116.0	O K
720 min Summer	1.095	1.095	5.0	0.0	5.0	109.5	O K
960 min Summer	0.970	0.970	5.0	0.0	5.0	97.0	O K
1440 min Summer	0.741	0.741	5.0	0.0	5.0	74.1	O K
2160 min Summer	0.455	0.455	5.0	0.0	5.0	45.5	O K
2880 min Summer	0.244	0.244	5.0	0.0	5.0	24.4	O K
4320 min Summer	0.022	0.022	5.0	0.0	5.0	2.2	O K
5760 min Summer	0.000	0.000	4.3	0.0	4.3	0.0	O K
7200 min Summer	0.000	0.000	3.6	0.0	3.6	0.0	O K
8640 min Summer	0.000	0.000	3.0	0.0	3.0	0.0	O K
10080 min Summer	0.000	0.000	2.7	0.0	2.7	0.0	O K
15 min Winter	1.043	1.043	5.0	0.0	5.0	104.3	O K
30 min Winter	1.321	1.321	5.0	0.0	5.0	132.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
15 min Summer	137.603	0.0	97.8	0.0	18
30 min Summer	88.845	0.0	126.6	0.0	33
60 min Summer	54.549	0.0	155.4	0.0	62
120 min Summer	32.353	0.0	184.7	0.0	122
180 min Summer	23.530	0.0	201.4	0.0	180
240 min Summer	18.670	0.0	212.6	0.0	234
360 min Summer	13.450	0.0	230.0	0.0	286
480 min Summer	10.655	0.0	242.7	0.0	348
600 min Summer	8.888	0.0	253.1	0.0	414
720 min Summer	7.661	0.0	262.0	0.0	484
960 min Summer	6.056	0.0	275.9	0.0	616
1440 min Summer	4.343	0.0	297.0	0.0	880
2160 min Summer	3.110	0.0	319.3	0.0	1252
2880 min Summer	2.451	0.0	335.0	0.0	1588
4320 min Summer	1.751	0.0	359.3	0.0	2208
5760 min Summer	1.378	0.0	377.2	0.0	0
7200 min Summer	1.144	0.0	391.4	0.0	0
8640 min Summer	0.983	0.0	403.3	0.0	0
10080 min Summer	0.864	0.0	413.5	0.0	0
15 min Winter	137.603	0.0	109.8	0.0	18
30 min Winter	88.845	0.0	141.8	0.0	33

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Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
60 min Winter	1.558	1.558	5.0	0.0	5.0	155.8	O K
120 min Winter	1.711	1.711	5.0	0.0	5.0	171.1	O K
180 min Winter	1.728	1.728	5.0	0.0	5.0	172.8	O K
240 min Winter	1.690	1.690	5.0	0.0	5.0	169.0	O K
360 min Winter	1.559	1.559	5.0	0.0	5.0	155.9	O K
480 min Winter	1.452	1.452	5.0	0.0	5.0	145.2	O K
600 min Winter	1.358	1.358	5.0	0.0	5.0	135.8	O K
720 min Winter	1.263	1.263	5.0	0.0	5.0	126.3	O K
960 min Winter	1.075	1.075	5.0	0.0	5.0	107.5	O K
1440 min Winter	0.727	0.727	5.0	0.0	5.0	72.7	O K
2160 min Winter	0.312	0.312	5.0	0.0	5.0	31.2	O K
2880 min Winter	0.051	0.051	5.0	0.0	5.0	5.1	O K
4320 min Winter	0.000	0.000	3.9	0.0	3.9	0.0	O K
5760 min Winter	0.000	0.000	3.1	0.0	3.1	0.0	O K
7200 min Winter	0.000	0.000	2.6	0.0	2.6	0.0	O K
8640 min Winter	0.000	0.000	2.2	0.0	2.2	0.0	O K
10080 min Winter	0.000	0.000	1.9	0.0	1.9	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
60 min Winter	54.549	0.0	174.4	0.0	62
120 min Winter	32.353	0.0	206.4	0.0	120
180 min Winter	23.530	0.0	225.2	0.0	176
240 min Winter	18.670	0.0	238.4	0.0	232
360 min Winter	13.450	0.0	257.6	0.0	334
480 min Winter	10.655	0.0	271.9	0.0	376
600 min Winter	8.888	0.0	283.7	0.0	452
720 min Winter	7.661	0.0	293.3	0.0	526
960 min Winter	6.056	0.0	309.4	0.0	674
1440 min Winter	4.343	0.0	332.9	0.0	940
2160 min Winter	3.110	0.0	356.9	0.0	1300
2880 min Winter	2.451	0.0	375.5	0.0	1584
4320 min Winter	1.751	0.0	402.5	0.0	0
5760 min Winter	1.378	0.0	422.4	0.0	0
7200 min Winter	1.144	0.0	438.3	0.0	0
8640 min Winter	0.983	0.0	451.7	0.0	0
10080 min Winter	0.864	0.0	463.1	0.0	0

Appendix 3

Microdrainage Calculations – Incorporating Blue / Green Roofs

The following calculations have been undertaken to size an attenuation tank after the roof areas suitable for rooftop attenuation have been deducted.

The assumptions are;

- 2.3 l/s maximum discharge to sewer (2.7 l/s having been allocated to blue roof discharges)
- 1000m2 roof minimal attenuation
- 600m2 roof intensive green roof
- 2200m2 blue roof
- 1:100 + 30% CC

This gives a attenuation tank size for this alternative (Options 1, 2a and 2b) of just under 60m3

