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Proposed Residential Development

# 9 Mill Road, Worthing

# West Sussex

# BN11 4JX

Flood Risk Assessment

and

Code for Sustainable Homes
Category 4: Surface Water Run-off Assessment

On behalf of

**Blythe Properties**

March 2012
1438-R1

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# 9 MILL ROAD, WORTHING

# WEST SUSSEX

# BN11 4JX

## Flood Risk Assessment

## and

## Code for Sustainable Homes

## Category 4: Surface Water Run-off Assessment

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# 9 MILL ROAD, WORTHING
# WEST SUSSEX
# BN11 4JX

## Proposed Residential Development

## Flood Risk Assessment
## and
## Code for Sustainable Homes
## Category 4: Surface Water Run-off Assessment

## 1. BACKGROUND

1.1 This report has been produced on behalf of Blythe Properties in respect of their residential development at 9 Mill Road, Worthing. Planning consent for the development was received from Worthing Borough Council under reference 09/0346/FUL on 2nd March 2010.

1.2 The Flood Risk Assessment has been prepared generally in accordance with the recommendations of Planning Policy Statement 25 – Development and Flood Risk (PPS 25).

1.3 The Surface Water Run-off Assessment has been prepared generally in accordance with the Code for Sustainable Homes Technical Guide, November 2010.

1.4 The drawings supporting this report are as follows:

Dwg. No. 1438/D1.1 Drainage Layout

## 2. THE SITE

2.1 The site is located on the south side of Mill Road, 140 metres east of its junction with Belsize Road, at OS Grid Reference TQ 1369 0289. See Dwg. No. 1438/D1.1 for a Location Plan.

2.2 The site has an area of 0.11 hectares and currently comprises a large detached house in surrounding gardens.

2.3 The site is bounded by other residential development and lies some 800 metres from the coast.

## 3. TOPOGRAPHY

3.1 Ground levels on the site are fairly consistent at around 10.7 metres Above Ordnance Datum (m AOD).

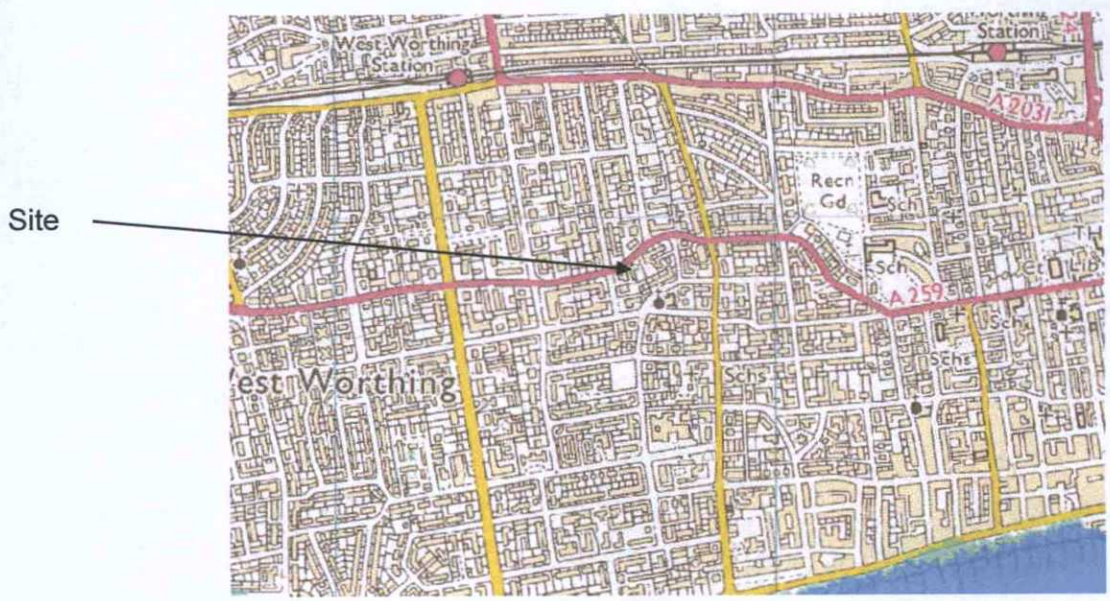
3.2 Levels fall gradually in a southerly direction towards the coast where road levels are at around 5m AOD.

## 4 DEVELOPMENT

4.1 The development comprises alterations and extensions to the existing building to form 9 flats.

## 5. CONSIDERATION OF FLOODING ISSUES

5.1 The relevant extract from the Environment Agency's Flood Map in reproduced below:



5.2 The Flood Map indicates the site to be in Flood Zones 1 and to therefore have a *low* risk of flooding. The risk of tidal and fluvial flooding is likely to have a probability of occurrence in excess of 1 in 1000 years.

5.3 The proposed development is classed as 'more vulnerable' in PPS 25 and this is considered to be appropriate in Flood Zone 1.

## 6. FOUL AND SURFACE WATER DRAINAGE

6.1 There is an existing 150mm diameter public foul water sewer in the footpath outside the site and this is indicated on the accompanying plan. The connection to this sewer from the existing building will be checked by CCTV to ensure that it is suitable for the new development. Any flooding from this sewer due to a blockage or collapse is unlikely to affect the new building, which will be set a minimum of 150mm above the general surrounding ground level.

6.2 Surface water run-off from the building will be drained to on-site soakaways. The drainage design is based on a combination of SUDS features comprising permeable surfaces, geocellular storage/ soakage structures and traditional concrete ring soakaways. The design is based on trial holes excavated on 13 February 2012, followed by percolation testing to BRE 365.

6.3 Ground conditions comprised approximately 300mm of topsoil over sandy clays to a maximum depth of 1.5 metres underlain by stiff clays with some gravel. No groundwater was encountered.

6.4 Percolation tests carried out within the deeper strata gave very poor percolation values, indicating that shallow structures would be required for soakaways. Subsequent percolation tests within the upper 1.2 to 1.5 metres of sandy clays gave fairly consistent soil infiltration rates with a minimum percolation rate of $1.02 \times 10^{-5}$ m/s (0.03672 m/hr) for the third test.

6.5 The design presented here is robust and caters for the 1 in 100 year rainfall event with an additional 30% for climate change, without any resultant surface flooding. As indicated above, the ground floor level of the building will be a minimum of 150mm above the general surrounding ground level and this will provide suitable protection against exceedence.

6.6 Two conventional concrete ring soakaways have been included in the front car parking area and these will assist with drainage of the permeable surfaces here. Each is 2m deep and 1.2m diameter with 500mm of granular surround. A link pipe has been included to help spread the soakage throughout the site.

## 7. OTHER SOURCES OF FLOODING

7.1 The site is not located in a low-lying area and is not at risk of flooding from groundwater, infrastructure failure or other source.

## 8. CODE FOR SUSTAINABLE HOMES ASSESSMENT

8.1 The assessment has been carried out in accordance with The Department for Communities and Local Government Technical Guide November 2010. The site is classed as 'brownfield' and the existing run-off has been calculated as a greenfield site but using Soil Type 5.

8.2 The detailed calculations and MicroDrainage results are included in Appendix 2 but are summarised below for ease of reference:

| **Pre-development run-off** | |
|---|---|
| Rainfall return period | Rate of run-off from whole site (litres/second) |
| 1 year | **0.50** |
| 30 years | **1.40** |
| 100 years | **2.00** |

| **Post-development run-off prior to mitigation (litres/second)**<br>Includes an addition of 30% for climate change | | | | |
|---|---|---|---|---|
| Rainfall return period | Soft landscaped areas (516 $m^2$) | Permeable paving (189 $m^2$) | Impermeable areas (405 $m^2$) | Total (1110 $m^2$) |
| 1 year | **0.26** | 2.15 | 4.61 | 7.02 |
| 30 years | **0.52** | 5.27 | 11.30 | 17.09 |
| 100 years | **0.78** | 6.82 | 14.62 | 22.23 |

8.3 All positive surface water drainage is being taken to soakaways (see paragraph 6 above), so that following mitigation, only the soft landscaped areas are likely to contribute to site run-off. As can be seen from the tables above, this run-off is less than the existing situation.

8.4 The volume of run-off calculations and MicroDrainage results are included in Appendix 2 but are summarised below for ease of reference:

| **Pre-development volume of run-off** | |
|---|---|
| Rainfall return period | Volume of run-off from whole site (cu.m) |
| 1 year | 12.5 |
| 30 years | 28.5 |
| 100 years | **38.3** |

| **Post-development volume of run-off prior to mitigation (cu.m)**<br>Includes an addition of 30% for climate change | | | | |
|---|---|---|---|---|
| Rainfall return period | Soft landscaped areas (516 $m^2$) | Permeable paving (189 $m^2$) | Impermeable areas (405 $m^2$) | Total (1110 $m^2$) |
| 1 year | 5.0 | 4.7 | 10.2 | 19.9 |
| 30 years | 11.8 | 10.3 | 22.3 | 44.4 |
| 100 years | **16.1** | 13.4 | 28.9 | 58.4 |

8.5 As above, all surface water is being drained to soakaways, so that following mitigation, only the soft landscaped areas are likely to contribute to site run-off. As can be seen from the tables above, this run-off is less than the existing situation.

8.6 See Appendix 3 for a completed STROMA Summary Report Template.

## 9. CONCLUSIONS

9.1 The site is shown to lie in Flood Zone 1 on the Environment Agency's flood map and a site-specific Flood Risk Assessment has shown that the site is at *low* risk of flooding from all sources. Thus, 2 additional credits are available under the Code for Sustainable Homes Sur 2 Assessment Criteria.

9.2 The rate of surface water run-off post-development has been shown to be less than that pre-development and the mandatory elements of the Code for Sustainable Homes Sur 1 Assessment Criteria 1 and met.

9.3 The volume of surface water run-off post-development has been shown to be less than that pre-development and the mandatory elements of the Code for Sustainable Homes Sur 1 Assessment Criteria 2 and met.

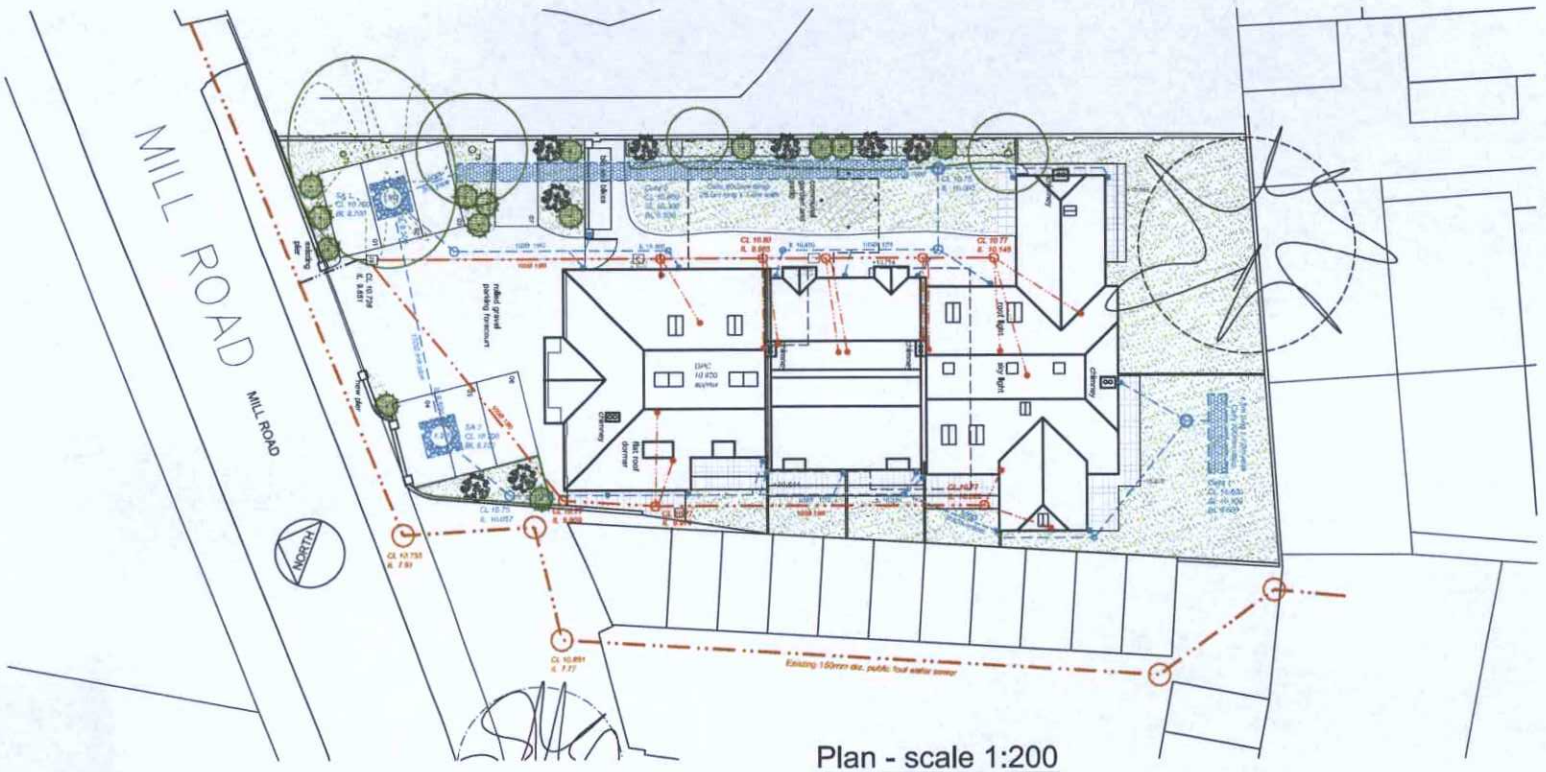
9.4 In addition, 2 additional credits are available under the Water Quality Criteria as all hard surfaces are being drained to soakaways on site.

1438-R1

# Appendix 1

## Drainage Layout Plan

Drawing No. 1438/D1.1




Plan - scale 1:200

## PRIVATE DRAINAGE NOTES

1. All levels are related to Ordnance Datum.
2. All pipes with less than 1.2m of cover when laid beneath the access and parking areas and less than 0.6m of cover under hard and soft landscaped areas shall be provided with ST2 concrete bed and surround or as otherwise detailed.
3. All trenches in vehicular areas shall be backfilled with lean-mix concrete or an approved imported granular material compacted in 225mm thick layers and reinstated in accordance with the specification.
4. All private drainage work is to be carried out in accordance with the Building Regulations Approved Document "H" BS EN 752, and to the satisfaction of the local authority building control section.
5. All pipes to be vitrified clay to BS EN 295 or approved pvcu, unless otherwise stated. No plastics pipework to be incorporated into any concrete manhole construction. All pipes to be 100mm diameter unless otherwise shown on the layout drawing.
6. Manholes situated within vehicular areas are to be fitted with class D400 ductile iron covers and frames to BS EN 124. Other manholes to be fitted with class B125 covers and frames in areas restricted to light motor vehicles and class A15 elsewhere.
7. Where drains pass through foundations, a flexible joint should be provided within 150mm of the face of the structure.
8. Rocker pipes are to be min 500mm, max 700mm in length and provided either side of all manholes.
9. All pipes are to be laid soffits level unless indicated otherwise.
10. The contractor should check all dimensions on site. No dimensions are to be scaled from these drawings. The engineer is to be notified immediately of any discrepancies encountered.
11. It is the contractor's responsibility to ensure compliance with current building regulations and codes of practice.
12. Pipe bedding material shall conform to BS EN 1610 annex b table b.15 and shall be 10mm single size or graded 5mm to 20mm with minimum 150mm thickness of bed and surround carefully compacted.
13. Where the trench for any new pipeline is within the zone of influence of an adjacent building, class Z bedding shall be used and the trench backfilled with lean mix concrete or as otherwise detailed.
14. All trenches in vehicular areas shall be backfilled with an approved imported granular material compacted in 225mm thick layers and reinstated in accordance with the specification
15. The contractor is to commence works on site by checking the invert level of the existing foul water drain at the proposed point of connection and checking the invert level/position of the drain at this point. Any discrepancy between this invert levels/position and the level/position indicated on the drawings is to be reported to the engineer before proceeding with any further works.
16. All existing manholes and pipe runs on site are to be investigated and, if found to be redundant, they shall be grubbed out during the construction works or filled with concrete.
17. Prior to works commencing, the contractor shall carry out an inspection of the existing sewerage connection that is to be re-used in order to confirm its structural and hydraulic condition.
18. The contractor is to keep a record of all variations made on site, including the relocation of sewers or drains, and pass the information to the engineer so that as-constructed drawings can be prepared upon completion of the project.
19. Reference is to be made to all statutory undertakers to ensure that any new works do not interfere or conflict with any existing apparatus.
20. Geocellular units are to comprise Wavin AquaCell or similar approved - see Layout Plan for levels and connection details. Units are to be suitable for the loading condition and laid and jointed in accordance with the manufacturers recommendations for infiltration applications.
21. All flow entering geocellular storage/ soakage structures shall be routed either through a trapped gulley or catchpit manhole incorporating a 300mm deep sump or as otherwise detailed.



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Location Plan
scale 1:1250

### Surface Water Drainage Design Notes

The drainage design is based on a combination of SUDS features comprising permeable surfaces, geocellular storage/ soakage structures and traditional concrete ring soakaways. The design is based on trial holes excavated on 13 February 2012, followed by percolation testing to BRE 365.

Ground conditions comprised approximately 300mm of topsoil over sandy clays to a maximum depth of 1.5 metres underlain by stiff clays with some gravel. No groundwater was encountered.

Percolation tests carried out within the deeper strata gave very poor percolation values, indicating that shallow structures would be required for soakaways. Subsequent percolation tests within the upper 1.2 to 1.5 metres of sandy clays gave fairly consistent soil infiltration rates with a minimum percolation rate of 1.02E-5 m/s (0.03672 m/hr) for the third test.

The design presented here is robust and caters for the 1 in 100 year rainfall event with an additional 30% for climate change, without any resultant surface flooding.

Two conventional concrete ring soakaways have been included in the front car parking area and these will assist with drainage of the permeable surfaces here. Each is 2m deep and 1.2m diameter with 500mm of granular surround. A link pipe has been included to help spread the soakage throughout the site.