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Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	0.230	0.230	2.3	0.0	2.3	23.0	O K
30 min Summer	0.331	0.331	2.3	0.0	2.3	33.1	O K
60 min Summer	0.423	0.423	2.3	0.0	2.3	42.3	O K
120 min Summer	0.485	0.485	2.3	0.0	2.3	48.5	O K
180 min Summer	0.494	0.494	2.3	0.0	2.3	49.4	O K
240 min Summer	0.483	0.483	2.3	0.0	2.3	48.3	O K
360 min Summer	0.459	0.459	2.3	0.0	2.3	45.9	O K
480 min Summer	0.439	0.439	2.3	0.0	2.3	43.9	O K
600 min Summer	0.418	0.418	2.3	0.0	2.3	41.8	O K
720 min Summer	0.397	0.397	2.3	0.0	2.3	39.7	O K
960 min Summer	0.357	0.357	2.3	0.0	2.3	35.7	O K
1440 min Summer	0.267	0.267	2.3	0.0	2.3	26.7	O K
2160 min Summer	0.147	0.147	2.3	0.0	2.3	14.7	O K
2880 min Summer	0.065	0.065	2.3	0.0	2.3	6.5	O K
4320 min Summer	0.000	0.000	2.3	0.0	2.3	0.0	O K
5760 min Summer	0.000	0.000	1.8	0.0	1.8	0.0	O K
7200 min Summer	0.000	0.000	1.5	0.0	1.5	0.0	O K
8640 min Summer	0.000	0.000	1.3	0.0	1.3	0.0	O K
10080 min Summer	0.000	0.000	1.1	0.0	1.1	0.0	O K
15 min Winter	0.276	0.276	2.3	0.0	2.3	27.6	O K
30 min Winter	0.391	0.391	2.3	0.0	2.3	39.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
15 min Summer	134.993	0.0	31.3	0.0	42
30 min Summer	87.328	0.0	43.1	0.0	55
60 min Summer	53.743	0.0	55.1	0.0	76
120 min Summer	31.958	0.0	67.5	0.0	124
180 min Summer	23.281	0.0	74.5	0.0	182
240 min Summer	18.495	0.0	79.3	0.0	230
360 min Summer	13.329	0.0	86.4	0.0	288
480 min Summer	10.567	0.0	91.7	0.0	350
600 min Summer	8.819	0.0	96.0	0.0	416
720 min Summer	7.605	0.0	99.5	0.0	484
960 min Summer	6.016	0.0	105.3	0.0	616
1440 min Summer	4.317	0.0	113.4	0.0	872
2160 min Summer	3.094	0.0	121.8	0.0	1232
2880 min Summer	2.441	0.0	127.8	0.0	1560
4320 min Summer	1.745	0.0	136.3	0.0	0
5760 min Summer	1.374	0.0	142.1	0.0	0
7200 min Summer	1.142	0.0	146.4	0.0	0
8640 min Summer	0.981	0.0	149.6	0.0	0
10080 min Summer	0.862	0.0	152.2	0.0	0
15 min Winter	134.993	0.0	36.1	0.0	44
30 min Winter	87.328	0.0	49.4	0.0	57

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XP Solutions	Source Control 2015.1	

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Σ Max Outflow (l/s)	Max Volume (m³)	Status
60 min Winter	0.498	0.498	2.3	0.0	2.3	49.8	O K
120 min Winter	0.577	0.577	2.3	0.0	2.3	57.7	O K
180 min Winter	0.592	0.592	2.3	0.0	2.3	59.2	O K
240 min Winter	0.584	0.584	2.3	0.0	2.3	58.4	O K
360 min Winter	0.549	0.549	2.3	0.0	2.3	54.9	O K
480 min Winter	0.516	0.516	2.3	0.0	2.3	51.6	O K
600 min Winter	0.484	0.484	2.3	0.0	2.3	48.4	O K
720 min Winter	0.450	0.450	2.3	0.0	2.3	45.0	O K
960 min Winter	0.385	0.385	2.3	0.0	2.3	38.5	O K
1440 min Winter	0.245	0.245	2.3	0.0	2.3	24.5	O K
2160 min Winter	0.076	0.076	2.3	0.0	2.3	7.6	O K
2880 min Winter	0.000	0.000	2.3	0.0	2.3	0.0	O K
4320 min Winter	0.000	0.000	1.6	0.0	1.6	0.0	O K
5760 min Winter	0.000	0.000	1.3	0.0	1.3	0.0	O K
7200 min Winter	0.000	0.000	1.1	0.0	1.1	0.0	O K
8640 min Winter	0.000	0.000	0.9	0.0	0.9	0.0	O K
10080 min Winter	0.000	0.000	0.8	0.0	0.8	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
60 min Winter	53.743	0.0	63.0	0.0	80
120 min Winter	31.958	0.0	76.6	0.0	124
180 min Winter	23.281	0.0	84.4	0.0	178
240 min Winter	18.495	0.0	90.0	0.0	234
360 min Winter	13.329	0.0	98.0	0.0	320
480 min Winter	10.567	0.0	103.9	0.0	376
600 min Winter	8.819	0.0	108.6	0.0	452
720 min Winter	7.605	0.0	112.6	0.0	524
960 min Winter	6.016	0.0	118.9	0.0	666
1440 min Winter	4.317	0.0	128.4	0.0	926
2160 min Winter	3.094	0.0	138.0	0.0	1260
2880 min Winter	2.441	0.0	144.9	0.0	0
4320 min Winter	1.745	0.0	154.5	0.0	0
5760 min Winter	1.374	0.0	161.2	0.0	0
7200 min Winter	1.142	0.0	166.2	0.0	0
8640 min Winter	0.981	0.0	170.2	0.0	0
10080 min Winter	0.862	0.0	173.3	0.0	0

Appendix 4

Blue Roof Calculation Summary

The following calculations assume the following;

- 1 No. blue roof @ 1900m2 approx discharging 2.0 l/s
- 1 No blue roof @ 300m2 approx discharging 0.7 l/s
- 1:100 + 30% CC

There are two calculations provided for each roof. The first assumes that the entire area is available for 100% storage. This gives the total volume but is unrealistic because as the design develops there will building elements, void ratios and services that may use some of the available volume. The second calculation therefore looks to estimate, with the current limited information, the actual water depth that will occur in those areas where storage is permitted.

Project: Stephenson House Client: GLP Designer: CDH		Ref:		Date: 30/08/2017	
Rainfall: London		r: 0.42		M5-60: 20 mm	
Return Period: Percentage Increase:	100 years 30	100 years 30	100 years 30	100 years 30	
Roof	**Roof 1**	**Roof 2**	**Roof 3**	**Roof 4**	
Blue Roof Area (m2)	1900	1650	340	226	
Percentage Multiplier	100	100	100	100	
Additional Area (m2)	0	250	0	114	
Percentage Multiplier	100	100	100	100	
Total Area (m2)	**1900**	**1900**	**340**	**340**	
Storage void ratio (%)	100	95	100	95	
Drop to orifice (m)	0	0	0	0	
Results					
Critical Storm Duration	3.93 hrs	3.93 hrs	2.07 hrs	2.07 hrs	
Critical Rainfall (mm/h)	18.6	18.6	30.8	30.8	
Time to Half Empty	7.7 hrs	7.7 hrs	3.26 hrs	3.26 hrs	
Storage Depth (mm)	58	71	48	76	
Max. Outflow Rate (l/s)	2	2	0.7	0.7	
Orifice Diameter (mm)	siphonic	siphonic	siphonic	siphonic	
	Pass	Pass	Pass	Pass	

Roof 2 = the main roof

Roof 4 = the 1st / 2nd floor terraces

Appendix 5

Camden Pro forma

Advice Note on contents of a Surface Water Drainage Statement

London Borough of Camden

1. Introduction

1.1 The Government has strengthened planning policy on the provision of sustainable drainage and new consultation arrangements for 'major' planning applications will come into force from 6 April 2015 as defined in the Written Ministerial Statement (18th Dec 2014).