### KEY

- Geocellular soakage/ storage units as specified
- Proposed new foul water drainage
- Proposed new surface water drainage
- Existing public foul water sewer
- Concrete ring soakaway with granular surround
- Silt trap - sump manhole 1.05m dia.
- Surface Water inspection chamber 450mm dia.
- Surface Water trapped yard gulley
- Foul inspection chamber 450mm dia.

| Res. | Description | App. | Chk. | Drn. | Date |
|---|---|---|---|---|---|
| - | Original | PTC | | RTFC | 6.3.12 |

Client: Blythe Properties

Project: 9 Mill Road
Worthing

Drawing Title: Drainage Layout

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| Scale | At original |
|---|---|
| 1:200 & 1:1250 | A2 |

| Drawing Number | Revision |
|---|---|
| 1438/D1.1 | - |

# Appendix 2

## Calculations and Results

## Robert Clark Associates Ltd

9 Mill Road, Worthing

Calculation of runoff rates pre and post-development - see attached Microdrainage results

Pre-development rates of run-off

| | Soft Landscaped Area (sq.m) | Permeable Paving Area (sq.m) | Impermeable Areas (sq.m) | Total Areas (sq.m) |
|---|---|---|---|---|
| Area contributing to runoff (sq.m) | 1110 | 0 | 0 | 1110 |
| SAAR | 700 | | | |
| Soil factor (for Soil Class 5) | 0.50 | | | |
| Climate change addition (%) | 0 | 0 | 0 | |
| Geographical region | 7 | | | |
| Urban factor | 0.00 | | | |
| M5-60 | | 20.0 | 20.0 | |
| R | | 0.350 | 0.350 | |
| Cv (Summer) | | 0.500 | 0.750 | |
| Cv (Winter) | | 0.600 | 0.840 | |
| PIMP (%) | | 100 | 100 | |
| Rate of runoff 1-year (litres/second) | 0.50 | 0.00 | 0.00 | 0.50 |
| Rate of runoff 30-year (litres/second) | 1.40 | 0.00 | 0.00 | 1.40 |
| Rate of runoff 100-year (litres/second) | 2.00 | 0.00 | 0.00 | 2.00 |

Notes:
Site is 'brownfield' as there is an existing building on the site which is assumed to drain to soakaways
Assessment has been made in accordance with CfSH Technical Guide 2010 as a greenfield site but using Soil Type 5

Post-development rates of run-off prior to mitigation

| | Soft Landscaped Area (sq.m) | Permeable Paving Area (sq.m) | Impermeable Areas (sq.m) | Total Areas (sq.m) |
|---|---|---|---|---|
| Area total contributing to runoff (sq.m) | 516 | 189 | 405 | 1110 |
| SAAR | 700 | | | |
| Soil factor | 0.40 | | | |
| Climate change addition (%) | 30 | 30 | 30 | |
| Geographical region | 7 | | | |
| Urban factor | 0.00 | | | |
| M5-60 | | 20 | 20 | |
| R | | 0.35 | 0.35 | |
| Cv (Summer) | | 0.750 | 0.750 | |
| Cv (Winter) | | 0.840 | 0.840 | |
| PIMP (%) | | 100 | 100 | |
| Peak rate of rainfall (mm/hr) | | 28.88 | 28.88 | |
| Rate of runoff 1-year (litres/second) | 0.20 | 1.66 | 3.55 | |
| With climate change | **0.26** | **2.15** | **4.61** | **7.02** |
| Peak rate of rainfall (mm/hr) | | 70.76 | 70.76 | |
| Rate of runoff 30-year (litres/second) | 0.40 | 4.06 | 8.69 | |
| With climate change | **0.52** | **5.27** | **11.30** | **17.09** |
| Peak rate of rainfall (mm/hr) | | 91.60 | 91.60 | |
| Rate of runoff 100-year (litres/second) | 0.60 | 5.25 | 11.25 | |
| With climate change | **0.78** | **6.82** | **14.62** | **22.23** |

Notes:
After mitigation, only soft landscaping areas will contribute to runoff post development

## Robert Clark Associates Ltd

9 Mill Road, Worthing

Calculation of runoff volumes pre and post-development

| | Pre-development | | |
|---|---|---|---|
| | Permeable Area (sq.m) | semi-permeable Area (sq.m) | Impermeable Area (sq.m) |
| | 1110 | 0 | 0 |
| SAAR | 700 | | |
| M5-60 | 20.0 | | |
| R | 0.350 | | |
| Cv (Summer) | 0.750 | | |
| Cv (Winter) | 0.840 | | |
| SPR | 53 | | |
| Total rain 1-year (cu.m/Ha) | 233.881 | | |
| Total rain 30-year (cu.m/Ha) | 509.594 | | |
| Total rain 100-year (cu.m/Ha) | 658.491 | | |
| %age runoff 1-year (SPR +) | -5.000 | | |
| %age runoff 30-year (SPR +) | -2.600 | | |
| %age runoff 100-year (SPR +) | -0.620 | | |
| Climate change addition (%) | 0 | | |
| Volume of runoff 1-year (cu.m) | **12.5** | | |
| Volume of runoff 30-year (cu.m) | **28.5** | | |
| Volume of runoff 100-year (cu.m) | **38.3** | | |

Notes:
Site is 'brownfield' as there is an existing building on the site which is assumed to drain to soakaways
Assessment has been made in accordance with CfSH Technical Guide 2010 as a greenfield site but using Soil Type 5

| Note: 360 minute duration rainfall only | Post-development prior to mitigation | | | |
|---|---|---|---|---|
| | Soft Landscaped Area (sq.m) | Permeable Paving Area (sq.m) | Impermeable Areas (sq.m) | Total Areas (sq.m) |
| | 516 | 189 | 405 | 1110 |
| SAAR | 700 | | | |
| M5-60 | 20.0 | 20.0 | 20.0 | |
| R | 0.350 | 0.350 | 0.350 | |
| Cv (Summer) | | 0.750 | 0.750 | |
| Cv (Winter) | | 0.840 | 0.840 | |
| SPR | 37 | | | |
| Total rain 1-year (cu.m/Ha) | 233.881 | | | |
| Total rain 30-year (cu.m/Ha) | 509.594 | | | |
| Total rain 100-year (cu.m/Ha) | 658.491 | | | |
| %age runoff 1-year (SPR +) | -5.000 | | | |
| %age runoff 30-year (SPR +) | -2.600 | | | |
| %age runoff 100-year (SPR +) | -0.620 | | | |
| Climate change addition (%) | 30 | 30 | 30 | |
| Volume of runoff 1-year (cu.m) | **5.0** | 4.7 | 10.2 | 19.9 |
| Volume of runoff 30-year (cu.m) | **11.8** | 10.3 | 22.3 | 44.4 |
| Volume of runoff 100-year (cu.m) | **16.1** | 13.4 | 28.9 | 58.4 |

Notes:
After mitigation, only soft landscaped areas will contribute to site run-off

## ICP SUDS Mean Annual Flood

**Input**

| | | | | | |
|---|---|---|---|---|---|
| Return Period (years) | 100 | SAAR (mm) | 700.000 | Urban | 0.000 |
| Area (Ha) | 0.111 | Soil | 0.500 | Region Number | 7 |

**Results** l/s

| | |
|---|---|
| QBAR Rural | 0.6 |
| QBAR Urban | 0.6 |
| Q 100 years | 2.0 |
| Q 1 year | 0.5 |
| Q 30 years | 1.4 |
| Q 100 years | 2.0 |

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## ICP SUDS Mean Annual Flood

Input

| | | | | | |
|---|---|---|---|---|---|
| Return Period (years) | 100 | SAAR (mm) | 700.000 | Urban | 0.000 |
| Area (Ha) | 0.052 | Soil | 0.400 | Region Number | 7 |

Results l/s

| | |
|---|---|
| QBAR Rural | 0.2 |
| QBAR Urban | 0.2 |
| Q 100 years | 0.6 |
| Q 1 year | 0.2 |
| Q 30 years | 0.4 |
| Q 100 years | 0.6 |

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## Summary of Results for 1 year Return Period (+30%)

**Half Drain Time : 258 minutes**

| Storm Duration (mins) | Maximum Filtration (l/s) | Maximum Outflow (l/s) | Maximum Water Level (m OD) | Maximum Depth (m) | Maximum Volume ($m^3$) | Status |
|---|---|---|---|---|---|---|
| 15 Summer | 0.2 | 0.2 | 9.4907 | 0.0908 | 2.2 | O K |
| 30 Summer | 0.2 | 0.2 | 9.5178 | 0.1178 | 2.8 | O K |
| 60 Summer | 0.2 | 0.2 | 9.5462 | 0.1462 | 3.5 | O K |
| 120 Summer | 0.2 | 0.2 | 9.5722 | 0.1722 | 4.1 | O K |
| 180 Summer | 0.2 | 0.2 | 9.5837 | 0.1837 | 4.4 | O K |
| 240 Summer | 0.2 | 0.2 | 9.5902 | 0.1902 | 4.5 | O K |
| 360 Summer | 0.2 | 0.2 | 9.5962 | 0.1962 | 4.7 | O K |
| 480 Summer | 0.2 | 0.2 | 9.5977 | 0.1977 | 4.7 | O K |
| 600 Summer | 0.2 | 0.2 | 9.5972 | 0.1972 | 4.7 | O K |
| 720 Summer | 0.2 | 0.2 | 9.5952 | 0.1952 | 4.6 | O K |
| 960 Summer | 0.2 | 0.2 | 9.5897 | 0.1897 | 4.5 | O K |
| 1440 Summer | 0.2 | 0.2 | 9.5753 | 0.1752 | 4.2 | O K |
| 15 Winter | 0.2 | 0.2 | 9.5018 | 0.1018 | 2.4 | O K |
| 30 Winter | 0.2 | 0.2 | 9.5328 | 0.1328 | 3.1 | O K |
| 60 Winter | 0.2 | 0.2 | 9.5652 | 0.1652 | 3.9 | O K |
| 120 Winter | 0.2 | 0.2 | 9.5962 | 0.1962 | 4.7 | O K |
| 180 Winter | 0.2 | 0.2 | 9.6112 | 0.2112 | 5.0 | O K |
| 240 Winter | 0.2 | 0.2 | 9.6187 | 0.2187 | 5.2 | O K |
| 360 Winter | 0.2 | 0.2 | 9.6232 | 0.2232 | 5.3 | O K |
| 480 Winter | 0.2 | 0.2 | 9.6237 | 0.2237 | 5.3 | O K |
| 600 Winter | 0.2 | 0.2 | 9.6217 | 0.2217 | 5.3 | O K |
| 720 Winter | 0.2 | 0.2 | 9.6177 | 0.2177 | 5.2 | O K |
| 960 Winter | 0.2 | 0.2 | 9.6067 | 0.2067 | 4.9 | O K |
| 1440 Winter | 0.2 | 0.2 | 9.5823 | 0.1822 | 4.3 | O K |

| Storm Duration (mins) | Rain (mm/hr) | Time-Peak (mins) |
|---|---|---|
| 15 Summer | 37.54 | 18 |
| 30 Summer | 24.94 | 33 |
| 60 Summer | 16.17 | 62 |
| 120 Summer | 10.30 | 120 |
| 180 Summer | 7.88 | 176 |
| 240 Summer | 6.51 | 204 |
| 360 Summer | 4.93 | 270 |
| 480 Summer | 4.04 | 338 |
| 600 Summer | 3.46 | 408 |
| 720 Summer | 3.05 | 476 |
| 960 Summer | 2.51 | 616 |
| 1440 Summer | 1.90 | 882 |
| 15 Winter | 37.54 | 18 |
| 30 Winter | 24.94 | 32 |
| 60 Winter | 16.17 | 62 |
| 120 Winter | 10.30 | 118 |
| 180 Winter | 7.88 | 174 |
| 240 Winter | 6.51 | 228 |
| 360 Winter | 4.93 | 286 |
| 480 Winter | 4.04 | 362 |
| 600 Winter | 3.46 | 440 |
| 720 Winter | 3.05 | 518 |
| 960 Winter | 2.51 | 666 |
| 1440 Winter | 1.90 | 952 |

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## Rainfall Details

| | | | | | |
|---|---|---|---|---|---|
| Region | ENG+WAL | Cv (Summer) | 0.750 | Summer Storms | Yes |
| Return Period (years) | 1 | Cv (Winter) | 0.840 | Winter Storms | Yes |
| M5-60 (mm) | 19.500 | Shortest Storm (mins) | 15 | Climate Change % | +30 |
| Ratio-R | 0.350 | Longest Storm (mins) | 1440 | | |

## Time / Area Diagram

Total Area (ha) = 0.032

| Time from: | (mins) to: | Area (ha) |
|---|---|---|
| 0 | 4 | 0.032 |

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## Cellular Storage Details

| | | | |
|---|---|---|---|
| Infil Coef - Base (m/hr) | 0.036720 | Porosity | 0.95 |
| Infil Coef - Sides (m/hr) | 0.036720 | Invert Level (m) | 9.400 |
| Safety Factor | 2.0 | Ground Level (m) | 10.700 |

| Depth (m) | Area (m²) | Infil. Area (m²) | Depth (m) | Area (m²) | Infil. Area (m²) | Depth (m) | Area (m²) | Infil. Area (m²) | Depth (m) | Area (m²) | Infil. Area (m²) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 25.0 | 25.0 | 0.70 | 25.0 | 61.4 | 1.40 | 0.0 | 66.6 | 2.10 | 0.0 | 66.6 |
| 0.10 | 25.0 | 30.2 | 0.80 | 25.0 | 66.6 | 1.50 | 0.0 | 66.6 | 2.20 | 0.0 | 66.6 |
| 0.20 | 25.0 | 35.4 | 0.90 | 0.0 | 66.6 | 1.60 | 0.0 | 66.6 | 2.30 | 0.0 | 66.6 |
| 0.30 | 25.0 | 40.6 | 1.00 | 0.0 | 66.6 | 1.70 | 0.0 | 66.6 | 2.40 | 0.0 | 66.6 |
| 0.40 | 25.0 | 45.8 | 1.10 | 0.0 | 66.6 | 1.80 | 0.0 | 66.6 | 2.50 | 0.0 | 66.6 |
| 0.50 | 25.0 | 51.0 | 1.20 | 0.0 | 66.6 | 1.90 | 0.0 | 66.6 | | | |
| 0.60 | 25.0 | 56.2 | 1.30 | 0.0 | 66.6 | 2.00 | 0.0 | 66.6 | | | |

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

**Half Drain Time : 474 minutes**

| Storm Duration (mins) | Maximum Filtration (l/s) | Maximum Outflow (l/s) | Maximum Water Level (m OD) | Maximum Depth (m) | Maximum Volume ($m^3$) | Status |
|---|---|---|---|---|---|---|
| 15 Summer | 0.2 | 0.2 | 9.6267 | 0.2267 | 5.4 | O K |
| 30 Summer | 0.2 | 0.2 | 9.6977 | 0.2977 | 7.1 | O K |
| 60 Summer | 0.2 | 0.2 | 9.7697 | 0.3697 | 8.8 | O K |
| 120 Summer | 0.2 | 0.2 | 9.8362 | 0.4362 | 10.4 | O K |
| 180 Summer | 0.3 | 0.3 | 9.8667 | 0.4667 | 11.1 | O K |
| 240 Summer | 0.3 | 0.3 | 9.8807 | 0.4807 | 11.4 | O K |
| 360 Summer | 0.3 | 0.3 | 9.8902 | 0.4902 | 11.6 | O K |
| 480 Summer | 0.3 | 0.3 | 9.8922 | 0.4922 | 11.7 | O K |
| 600 Summer | 0.3 | 0.3 | 9.8912 | 0.4912 | 11.7 | O K |
| 720 Summer | 0.3 | 0.3 | 9.8882 | 0.4882 | 11.6 | O K |
| 960 Summer | 0.3 | 0.3 | 9.8782 | 0.4782 | 11.4 | O K |
| 1440 Summer | 0.2 | 0.2 | 9.8522 | 0.4522 | 10.7 | O K |
| 15 Winter | 0.2 | 0.2 | 9.6542 | 0.2542 | 6.0 | O K |
| 30 Winter | 0.2 | 0.2 | 9.7342 | 0.3342 | 7.9 | O K |
| 60 Winter | 0.2 | 0.2 | 9.8162 | 0.4162 | 9.9 | O K |
| 120 Winter | 0.3 | 0.3 | 9.8932 | 0.4932 | 11.7 | O K |
| 180 Winter | 0.3 | 0.3 | 9.9297 | 0.5297 | 12.6 | O K |
| 240 Winter | 0.3 | 0.3 | 9.9482 | 0.5482 | 13.0 | O K |
| 360 Winter | 0.3 | 0.3 | 9.9638 | 0.5638 | 13.4 | O K |
| 480 Winter | 0.3 | 0.3 | 9.9643 | 0.5643 | 13.4 | O K |
| 600 Winter | 0.3 | 0.3 | 9.9618 | 0.5617 | 13.3 | O K |
| 720 Winter | 0.3 | 0.3 | 9.9577 | 0.5577 | 13.2 | O K |
| 960 Winter | 0.3 | 0.3 | 9.9427 | 0.5427 | 12.9 | O K |
| 1440 Winter | 0.3 | 0.3 | 9.9037 | 0.5037 | 12.0 | O K |

| Storm Duration (mins) | Rain (mm/hr) | Time-Peak (mins) |
|---|---|---|
| 15 Summer | 91.99 | 19 |
| 30 Summer | 61.22 | 33 |
| 60 Summer | 39.03 | 62 |
| 120 Summer | 24.15 | 122 |
| 180 Summer | 18.02 | 182 |
| 240 Summer | 14.57 | 240 |
| 360 Summer | 10.79 | 336 |
| 480 Summer | 8.71 | 392 |
| 600 Summer | 7.37 | 454 |
| 720 Summer | 6.43 | 520 |
| 960 Summer | 5.18 | 656 |
| 1440 Summer | 3.81 | 936 |
| 15 Winter | 91.99 | 19 |
| 30 Winter | 61.22 | 33 |
| 60 Winter | 39.03 | 62 |
| 120 Winter | 24.15 | 120 |
| 180 Winter | 18.02 | 178 |
| 240 Winter | 14.57 | 234 |
| 360 Winter | 10.79 | 344 |
| 480 Winter | 8.71 | 442 |
| 600 Winter | 7.37 | 476 |
| 720 Winter | 6.43 | 550 |
| 960 Winter | 5.18 | 706 |
| 1440 Winter | 3.81 | 1010 |

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## Rainfall Details

| | | | | | |
|---|---|---|---|---|---|
| Region | ENG+WAL | Cv (Summer) | 0.750 | Summer Storms | Yes |
| Return Period (years) | 30 | Cv (Winter) | 0.840 | Winter Storms | Yes |
| M5-60 (mm) | 19.500 | Shortest Storm (mins) | 15 | Climate Change % | +30 |
| Ratio-R | 0.350 | Longest Storm (mins) | 1440 | | |