1.2 The new requirements make Lead Local Flood Authorises statutory consultees with respect to flood risk and SuDS for all major applications. Previously the Environment Agency had that statutory responsibility for sites above 1ha in flood zone 1.

1.3 Therefore all 'major' planning applications submitted from 6 April 2015 are required demonstrate compliance with this policy and we'd encourage this is shown in a **Surface Water Drainage Statement**.

1.4 The purpose of this advice note is to set out what information should be included in such statements.

2. Requirements

2.1 It is essential that the type of Sustainable Drainage System (SuDS) for a site, along with **details of its extent and position**, is identified within the planning application to clearly demonstrate that the proposed SuDS can be accommodated within the development.

2.2 It will now not be acceptable to leave the design of SuDs to a later stage to be dealt with by planning conditions.

2.3 The NPPF paragraph 103 requires that developments do not increase flood risk elsewhere, and gives priority to the use of SuDS. Major developments must include SuDS for the management of run-off, unless demonstrated to be inappropriate. The proposed minimum standards of operation must be appropriate and as such, a **maintenance plan** should be included within the Surface Water Drainage Statement,clearly demonstrating that the SuDS have been designed to ensure that the maintenance and operation requirements are economically proportionate Planning Practice Guidance suggests that this should be considered by reference to the costs that would be incurred by consumers for the use of an effective drainage system connecting directly to a public sewer.

2.4 Camden Council will use planning conditions or obligations to ensure that there are clear arrangements in place for ongoing maintenance over the lifetime of the development.

2.5 Within Camden, SuDS systems must be designed in accordance with London Plan policy 5.13. This requires that developments should utilise sustainable urban drainage systems (SUDS) unless there are practical reasons for not doing so, and should aim to achieve **greenfield run-off rates** and ensure that surface water run-off is managed as close to its source as possible in line with the following **drainage hierarchy**:

1 store rainwater for later use
2 use infiltration techniques, such as porous surfaces in non-clay areas
3 attenuate rainwater in ponds or open water features for gradual release
4 attenuate rainwater by storing in tanks or sealed water features for gradual release
5 discharge rainwater direct to a watercourse
6 discharge rainwater to a surface water sewer/drain
7 discharge rainwater to the combined sewer.

2.6 The hierarchy above seeks to ensure that surface water run-off is controlled as near to its source as possible to mimic natural drainage systems and retain water on or near to the site, in contrast to traditional drainage approaches, which tend to pipe water off-site as quickly as possible.

2.7 Before disposal of surface water to the public sewer is considered all other options set out in the drainage hierarchy should be exhausted. When no other practicable alternative exists to dispose of surface water other than the public sewer, the Water Company or its agents should confirm that there is adequate spare capacity in the existing system taking future development requirements into account.

2.8 Best practice guidance within the non-statutory technical standards for the design, maintenance and operation of sustainable drainage systems will also need to be followed. Runoff volumes from the development to any highway drain, sewer or surface water body in the 1 in 100 year, 6 hour rainfall event must be constrained to a value as close as is reasonably practicable to the **greenfield runoff volume** for the same event.

2.9 Camden Development Policy 23 (Water) requires developments to reduce pressure on combined sewer network and the risk of flooding by limiting the rate of run-off through sustainable urban drainage systems. This policy also requires that developments in areas known to be at risk of surface water flooding are designed to cope with being flooded. Camden's SFRA surface water flood maps, updated SFRA figures 6 (LFRZs), and 4e (increased susceptibility to elevated groundwater) , as well as the Environment Agency updated flood maps for surface water (ufmfsw), should be referred to when determining whether developments are in an area at risk of flooding.

2.10 Camden Planning Guidance 3 (CPG3) requires developments to achieve a greenfield run off rate once SuDS have been installed. Where it can be demonstrated that this is not feasible, a minimum 50% reduction in run off rate across the development is required. Further guidance on how to reduce the risk of flooding can be found in CPG3 paragraphs 11.4-11.8.

2.11 Where an application is part of a larger site which already has planning permission it is essential that the new proposal does not compromise the drainage scheme already approved.

3. Further information and guidance

3.1 Applicants are strongly advised to discuss their proposals with the Lead Local Flood Authority at the pre-application stage to ensure that an acceptable SuDS scheme is submitted.

3.2 For general clarification of these requirements please Camden's Local Planning Authority or Lead Local Flood Authority

Surface Water Drainage Pro-forma for new developments

This pro-forma accompanies our advice note on surface water drainage. Developers should complete this form and submit it to the Local Planning Authority, referencing from where in their submission documents this information is taken. The pro-forma is supported by the Defra/EA guidance on Rainfall Runoff Management and uses the storage calculator on www.UKsuds.com. This pro-forma is based on current industry best practice and focuses on ensuring surface water drainage proposals meet national and local policy requirements. The pro-forma should be considered alongside other supporting SuDS Guidance.

1. Site Details

Site	STEPHENSON HOUSE
Address & post code or LPA reference	75 HAMPSTEAD ROAD NW1 2PL
Grid reference	529 178 182 506
Is the existing site developed or Greenfield?	DEVELOPED
Is the development in a LFRZ or in an area known to be at risk of surface or ground water flooding? If yes, please demonstrate how this is managed, in line with DP23?	NO
Total Site Area served by drainage system (excluding open space) (Ha)*	0.38Ha - 0.22Ha to be provided with Roof Top attenuation - 0.16 to be provided with Storage tank

***** The Greenfield runoff off rate from the development which is to be used for assessing the requirements for limiting discharge flow rates and attenuation storage from a site should be calculated for the area that forms the drainage network for the site whatever size of site and type of drainage technique. Please refer to the Rainfall Runoff Management document or CIRIA manual for detail on this.