## Time / Area Diagram

Total Area (ha) = 0.032

| Time (mins) from: | to: | Area (ha) |
|---|---|---|
| 0 | 4 | 0.032 |

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## Cellular Storage Details

| | | | |
|---|---|---|---|
| Infil Coef - Base (m/hr) | 0.036720 | Porosity | 0.95 |
| Infil Coef - Sides (m/hr) | 0.036720 | Invert Level (m) | 9.400 |
| Safety Factor | 2.0 | Ground Level (m) | 10.700 |

| Depth (m) | Area (m²) | Infil. Area (m²) | Depth (m) | Area (m²) | Infil. Area (m²) | Depth (m) | Area (m²) | Infil. Area (m²) | Depth (m) | Area (m²) | Infil. Area (m²) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 25.0 | 25.0 | 0.70 | 25.0 | 61.4 | 1.40 | 0.0 | 66.6 | 2.10 | 0.0 | 66.6 |
| 0.10 | 25.0 | 30.2 | 0.80 | 25.0 | 66.6 | 1.50 | 0.0 | 66.6 | 2.20 | 0.0 | 66.6 |
| 0.20 | 25.0 | 35.4 | 0.90 | 0.0 | 66.6 | 1.60 | 0.0 | 66.6 | 2.30 | 0.0 | 66.6 |
| 0.30 | 25.0 | 40.6 | 1.00 | 0.0 | 66.6 | 1.70 | 0.0 | 66.6 | 2.40 | 0.0 | 66.6 |
| 0.40 | 25.0 | 45.8 | 1.10 | 0.0 | 66.6 | 1.80 | 0.0 | 66.6 | 2.50 | 0.0 | 66.6 |
| 0.50 | 25.0 | 51.0 | 1.20 | 0.0 | 66.6 | 1.90 | 0.0 | 66.6 | | | |
| 0.60 | 25.0 | 56.2 | 1.30 | 0.0 | 66.6 | 2.00 | 0.0 | 66.6 | | | |

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

Half Drain Time : 553 minutes

| Storm Duration (mins) | Maximum Filtration (l/s) | Maximum Outflow (l/s) | Maximum Water Level (m OD) | Maximum Depth (m) | Maximum Volume ($m^3$) | Status |
|---|---|---|---|---|---|---|
| 15 Summer | 0.2 | 0.2 | 9.6942 | 0.2942 | 7.0 | O K |
| 30 Summer | 0.2 | 0.2 | 9.7912 | 0.3912 | 9.3 | O K |
| 60 Summer | 0.3 | 0.3 | 9.8902 | 0.4902 | 11.6 | O K |
| 120 Summer | 0.3 | 0.3 | 9.9823 | 0.5823 | 13.8 | O K |
| 180 Summer | 0.3 | 0.3 | 10.0238 | 0.6238 | 14.8 | O K |
| 240 Summer | 0.3 | 0.3 | 10.0433 | 0.6433 | 15.3 | O K |
| 360 Summer | 0.3 | 0.3 | 10.0573 | 0.6573 | 15.6 | O K |
| 480 Summer | 0.3 | 0.3 | 10.0583 | 0.6583 | 15.6 | O K |
| 600 Summer | 0.3 | 0.3 | 10.0568 | 0.6568 | 15.6 | O K |
| 720 Summer | 0.3 | 0.3 | 10.0523 | 0.6523 | 15.5 | O K |
| 960 Summer | 0.3 | 0.3 | 10.0398 | 0.6398 | 15.2 | O K |
| 1440 Summer | 0.3 | 0.3 | 10.0058 | 0.6058 | 14.4 | O K |
| 15 Winter | 0.2 | 0.2 | 9.7302 | 0.3302 | 7.8 | O K |
| 30 Winter | 0.2 | 0.2 | 9.8392 | 0.4392 | 10.4 | O K |
| 60 Winter | 0.3 | 0.3 | 9.9517 | 0.5517 | 13.1 | O K |
| 120 Winter | 0.3 | 0.3 | 10.0573 | 0.6573 | 15.6 | O K |
| 180 Winter | 0.3 | 0.3 | 10.1068 | 0.7068 | 16.8 | O K |
| 240 Winter | 0.3 | 0.3 | 10.1308 | 0.7308 | 17.4 | O K |
| 360 Winter | 0.3 | 0.3 | 10.1533 | 0.7533 | 17.9 | O K |
| 480 Winter | 0.3 | 0.3 | 10.1553 | 0.7553 | 17.9 | O K |
| 600 Winter | 0.3 | 0.3 | 10.1498 | 0.7498 | 17.8 | O K |
| 720 Winter | 0.3 | 0.3 | 10.1453 | 0.7453 | 17.7 | O K |
| 960 Winter | 0.3 | 0.3 | 10.1278 | 0.7278 | 17.3 | O K |
| 1440 Winter | 0.3 | 0.3 | 10.0798 | 0.6798 | 16.1 | O K |

| Storm Duration (mins) | Rain (mm/hr) | Time-Peak (mins) |
|---|---|---|
| 15 Summer | 119.08 | 19 |
| 30 Summer | 80.02 | 33 |
| 60 Summer | 51.30 | 64 |
| 120 Summer | 31.74 | 122 |
| 180 Summer | 23.59 | 182 |
| 240 Summer | 18.98 | 242 |
| 360 Summer | 13.96 | 358 |
| 480 Summer | 11.22 | 410 |
| 600 Summer | 9.46 | 474 |
| 720 Summer | 8.22 | 536 |
| 960 Summer | 6.59 | 672 |
| 1440 Summer | 4.81 | 950 |
| 15 Winter | 119.08 | 19 |
| 30 Winter | 80.02 | 33 |
| 60 Winter | 51.30 | 62 |
| 120 Winter | 31.74 | 120 |
| 180 Winter | 23.59 | 178 |
| 240 Winter | 18.98 | 236 |
| 360 Winter | 13.96 | 346 |
| 480 Winter | 11.22 | 450 |
| 600 Winter | 9.46 | 490 |
| 720 Winter | 8.22 | 562 |
| 960 Winter | 6.59 | 714 |
| 1440 Winter | 4.81 | 1024 |

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## Rainfall Details

| | | | | | |
|---|---|---|---|---|---|
| Region | ENG+WAL | Cv (Summer) | 0.750 | Summer Storms | Yes |
| Return Period (years) | 100 | Cv (Winter) | 0.840 | Winter Storms | Yes |
| M5-60 (mm) | 19.500 | Shortest Storm (mins) | 15 | Climate Change % | +30 |
| Ratio-R | 0.350 | Longest Storm (mins) | 1440 | | |

## Time / Area Diagram

Total Area (ha) = 0.032

| Time from: | (mins) to: | Area (ha) |
|---|---|---|
| 0 | 4 | 0.032 |

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## Cellular Storage Details

| | | | |
|---|---|---|---|
| Infil Coef - Base (m/hr) | 0.036720 | Porosity | 0.95 |
| Infil Coef - Sides (m/hr) | 0.036720 | Invert Level (m) | 9.400 |
| Safety Factor | 2.0 | Ground Level (m) | 10.700 |

| Depth (m) | Area (m²) | Infil. Area (m²) | Depth (m) | Area (m²) | Infil. Area (m²) | Depth (m) | Area (m²) | Infil. Area (m²) | Depth (m) | Area (m²) | Infil. Area (m²) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 25.0 | 25.0 | 0.70 | 25.0 | 61.4 | 1.40 | 0.0 | 66.6 | 2.10 | 0.0 | 66.6 |
| 0.10 | 25.0 | 30.2 | 0.80 | 25.0 | 66.6 | 1.50 | 0.0 | 66.6 | 2.20 | 0.0 | 66.6 |
| 0.20 | 25.0 | 35.4 | 0.90 | 0.0 | 66.6 | 1.60 | 0.0 | 66.6 | 2.30 | 0.0 | 66.6 |
| 0.30 | 25.0 | 40.6 | 1.00 | 0.0 | 66.6 | 1.70 | 0.0 | 66.6 | 2.40 | 0.0 | 66.6 |
| 0.40 | 25.0 | 45.8 | 1.10 | 0.0 | 66.6 | 1.80 | 0.0 | 66.6 | 2.50 | 0.0 | 66.6 |
| 0.50 | 25.0 | 51.0 | 1.20 | 0.0 | 66.6 | 1.90 | 0.0 | 66.6 | | | |
| 0.60 | 25.0 | 56.2 | 1.30 | 0.0 | 66.6 | 2.00 | 0.0 | 66.6 | | | |

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## Summary of Results for 1 year Return Period (+30%)

**Half Drain Time : 259 minutes**

| Storm Duration (mins) | Maximum Filtration (l/s) | Maximum Outflow (l/s) | Maximum Water Level (m OD) | Maximum Depth (m) | Maximum Volume ($m^3$) | Status |
|---|---|---|---|---|---|---|
| 15 Summer | 0.0 | 0.0 | 0.0943 | 0.0943 | 0.4 | O K |
| 30 Summer | 0.0 | 0.0 | 0.1228 | 0.1228 | 0.5 | O K |
| 60 Summer | 0.0 | 0.0 | 0.1522 | 0.1522 | 0.7 | O K |
| 120 Summer | 0.0 | 0.0 | 0.1792 | 0.1792 | 0.8 | O K |
| 180 Summer | 0.0 | 0.0 | 0.1907 | 0.1907 | 0.8 | O K |
| 240 Summer | 0.0 | 0.0 | 0.1977 | 0.1977 | 0.8 | O K |
| 360 Summer | 0.0 | 0.0 | 0.2032 | 0.2032 | 0.9 | O K |
| 480 Summer | 0.0 | 0.0 | 0.2047 | 0.2047 | 0.9 | O K |
| 600 Summer | 0.0 | 0.0 | 0.2042 | 0.2042 | 0.9 | O K |
| 720 Summer | 0.0 | 0.0 | 0.2022 | 0.2022 | 0.9 | O K |
| 960 Summer | 0.0 | 0.0 | 0.1962 | 0.1962 | 0.8 | O K |
| 1440 Summer | 0.0 | 0.0 | 0.1817 | 0.1817 | 0.8 | O K |
| 15 Winter | 0.0 | 0.0 | 0.1063 | 0.1063 | 0.5 | O K |
| 30 Winter | 0.0 | 0.0 | 0.1383 | 0.1383 | 0.6 | O K |
| 60 Winter | 0.0 | 0.0 | 0.1722 | 0.1722 | 0.7 | O K |
| 120 Winter | 0.0 | 0.0 | 0.2042 | 0.2042 | 0.9 | O K |
| 180 Winter | 0.0 | 0.0 | 0.2192 | 0.2192 | 0.9 | O K |
| 240 Winter | 0.0 | 0.0 | 0.2267 | 0.2267 | 1.0 | O K |
| 360 Winter | 0.0 | 0.0 | 0.2312 | 0.2312 | 1.0 | O K |
| 480 Winter | 0.0 | 0.0 | 0.2317 | 0.2317 | 1.0 | O K |
| 600 Winter | 0.0 | 0.0 | 0.2292 | 0.2292 | 1.0 | O K |
| 720 Winter | 0.0 | 0.0 | 0.2252 | 0.2252 | 1.0 | O K |
| 960 Winter | 0.0 | 0.0 | 0.2142 | 0.2142 | 0.9 | O K |
| 1440 Winter | 0.0 | 0.0 | 0.1887 | 0.1887 | 0.8 | O K |

| Storm Duration (mins) | Rain (mm/hr) | Time-Peak (mins) |
|---|---|---|
| 15 Summer | 37.54 | 18 |
| 30 Summer | 24.94 | 33 |
| 60 Summer | 16.17 | 62 |
| 120 Summer | 10.30 | 120 |
| 180 Summer | 7.88 | 174 |
| 240 Summer | 6.51 | 202 |
| 360 Summer | 4.93 | 268 |
| 480 Summer | 4.04 | 336 |
| 600 Summer | 3.46 | 406 |
| 720 Summer | 3.05 | 476 |
| 960 Summer | 2.51 | 614 |
| 1440 Summer | 1.90 | 882 |
| 15 Winter | 37.54 | 18 |
| 30 Winter | 24.94 | 32 |
| 60 Winter | 16.17 | 62 |
| 120 Winter | 10.30 | 118 |
| 180 Winter | 7.88 | 174 |
| 240 Winter | 6.51 | 226 |
| 360 Winter | 4.93 | 284 |
| 480 Winter | 4.04 | 362 |
| 600 Winter | 3.46 | 440 |
| 720 Winter | 3.05 | 514 |
| 960 Winter | 2.51 | 664 |
| 1440 Winter | 1.90 | 952 |

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## Rainfall Details

| | | | | | |
|---|---|---|---|---|---|
| Region | ENG+WAL | Cv (Summer) | 0.750 | Summer Storms | Yes |
| Return Period (years) | 1 | Cv (Winter) | 0.840 | Winter Storms | Yes |
| M5-60 (mm) | 19.500 | Shortest Storm (mins) | 15 | Climate Change % | +30 |
| Ratio-R | 0.350 | Longest Storm (mins) | 1440 | | |

## Time / Area Diagram

Total Area (ha) = 0.006

| Time from: | (mins) to: | Area (ha) |
|---|---|---|
| 0 | 4 | 0.006 |

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## Cellular Storage Details

| | | | |
|---|---|---|---|
| Infil Coef - Base (m/hr) | 0.036720 | Porosity | 0.95 |
| Infil Coef - Sides (m/hr) | 0.036720 | Invert Level (m) | 0.000 |
| Safety Factor | 2.0 | Ground Level (m) | 1.100 |

| Depth (m) | Area (m²) | Infil. Area (m²) | Depth (m) | Area (m²) | Infil. Area (m²) | Depth (m) | Area (m²) | Infil. Area (m²) | Depth (m) | Area (m²) | Infil. Area (m²) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 4.5 | 4.5 | 0.70 | 4.5 | 12.2 | 1.40 | 0.0 | 13.3 | 2.10 | 0.0 | 13.3 |
| 0.10 | 4.5 | 5.6 | 0.80 | 4.5 | 13.3 | 1.50 | 0.0 | 13.3 | 2.20 | 0.0 | 13.3 |
| 0.20 | 4.5 | 6.7 | 0.90 | 0.0 | 13.3 | 1.60 | 0.0 | 13.3 | 2.30 | 0.0 | 13.3 |
| 0.30 | 4.5 | 7.8 | 1.00 | 0.0 | 13.3 | 1.70 | 0.0 | 13.3 | 2.40 | 0.0 | 13.3 |
| 0.40 | 4.5 | 8.9 | 1.10 | 0.0 | 13.3 | 1.80 | 0.0 | 13.3 | 2.50 | 0.0 | 13.3 |
| 0.50 | 4.5 | 10.0 | 1.20 | 0.0 | 13.3 | 1.90 | 0.0 | 13.3 | | | |
| 0.60 | 4.5 | 11.1 | 1.30 | 0.0 | 13.3 | 2.00 | 0.0 | 13.3 | | | |

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

**Half Drain Time : 443 minutes**

| Storm Duration (mins) | Maximum Filtration (l/s) | Maximum Outflow (l/s) | Maximum Water Level (m OD) | Maximum Depth (m) | Maximum Volume ($m^3$) | Status |
|---|---|---|---|---|---|---|
| 15 Summer | 0.0 | 0.0 | 0.2357 | 0.2357 | 1.0 | O K |
| 30 Summer | 0.0 | 0.0 | 0.3097 | 0.3097 | 1.3 | O K |
| 60 Summer | 0.0 | 0.0 | 0.3842 | 0.3842 | 1.6 | O K |
| 120 Summer | 0.0 | 0.0 | 0.4522 | 0.4522 | 1.9 | O K |
| 180 Summer | 0.1 | 0.1 | 0.4827 | 0.4827 | 2.1 | O K |
| 240 Summer | 0.1 | 0.1 | 0.4962 | 0.4962 | 2.1 | O K |
| 360 Summer | 0.1 | 0.1 | 0.5047 | 0.5047 | 2.2 | O K |
| 480 Summer | 0.1 | 0.1 | 0.5067 | 0.5067 | 2.2 | O K |
| 600 Summer | 0.1 | 0.1 | 0.5057 | 0.5057 | 2.2 | O K |
| 720 Summer | 0.1 | 0.1 | 0.5022 | 0.5022 | 2.1 | O K |
| 960 Summer | 0.1 | 0.1 | 0.4912 | 0.4912 | 2.1 | O K |
| 1440 Summer | 0.0 | 0.0 | 0.4637 | 0.4637 | 2.0 | O K |
| 15 Winter | 0.0 | 0.0 | 0.2647 | 0.2647 | 1.1 | O K |
| 30 Winter | 0.0 | 0.0 | 0.3477 | 0.3477 | 1.5 | O K |
| 60 Winter | 0.0 | 0.0 | 0.4327 | 0.4327 | 1.9 | O K |
| 120 Winter | 0.1 | 0.1 | 0.5117 | 0.5117 | 2.2 | O K |
| 180 Winter | 0.1 | 0.1 | 0.5482 | 0.5482 | 2.3 | O K |
| 240 Winter | 0.1 | 0.1 | 0.5657 | 0.5657 | 2.4 | O K |
| 360 Winter | 0.1 | 0.1 | 0.5793 | 0.5793 | 2.5 | O K |
| 480 Winter | 0.1 | 0.1 | 0.5788 | 0.5788 | 2.5 | O K |
| 600 Winter | 0.1 | 0.1 | 0.5768 | 0.5768 | 2.5 | O K |
| 720 Winter | 0.1 | 0.1 | 0.5718 | 0.5718 | 2.4 | O K |
| 960 Winter | 0.1 | 0.1 | 0.5552 | 0.5552 | 2.4 | O K |
| 1440 Winter | 0.1 | 0.1 | 0.5127 | 0.5127 | 2.2 | O K |

| Storm Duration (mins) | Rain (mm/hr) | Time-Peak (mins) |
|---|---|---|
| 15 Summer | 91.99 | 19 |
| 30 Summer | 61.22 | 33 |
| 60 Summer | 39.03 | 62 |
| 120 Summer | 24.15 | 122 |
| 180 Summer | 18.02 | 182 |
| 240 Summer | 14.57 | 240 |
| 360 Summer | 10.79 | 318 |
| 480 Summer | 8.71 | 380 |
| 600 Summer | 7.37 | 444 |
| 720 Summer | 6.43 | 512 |
| 960 Summer | 5.18 | 648 |
| 1440 Summer | 3.81 | 924 |
| 15 Winter | 91.99 | 19 |
| 30 Winter | 61.22 | 33 |
| 60 Winter | 39.03 | 62 |
| 120 Winter | 24.15 | 120 |
| 180 Winter | 18.02 | 178 |
| 240 Winter | 14.57 | 234 |
| 360 Winter | 10.79 | 342 |
| 480 Winter | 8.71 | 396 |
| 600 Winter | 7.37 | 466 |
| 720 Winter | 6.43 | 544 |
| 960 Winter | 5.18 | 700 |
| 1440 Winter | 3.81 | 998 |

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## Rainfall Details

| | | | | | |
|---|---|---|---|---|---|
| Region | ENG+WAL | Cv (Summer) | 0.750 | Summer Storms | Yes |
| Return Period (years) | 30 | Cv (Winter) | 0.840 | Winter Storms | Yes |
| M5-60 (mm) | 19.500 | Shortest Storm (mins) | 15 | Climate Change % | +30 |
| Ratio-R | 0.350 | Longest Storm (mins) | 1440 | | |