2. Impermeable Area

	Existing	Proposed	Difference (Proposed-Existing)	Notes for developers
Impermeable area (ha)	0.38	0.38	N/A	If the proposed amount of impermeable surface is greater, then runoff rates and volumes will increase. Section 6 must be filled in. If proposed impermeability is equal or less than existing, then section 6 can be skipped and section 7 filled in.
Drainage Method (infiltration/sewer/watercourse)			N/A	If different from the existing, please fill in section 3. If existing drainage is by infiltration and the proposed is not, discharge volumes may increase. Fill in section 6.

3. Proposing to Discharge Surface Water via

	Yes	No	Evidence that this is possible	Notes for developers
Existing and proposed MicroDrainage calculations	✓		REFER TO MICRODRAINAGE CALCULATIONS PROVIDED FOR ALL RETURN PERIODS REQUIRED	Please provide MicroDrainage calculations of existing and proposed run-off rates and volumes in accordance with a recognised methodology or the results of a full infiltration test (see line below) if infiltration is proposed.
Infiltration		✓		e.g. soakage tests. Section 6 (infiltration) must be filled in if infiltration is proposed.
To watercourse		✓		e.g. Is there a watercourse nearby?
To surface water sewer	✓		EXISTING DRAINAGE LAYOUTS HAVE PROVEN THE SITE IS CURRENTLY POSTIVELY DRAINED THROUGH A NETWORK OF SUSPENDED DRAINAGE RUNS WITHIN THE BASEMENT VIA A PUMPED OUTFALL	Confirmation from sewer provider that sufficient capacity exists for this connection.
Combination of above				e.g. part infiltration part discharge to sewer or watercourse. Provide evidence above.
Has the drainage proposal had regard to the SuDS hierarchy?	✓		THE SITE HAS REGARDED SECTION 2.5 OF THE HIERARCHY AND WE WILL BE PROVIDING A SINGLE ATTENUATION TANK FOR A PORTION OF THE SITE, THERE WILL ALSO BE PARTS OF THE NEW ROOF AREAS PROVIDED WITH A GREEN ROOFS AND ROOF TOP ATTENUATION WHICH FURTHER ENHANCE OUR SUDS TECHNIQUES, WATER WILL BE LIMITED TO GREENFIELD RUN OFF RATES AND WILL ULTIMATELY DISCHARGE TO THE BASEMENT COMBINED DRAINAGE RUNS	Evidence must be provided to demonstrate that the proposed Sustainable Drainage strategy has had regard to the SuDS hierarchy as outlined in Section 2.5 above.
Layout plan showing where the sustainable drainage infrastructure will be located on site.	✓		PLEASE REFER TO THE DRAINAGE STRATEGY REPORT FOR FURTHER DETAILS AS THIS INDICATES WHICH ROOF LEVELS INCOPORATE ROOF TOP ATTENUATION AND WHERE GREEN ROOF ARE TO BE PROVIDED.	Please provide plan reference numbers showing the details of the site layout showing where the sustainable drainage infrastructure will be located on the site. If the development is to be constructed in phases this should be shown on a separate plan and confirmation should be provided that the sustainable drainage proposal for each phase can be constructed and can operate independently and is not reliant on any later phase of development.

4. Peak Discharge Rates – This is the maximum flow rate at which storm water runoff leaves the site during a particular storm event.

	Existing Rates (l/s)	Proposed Rates (l/s)	Difference (l/s) (Proposed-Existing)	% Difference (difference /existing x 100)	Notes for developers
Greenfield QBAR	1.7	N/A	N/A	N/A	QBAR is approx. 1 in 2 storm event. Provide this if Section 6 (QBAR) is proposed.
1 in 1	5.8	2.1	-3.7	63	Proposed discharge rates (with mitigation) should aim to be equivalent to greenfield rates for all corresponding storm events. As a minimum, peak discharge rates must be reduced by 50% from the existing sites for all corresponding rainfall events.
1 in 30	17.5	2.3	-15.2	87	
1in 100	19.7	2.3	-17.4	88	
1 in 100 plus climate change	N/A	2.3	2.3	88	The proposed 1 in 100 +CC peak discharge rate (with mitigation) should aim to be equivalent to greenfield rates. As a minimum, proposed 1 in 100 +CC peak discharge rate must be reduced by 50% from the existing 1 in 100 runoff rate sites.

Note: Attenuating to Greenfield run off rates through the tank improves the current run off for the redeveloped area by a significant 85%

5. Calculate additional volumes for storage –The total volume of water leaving the development site. New hard surfaces potentially restrict the amount of stormwater that can go to the ground, so this needs to be controlled so not to make flood risk worse to properties downstream.

	Greenfield runoff volume (m^3) (SEE NOTE 1)	Existing Volume (m^3) (SEE NOTE 2)	Proposed Volume (m^3) (SEE NOTE 3)	Difference (m^3) (Proposed-Existing)	Notes for developers
1 in 1	10.93	29.29	5	-24.29	Proposed discharge volumes (with mitigation) should be constrained to a value as close as is reasonably practicable to the greenfield runoff volume wherever practicable and as a minimum should be no greater than existing volumes for all corresponding storm events. Any increase in volume increases flood risk elsewhere. Where volumes are increased section 6 must be filled in.
1 in 30	25.24	64.59	24	-40.59	
1in 100 6 hour	34.2	83.7	34	-49.7	
1 in 100 6 hour plus climate change	33.5	83.7	54.9	-28.8	The proposed 1 in 100 +CC discharge volume should be constrained to a value as close as is reasonably practicable to the greenfield runoff volume wherever practicable. As a minimum, to mitigate for climate change the proposed 1 in 100 +CC volume discharge from site must be no greater than the existing 1 in 100 storm event. If not, flood risk increases under climate change.

Notes for reviewer

1) Greenfield run off volumes have been provided, please note these do not appear to be applicable to this project given that we are re-developing an existing brownfield site.

2)Existing Brownfield volumes have been provided in this column see micro-drainage result extracts below.

3) Proposed volumes are based on a pumped discharge limited to 2.3l/s.

6. Calculate attenuation storage – Attenuation storage is provided to enable the rate of runoff from the site into the receiving watercourse to be limited to an acceptable rate to protect against erosion and flooding downstream. The attenuation storage volume is a function of the degree of development relative to the greenfield discharge rate.

		Notes for developers
Storage Attenuation volume (Flow rate control) required to meet greenfield run off rates (m^3)	54.9 limited to 2.3l/s	Volume of water to attenuate on site if discharging at a greenfield run off rate. Can't be used where discharge volumes are increasing
Storage Attenuation volume (Flow rate control) required to reduce rates by 50% (m^3)		Volume of water to attenuate on site if discharging at a 50% reduction from existing rates. Can't be used where discharge volumes are increasing
Storage Attenuation volume (Flow rate control) required to meet [OTHER RUN OFF RATE (as close to greenfield rate as possible] (m^3)		Volume of water to attenuate on site if discharging at a rate different from the above – please state in 1st column what rate this volume corresponds to. On previously developed sites, runoff rates should not be more than three times the calculated greenfield rate. Can't be used where discharge volumes are increasing
Storage Attenuation volume (Flow rate control) required to retain rates as existing (m^3)		Volume of water to attenuate on site if discharging at existing rates. Can't be used where discharge volumes are increasing
Percentage of attenuation volume stored above ground,		Percentage of attenuation volume which will be held above ground in swales/ponds/basins/green roofs etc. If 0, please demonstrate why.

7. How is Storm Water stored on site?

Storage is required for the additional volume from site but also for holding back water to slow down the rate from the site. This is known as attenuation storage and long term storage. The idea is that the additional volume does not get into the watercourses, or if it does it is at an exceptionally low rate. You can either infiltrate the stored water back to ground, or if this isn't possible hold it back with on site storage. Firstly, can infiltration work on site?

			Notes for developers
Infiltration	**State the Site's Geology and known Source Protection Zones (SPZ)**	n/a	Avoid infiltrating in made ground. Infiltration rates are highly variable and refer to Environment Agency website to identify and source protection zones (SPZ)
	Are infiltration rates suitable?	n/a	Infiltration rates should be no lower than $1x10^{-6}$ m/s.
	State the distance between a proposed infiltration device base and the ground water (GW) level	n/a	Need 1m (min) between the base of the infiltration device & the water table to protect Groundwater quality & ensure GW doesn't enter infiltration devices. Avoid infiltration where this isn't possible.

	Were infiltration rates obtained by desk study or infiltration test?		Infiltration rates can be estimated from desk studies at most stages of the planning system if a back up attenuation scheme is provided..
	Is the site contaminated? If yes, consider advice from others on whether infiltration can happen.		Advice on contaminated Land in Camden can be found on our supporting documents webpage Water should not be infiltrated through land that is contaminated. The Environment Agency may provide bespoke advice in planning consultations for contaminated sites that should be considered.
In light of the above, is infiltration feasible?	**Yes/No? If the answer is No, please identify how the storm water will be stored prior to release**		If infiltration is not feasible how will the additional volume be stored?. The applicant should then consider the following options in the next section.

Storage requirements

The developer must confirm that either of the two methods for dealing with the amount of water that needs to be stored on site.

Option 1 Simple – Store both the additional volume and attenuation volume in order to make a final discharge from site at the greenfield run off rate. This is preferred if no infiltration can be made on site. This very simply satisfies the runoff rates and volume criteria.

Option 2 Complex – If some of the additional volume of water can be infiltrated back into the ground, the remainder can be discharged at a very low rate of 2 l/sec/hectare. A combined storage calculation using the partial permissible rate of 2 l/sec/hectare and the attenuation rate used to slow the runoff from site.

		Notes for developers
Please confirm what option has been chosen and how much storage is required on site.	Option 1 - 54.9m3 for the 1-100year + 30% 6hr storm	The developer at this stage should have an idea of the site characteristics and be able to explain what the storage requirements are on site and how it will be achieved.

Please note: it is our intention to provide storage to cater for the 3hour winter storm which requires 59.2 m3.

8. Please confirm

		Notes for developers
Which Drainage Systems measures have been used, including green roofs?	600m2 of green roof is incoporated within the area that serve this tank	SUDS can be adapted for most situations even where infiltration isn't feasible e.g. impermeable liners beneath some SUDS devices allows treatment but not infiltration. See CIRIA SUDS Manual C697.
Drainage system can contain in the 1 in 30 storm event without flooding	See micro-drainage calculations	This a requirement for sewers for adoption & is good practice even where drainage system is not adopted.
Will the drainage system contain the 1 in 100 +CC storm event? If no please demonstrate how buildings and utility plants will be protected.	yes as above	National standards require that the drainage system is designed so that flooding does not occur during a 1 in 100 year rainfall event in any part of: a building (including a basement); or in any utility plant susceptible to water (e.g. pumping station or electricity substation) within the development.
Any flooding between the 1 in 30 & 1 in 100 plus climate change storm events will be safely contained on site.		**Safely:** not causing property flooding or posing a hazard to site users i.e. no deeper than 300mm on roads/footpaths. Flood waters must drain away at section 6 rates. Existing rates can be used where runoff volumes are not increased.
How will exceedance events be catered on site without increasing flood risks (both on site and outside the development)?	n/a	**Safely:** not causing property flooding or posing a hazard to site users i.e. no deeper than 300mm on roads/footpaths. Flood waters must drain away at section 6 rates. Existing rates can be used where runoff volumes are not increased. Exceedance events are defined as those larger than the 1 in 100 +CC event.
How are rates being restricted (vortex control, orifice etc)	orifice within tank, Hydrobreak type, there will be access provided via the tank to deal with obstruct	Detail of how the flow control systems have been designed to avoid pipe blockages and ease of maintenance should be provided.
Please confirm the owners/adopters of the entire drainage systems throughout the development. Please list all the owners.	Private drainage on site	If these are multiple owners then a drawing illustrating exactly what features will be within each owner's remit must be submitted with this Proforma.
How is the entire drainage system to be maintained?	yes, the site will be maintained by the clients on-site maintenance team.	If the features are to be maintained directly by the owners as stated in answer to the above question please answer yes to this question and submit the relevant maintenance schedule for each feature. If it is to be maintained by others than above please give details of each feature and the maintenance schedule. Clear details of the maintenance proposals of all elements of the proposed drainage system must be provided. Details must demonstrate that maintenance and operation requirements are economically proportionate. Poorly maintained drainage can lead to increased flooding problems in the future.