## Time / Area Diagram

Total Area (ha) = 0.006

| Time (mins) from: | to: | Area (ha) |
|---|---|---|
| 0 | 4 | 0.006 |

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## Cellular Storage Details

| | | | |
|---|---|---|---|
| Infil Coef - Base (m/hr) | 0.036720 | Porosity | 0.95 |
| Infil Coef - Sides (m/hr) | 0.036720 | Invert Level (m) | 0.000 |
| Safety Factor | 2.0 | Ground Level (m) | 1.100 |

| Depth (m) | Area (m²) | Infil. Area (m²) | Depth (m) | Area (m²) | Infil. Area (m²) | Depth (m) | Area (m²) | Infil. Area (m²) | Depth (m) | Area (m²) | Infil. Area (m²) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 4.5 | 4.5 | 0.70 | 4.5 | 12.2 | 1.40 | 0.0 | 13.3 | 2.10 | 0.0 | 13.3 |
| 0.10 | 4.5 | 5.6 | 0.80 | 4.5 | 13.3 | 1.50 | 0.0 | 13.3 | 2.20 | 0.0 | 13.3 |
| 0.20 | 4.5 | 6.7 | 0.90 | 0.0 | 13.3 | 1.60 | 0.0 | 13.3 | 2.30 | 0.0 | 13.3 |
| 0.30 | 4.5 | 7.8 | 1.00 | 0.0 | 13.3 | 1.70 | 0.0 | 13.3 | 2.40 | 0.0 | 13.3 |
| 0.40 | 4.5 | 8.9 | 1.10 | 0.0 | 13.3 | 1.80 | 0.0 | 13.3 | 2.50 | 0.0 | 13.3 |
| 0.50 | 4.5 | 10.0 | 1.20 | 0.0 | 13.3 | 1.90 | 0.0 | 13.3 | | | |
| 0.60 | 4.5 | 11.1 | 1.30 | 0.0 | 13.3 | 2.00 | 0.0 | 13.3 | | | |

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

Half Drain Time : 507 minutes

| Storm Duration (mins) | Maximum Filtration (l/s) | Maximum Outflow (l/s) | Maximum Water Level (m OD) | Maximum Depth (m) | Maximum Volume ($m^3$) | Status |
|---|---|---|---|---|---|---|
| 15 Summer | 0.0 | 0.0 | 0.3062 | 0.3062 | 1.3 | O K |
| 30 Summer | 0.0 | 0.0 | 0.4067 | 0.4067 | 1.7 | O K |
| 60 Summer | 0.1 | 0.1 | 0.5097 | 0.5097 | 2.2 | O K |
| 120 Summer | 0.1 | 0.1 | 0.6038 | 0.6038 | 2.6 | O K |
| 180 Summer | 0.1 | 0.1 | 0.6448 | 0.6448 | 2.8 | O K |
| 240 Summer | 0.1 | 0.1 | 0.6628 | 0.6628 | 2.8 | O K |
| 360 Summer | 0.1 | 0.1 | 0.6748 | 0.6748 | 2.9 | O K |
| 480 Summer | 0.1 | 0.1 | 0.6763 | 0.6763 | 2.9 | O K |
| 600 Summer | 0.1 | 0.1 | 0.6743 | 0.6743 | 2.9 | O K |
| 720 Summer | 0.1 | 0.1 | 0.6698 | 0.6698 | 2.9 | O K |
| 960 Summer | 0.1 | 0.1 | 0.6558 | 0.6558 | 2.8 | O K |
| 1440 Summer | 0.1 | 0.1 | 0.6193 | 0.6193 | 2.6 | O K |
| 15 Winter | 0.0 | 0.0 | 0.3437 | 0.3437 | 1.5 | O K |
| 30 Winter | 0.0 | 0.0 | 0.4572 | 0.4572 | 2.0 | O K |
| 60 Winter | 0.1 | 0.1 | 0.5732 | 0.5732 | 2.5 | O K |
| 120 Winter | 0.1 | 0.1 | 0.6813 | 0.6813 | 2.9 | O K |
| 180 Winter | 0.1 | 0.1 | 0.7303 | 0.7303 | 3.1 | O K |
| 240 Winter | 0.1 | 0.1 | 0.7538 | 0.7538 | 3.2 | O K |
| 360 Winter | 0.1 | 0.1 | 0.7733 | 0.7733 | 3.3 | O K |
| 480 Winter | 0.1 | 0.1 | 0.7723 | 0.7723 | 3.3 | O K |
| 600 Winter | 0.1 | 0.1 | 0.7683 | 0.7683 | 3.3 | O K |
| 720 Winter | 0.1 | 0.1 | 0.7623 | 0.7623 | 3.3 | O K |
| 960 Winter | 0.1 | 0.1 | 0.7423 | 0.7423 | 3.2 | O K |
| 1440 Winter | 0.1 | 0.1 | 0.6898 | 0.6898 | 2.9 | O K |

| Storm Duration (mins) | Rain (mm/hr) | Time-Peak (mins) |
|---|---|---|
| 15 Summer | 119.08 | 19 |
| 30 Summer | 80.02 | 33 |
| 60 Summer | 51.30 | 64 |
| 120 Summer | 31.74 | 122 |
| 180 Summer | 23.59 | 182 |
| 240 Summer | 18.98 | 240 |
| 360 Summer | 13.96 | 342 |
| 480 Summer | 11.22 | 396 |
| 600 Summer | 9.46 | 458 |
| 720 Summer | 8.22 | 522 |
| 960 Summer | 6.59 | 658 |
| 1440 Summer | 4.81 | 938 |
| 15 Winter | 119.08 | 19 |
| 30 Winter | 80.02 | 33 |
| 60 Winter | 51.30 | 62 |
| 120 Winter | 31.74 | 120 |
| 180 Winter | 23.59 | 178 |
| 240 Winter | 18.98 | 234 |
| 360 Winter | 13.96 | 344 |
| 480 Winter | 11.22 | 444 |
| 600 Winter | 9.46 | 476 |
| 720 Winter | 8.22 | 552 |
| 960 Winter | 6.59 | 706 |
| 1440 Winter | 4.81 | 1010 |

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## Rainfall Details

| | | | | | |
|---|---|---|---|---|---|
| Region | ENG+WAL | Cv (Summer) | 0.750 | Summer Storms | Yes |
| Return Period (years) | 100 | Cv (Winter) | 0.840 | Winter Storms | Yes |
| M5-60 (mm) | 19.500 | Shortest Storm (mins) | 15 | Climate Change % | +30 |
| Ratio-R | 0.350 | Longest Storm (mins) | 1440 | | |

## Time / Area Diagram

Total Area (ha) = 0.006

| Time from: | (mins) to: | Area (ha) |
|---|---|---|
| 0 | 4 | 0.006 |

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## Cellular Storage Details

| | | | |
|---|---|---|---|
| Infil Coef - Base (m/hr) | 0.036720 | Porosity | 0.95 |
| Infil Coef - Sides (m/hr) | 0.036720 | Invert Level (m) | 0.000 |
| Safety Factor | 2.0 | Ground Level (m) | 1.100 |

| Depth (m) | Area (m²) | Infil. Area (m²) | Depth (m) | Area (m²) | Infil. Area (m²) | Depth (m) | Area (m²) | Infil. Area (m²) | Depth (m) | Area (m²) | Infil. Area (m²) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 4.5 | 4.5 | 0.70 | 4.5 | 12.2 | 1.40 | 0.0 | 13.3 | 2.10 | 0.0 | 13.3 |
| 0.10 | 4.5 | 5.6 | 0.80 | 4.5 | 13.3 | 1.50 | 0.0 | 13.3 | 2.20 | 0.0 | 13.3 |
| 0.20 | 4.5 | 6.7 | 0.90 | 0.0 | 13.3 | 1.60 | 0.0 | 13.3 | 2.30 | 0.0 | 13.3 |
| 0.30 | 4.5 | 7.8 | 1.00 | 0.0 | 13.3 | 1.70 | 0.0 | 13.3 | 2.40 | 0.0 | 13.3 |
| 0.40 | 4.5 | 8.9 | 1.10 | 0.0 | 13.3 | 1.80 | 0.0 | 13.3 | 2.50 | 0.0 | 13.3 |
| 0.50 | 4.5 | 10.0 | 1.20 | 0.0 | 13.3 | 1.90 | 0.0 | 13.3 | | | |
| 0.60 | 4.5 | 11.1 | 1.30 | 0.0 | 13.3 | 2.00 | 0.0 | 13.3 | | | |

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# Appendix 3

## STROMA Summary Report Template

## SUR 1 - Summary Report Template

### Introduction:

This template can be used to demonstrate compliance with the criteria specified in Sur 1 in the Code for Sustainable Homes. The form can be used by the Code Assessor to aid in assessing the Sur 1 issue and can be provided as supporting evidence in addition to the items listed in the schedule of evidence for Sur 1. Completing this template is optional (where this template is not used, a summary in the format of this template must be provided).

National policy documents have been used to set the standards for the mandatory element of Sur 1. PPS25 Development and Flood Risk (ODPM, 2006) and the SuDS manual are two of the key documents used. Further reading is listed in the References section of the Technical Guide.

### Instructions:

Where submitting this template as supporting evidence for a Code assessment please ensure that the assessor completes the contact details (Section A) and the appropriately qualified professional completes the rest of the template, ensuring that it is signed and dated. If the form is incomplete and / or unsigned it will not be accepted as evidence supporting a Code assessment.