9. Evidence Please identify where the details quoted in the sections above were taken from. i.e. Plans, reports etc. Please also provide relevant drawings that need to accompany your proforma, in particular exceedance routes and ownership and location of SuDS (maintenance access strips etc

Pro-forma Section	Document reference where details quoted above are taken from	Page Number
Section 2	REPORT	
Section 3	MAINTAINANCE INFORMATION	
Section 4	DRAINAGE LAYOUT APPENDIX A1	
Section 5	MICRODRAINAGE CALCULATIONS	
Section 6		
Section 7		
Section 8		

The above form should be completed using evidence from the Flood Risk Assessment and site plans. It should serve as a summary sheet of the drainage proposals and should clearly show that the proposed rate and volume as a result of development will not be increasing. If there is an increase in rate or volume, the rate or volume section should be completed to set out how the additional rate/volume is being dealt with.

This form is completed using factual information from the Flood Risk Assessment and Site Plans and can be used as a summary of the surface water drainage strategy on this site.

Form Completed By……… RICKESH MIYANGAR ………………………………

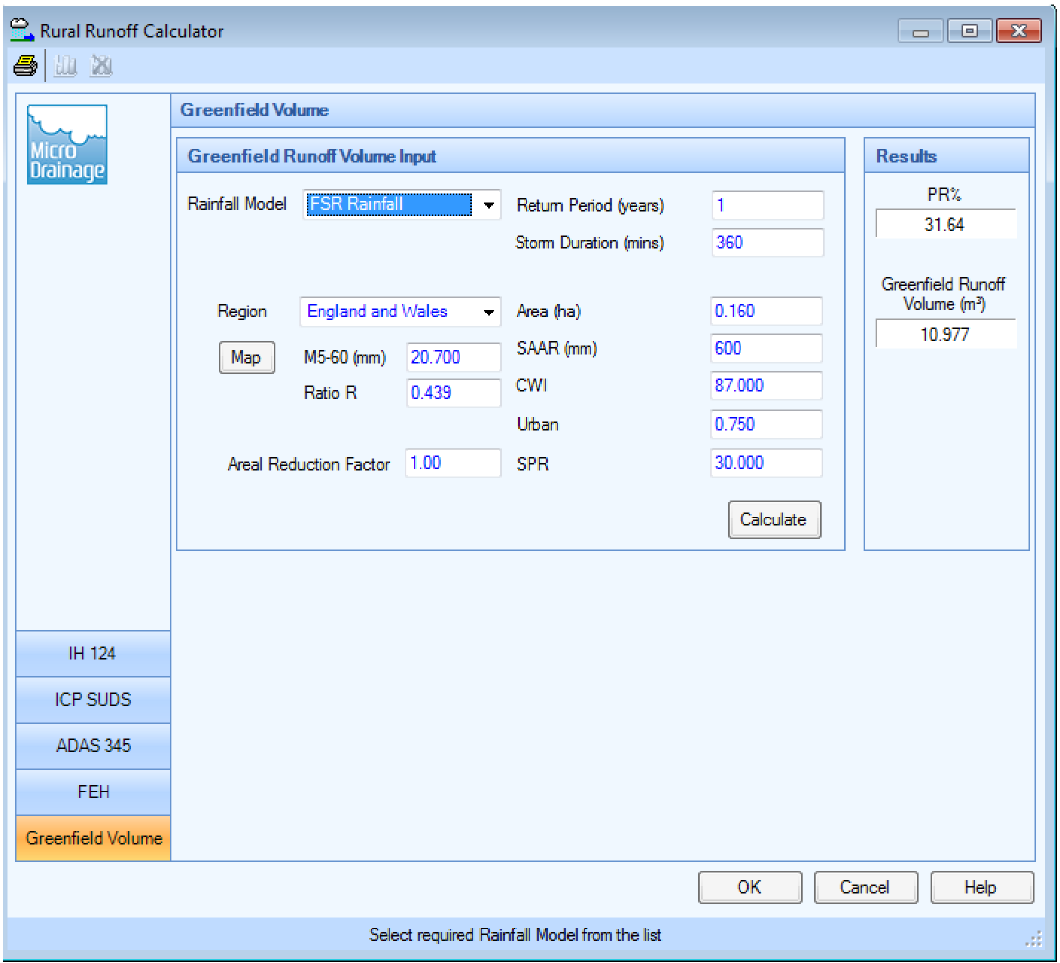
Qualification of person responsible for signing off this pro-forma CHARTERED ENGINEER ……

Company……… GLP ………………………………

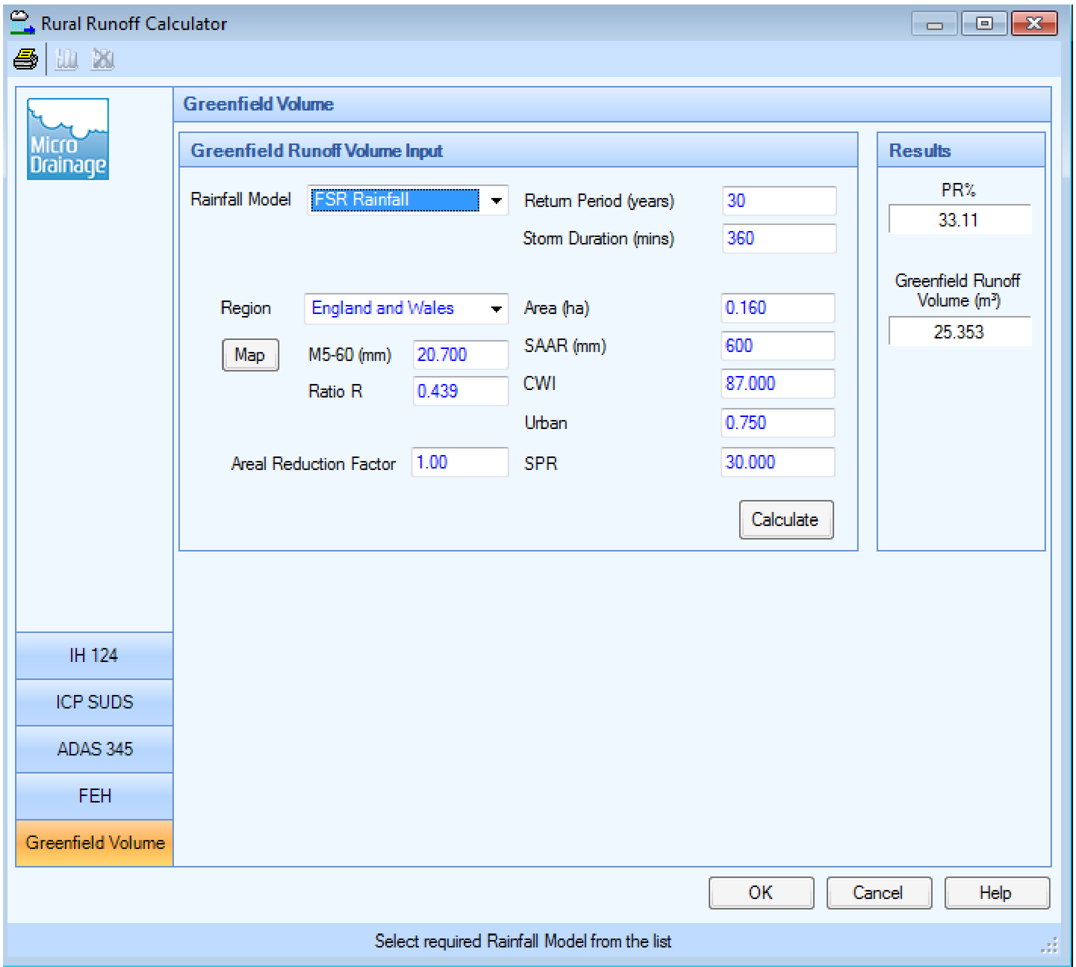
On behalf of (Client's details) ... LANZARI INVESTMENTS LTD ………………

Date:……… 03/09/2017 ………

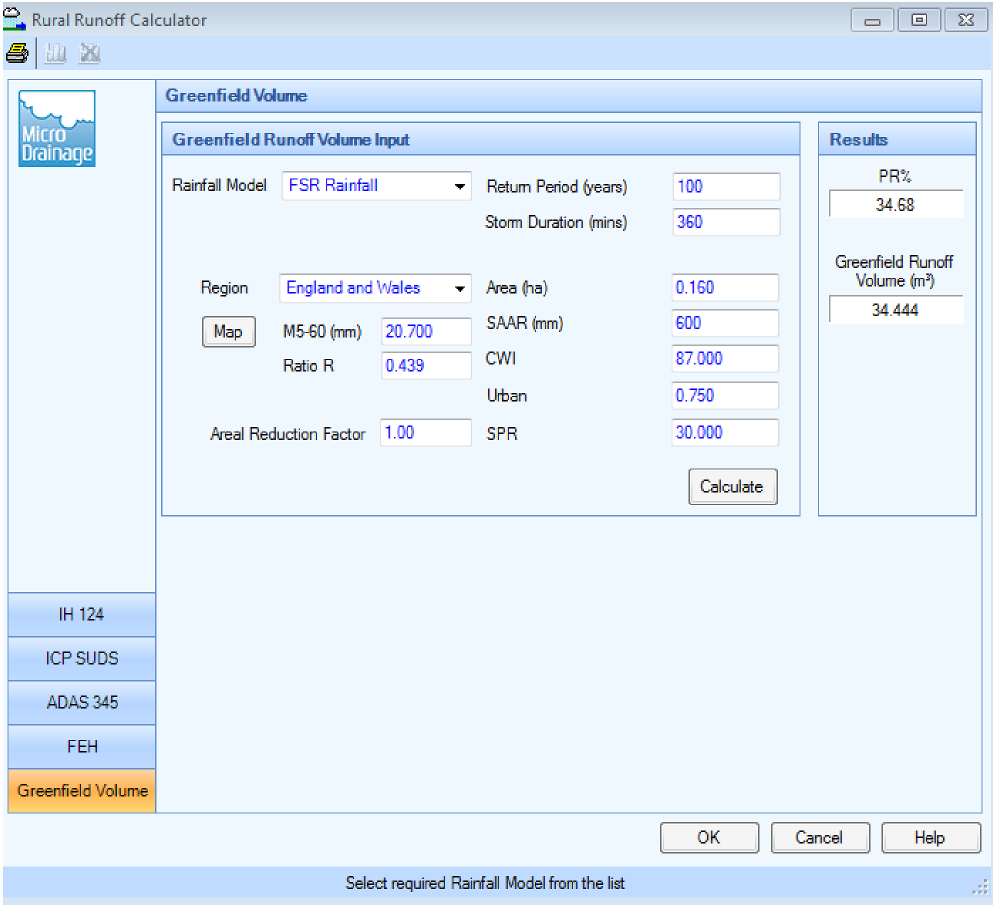
1 in 1 Greenfield Run off Volume



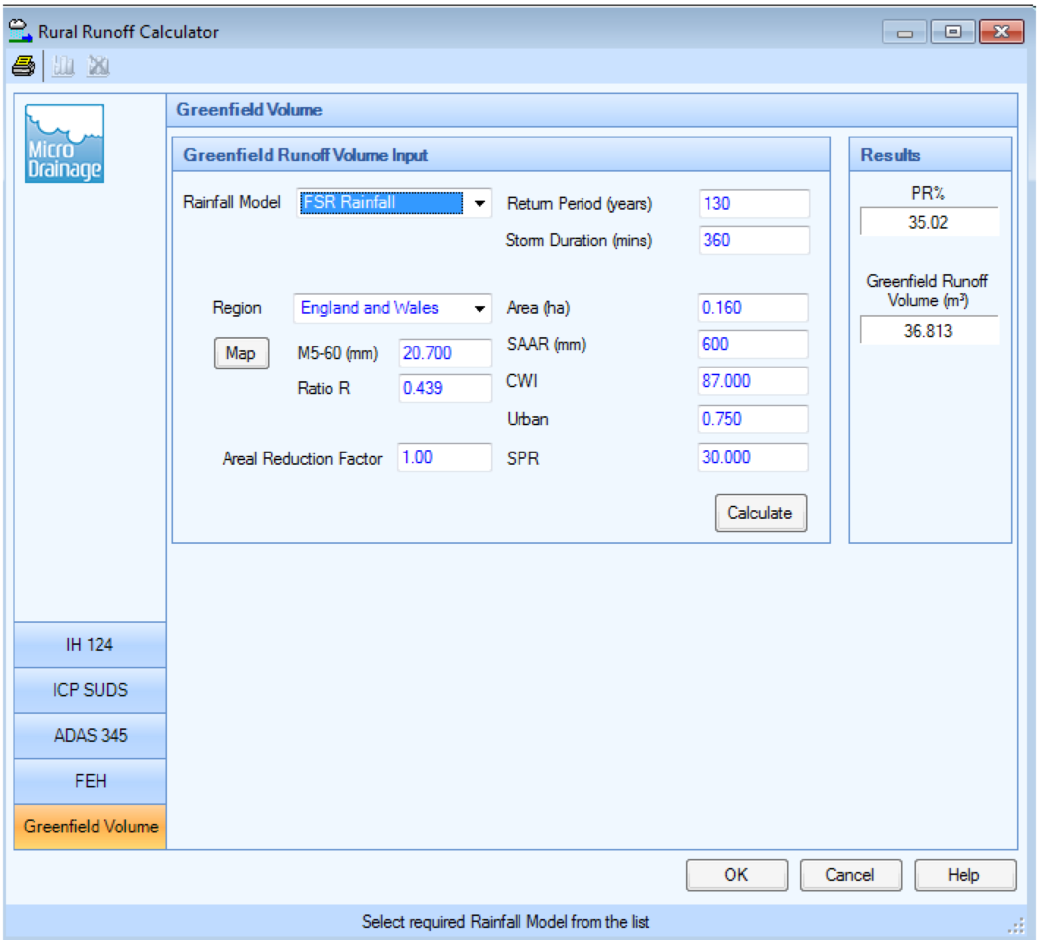
1 in 30 Greenfield Run off Volume



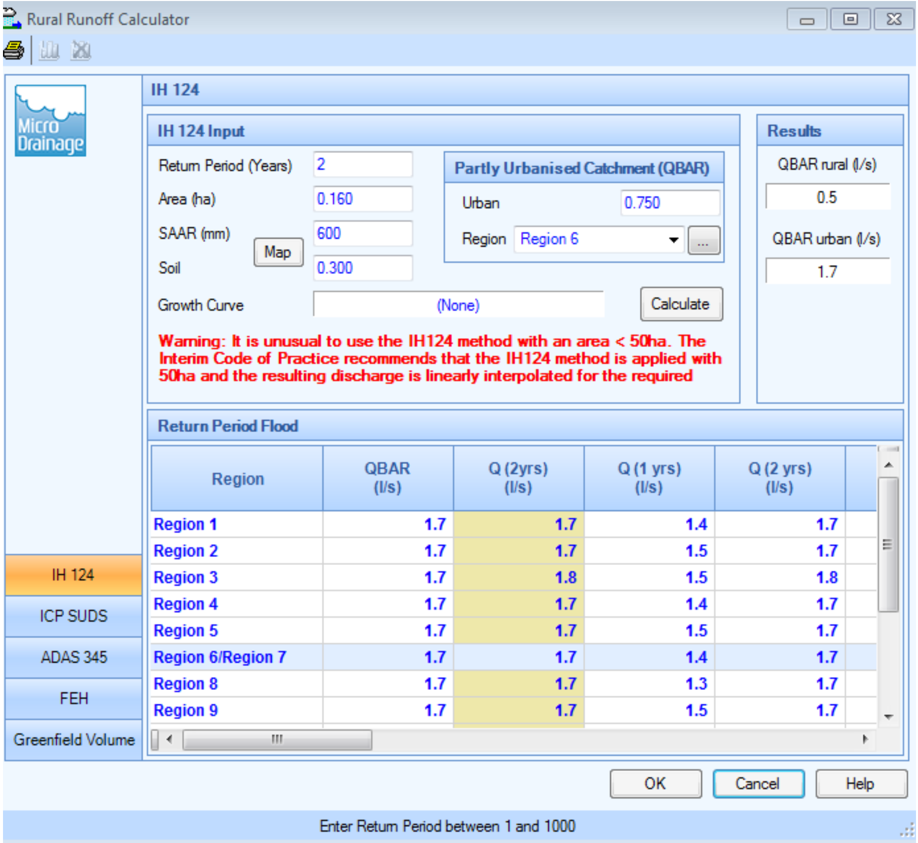
1 in 100 Greenfield Run off Volume



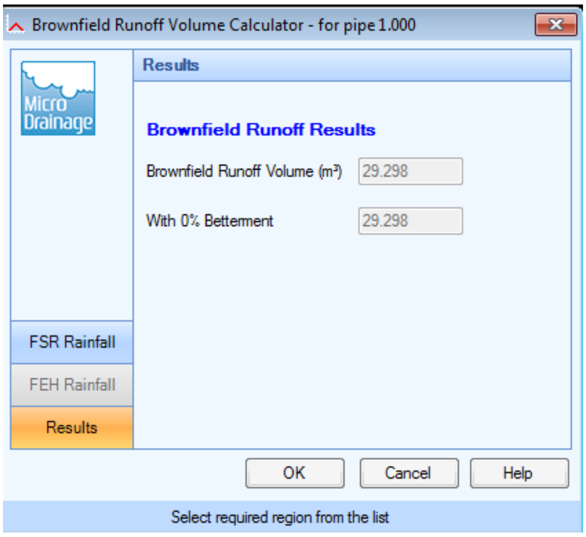
1 in 100 + 30% Greenfield Run off Volume



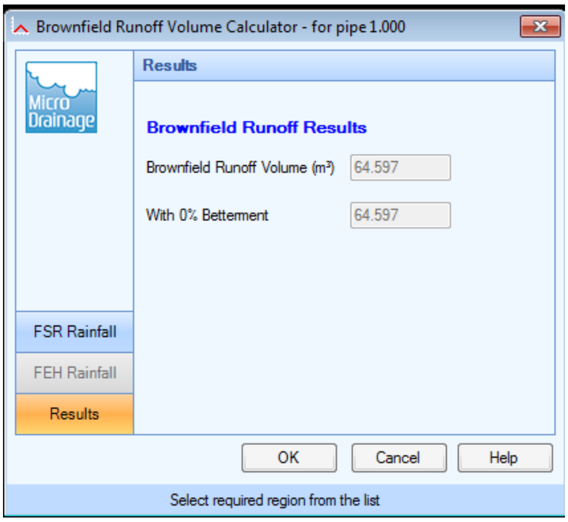
(Greenfield QBAR)



(1in 1 year Brownfield Run-off)



(1in 30 year Brownfield Run-off)



(1in 100 year Brownfield Run-off)