The Technical Guide states the calculation methodologies to be used to demonstrate compliance with some aspects of the criteria, for example the greenfield runoff rates. Although flexibility in choice of methodology is available for some of the criteria, best practice methodologies should always be used. If required, information regarding applicable calculation methodologies can be found in the SUDS Manual (CIRIA, 2007). Reputable software, such as Microdrainage, can be used for calculation purposes.

## Code for Sustainable Homes - Technical Guidance Issue

This template is for use with the following technical guidance issue(s):

- November 2010

| Section A - To be completed by the Code assessor | |
|---|---|
| **Contact Details:** | |
| **Consultant / Engineer details** | |
| Company Name: | Robert Clark Associates Ltd |
| Company Address: | Willow Cottage, Herne Lane, Rustington, West Sussex BN16 3EE |
| Contact Name: | Robert Clark |
| Contact Telephone Number: | 01903 778945 |
| **Developer / Client details** | |
| Company Name: | Blythe Properties |
| Company Address: | |
| Contact Name: | Daniel Hoskin |
| Contact Telephone Number: | 0777 8811 772 |
| **Developer details** | |
| Company Name: | Blythe Properties |
| Company Address: | |
| Contact Name: | Daniel Hoskin |
| Contact Telephone Number: | 0777 8811 772 |

| Section B - To be completed by the Appropriately Qualified Professional | | |
|---|---|---|
| **Mandatory Requirements** | | |
| **Part 1: Appropriately Qualified Professional** | | |
| 1. | Please tick one of the appropriate boxes to confirm where details have been provided to corroborate your suitability to undertake the calculations and design criteria for the SUR 1 assessment.[1] | |
| | A. Details have been provided within the SUR 1 report and issued to the Code assessor. | ☐ |
| | **Or:** | |
| | B. Details have been provided within a CV and issued to the Code assessor. | ☐ |
| | **Or:** | |
| | C. Details have been provided within a letter/email and issued to the Code assessor. | ☐ |
| | **Or:** | |
| | D. Details are provided below. | ☒ |
| | Please state your experience / qualifications to undertake the calculations and design criteria:<br><br>BSc CEng MICE with 39 years of experience in the civil engineering industry | |

| **Part 2: Assessment Information** | | |
|---|---|---|
| 2. | For sites containing a mixture of non-Code and Code assessed dwellings there are several assessment options for Sur 1. The first would be to assess the whole site (including the non-Code dwellings) under the Code criteria. The second would be to demonstrate with several separate reports that each group of Code dwellings (and the associated sub catchments serving those dwellings) on the site have met the criteria individually. Please tick one of the following boxes; | |
| | A. The site contains a mixture of Code and non-Code dwellings and the whole site has been assessed under the Sur 1 criteria including any associated sub catchments serving these dwellings. | ☒ |
| | **Or:** | |
| | B. The site contains a mixture of Code and non-Code dwellings and there is more than one assessed area for Sur 1 within the site boundary.<br>Please write the number of assessed areas within the site in the space provided below (you will need to complete this template for each assessed area)[2]. | ☐ |
| | Number of assessed areas: | |
| | **Or:** | |
| | C. The site only contains Code assessed dwellings and the associated sub catchment serving those dwellings. | ☐ |

| **Part 3: Site Information** | | | |
|---|---|---|---|
| 3. | A. Please provide the site area[3] (delete units of measurement as applicable) | 1110 | $m^2$ |
| | B. Please provide the impermeable area of the site pre-development (delete units of measurement as applicable) | 152 | $m^2$ |
| | C. Please provide the impermeable area of the site post development (delete units of measurement | 594 | $m^2$ |

[1] Refer to the technical guide for details on the definition of an appropriately qualified professional.

[2] It would aid the QA process to provide a site plan highlighting each assessment area and highlighting which area is being assessed in this report.

[3] The site area will include all areas within the boundaries of the site, including both permeable and impermeable areas. If box B, Part 2 has been ticked, the 'site area' will be only that for which this template demonstrates compliance.

| | | | |
|---|---|---|---|
| | as applicable) | | |

| Part 4: Special Cases[4] | | |
|---|---|---|
| 4. | Please tick the relevant box below to identify where a special case applies for the site: | |
| | A. The impermeable area has decreased as a result of the development, and the mandatory element of this issue has been met by default. | ☐ |
| | B. A minimum flow rate or maximum storage requirement has been set by the sewerage undertaker (or other statutory body). | ☐ |
| | C. Planning approval has been granted for the detailed drainage strategy prior to the Code requirement being set for the development | ☐ |
| | D. The assessed dwelling is directly connected to existing infra-structure which pre-dates the Code requirement. | ☐ |
| | E. Not applicable. | ☒ |
| 5. | Tick one or both of the following to confirm if some or all of the highways will be omitted from the impermeable areas in the calculations for one of the following reasons[5]: | |
| | A. The highways are being adopted | ☐ |
| | B. The Code dwellings are being built beside existing highways. | ☐ |
| | C. Not applicable. | ☒ |

| Part 5: Peak Rate of Runoff | | | |
|---|---|---|---|
| 6. | A. Pre-development peak rate of runoff for the **1 year return period event** [6] | 0.50 | l/s |
| | B. Post-development peak rate of runoff for the **1 year return period event** [6] (this figure must be less than or equal to A, except where the 5l/s rule has been used) | 0.26 | l/s |
| | C. Pre-development peak rate of runoff for the **100 year return period event** [6] | 2.00 | l/s |
| | D. Post-development peak rate of runoff for the **100 year return period event** [6] (this figure must be less than or equal to C, except where the 5l/s rule has been used) | 0.78 | l/s |
| 7. | Please tick this box to confirm that the 5l/s rule has been applied where the peak rates of runoff have increased post development, but are still equal to or less than 5l/s. | | ☐ |
| 8. | If, post-development, it was necessary to reduce the peak rate of runoff to meet the Code criteria, please provide a brief explanation below describing how the peak rate was reduced. For example, 'soakaways reduce the peak rate of runoff to pre-development levels'.[7]<br><br>Geocellular and concrete ring soakaways, together with permeable paved areas have been used to reduce the peak rate of run-off to less than pre-development levels | | ☒ |
| 9. | Please tick this box to confirm that the post development peak rate of runoff calculations include an allowance for climate change in accordance with current best practice (PPS25, 2006). | | ☒ |

[4] Refer to the Technical Guide for details on the supporting evidence required to demonstrate compliance with these special cases. This evidence must be provided to demonstrate how the special case is being met.

[5] Refer to the technical guide for details on when an adoptable road can be omitted from the assessment.

[6] Peak rate of runoff calculations should be carried out for the range of storm durations up to and including the 6 hour storm. The peak rate of runoff for the storm event will then be the 'worst case' runoff rate for the range of storm durations. The climate change allowance should be added only to the post development calculations.

[7] Note that detailed documentary evidence (as per the schedule of evidence table in the Technical guide) is required to demonstrate how the peak rate of runoff has been reduced.

| | | |
|---|---|---|
| 10. | Please tick one of the following boxes as applicable to this site: | |
| | A. This is a greenfield site and is less than 50 ha therefore runoff rate calculations have been carried out in accordance with the IH Report 124 'Flood estimation for small catchments' (Marshall and Bayliss, 1994). The pro rata method on the size of catchment detailed in table 4.2 of the SuDS manual has been used. | ☒ |
| | B. This is a greenfield site of 50 to 200 ha therefore runoff rate calculations have been carried out in accordance with the IH Report 124 'Flood estimation for small catchments' (Marshall and Bayliss, 1994). | ☐ |
| | C. This is a greenfield site of more than 200 ha (or where there is a preference to do so and the catchment is considered suitable for its application) therefore runoff rate calculations have been carried out in accordance with the 'Flood estimation handbook' (Centre for Ecology and Hydrology, 1999). | ☐ |
| | D. This is a greenfield site of more than 200ha where the Flood Estimation handbook is considered inappropriate for the development therefore the IH Report 124 has been used. | ☐ |
| | E. This is a brownfield site and runoff rates have been calculated in accordance with current best practice simulation modelling. | ☐ |
| | F. This is a Brownfield site where the pre development surface water drainage system is not known therefore the runoff rates have been calculated using the Greenfield run-off model ticked above (please tick the relevant methodology), but using soil type 5. | ☒ |

| **Part 6A: Volume of Runoff** | | | |
|---|---|---|---|
| 11. | Please tick this box to confirm that the following post development volume of runoff calculations include an allowance for climate change in accordance with current best practice (PPS25, 2006). | | ☒ |
| | Please tick this box to confirm that the following volume of runoff calculations are for the 100 year event of 6 hour duration. | | ☒ |
| 12. | A. Pre-development volume of runoff | 38.3 | $m^3$ |
| | B. Volume of runoff caused by the new development **prior to mitigation** | 58.4 | $m^3$ |
| | C. **Additional** predicted volume of rainwater caused by the new development prior to mitigation (= 12B - 12A) | 16.1 | $m^3$ |
| | D. If the answer to 12C is greater than zero, please provide a brief explanation below describing how you have reduced the additional volume discharged from the developed site, for example, 'soakaways will infiltrate all of the additional volume':<br>Geocellular and concrete ring soakaways, together with permeable paved areas have been used to reduce the peak rate of run-off to less than pre-development levels<br>(criterion Part 6A cannot be satisfied, see section 13) | | N/A ☐ |
| | Please provide the additional volume of runoff discharged from the site when all (if any) mitigation measures described in 12D are in place. | -22.2<br>Ie a reduction | $m^3$ |
| 13. | A. Where there is an increase in the volume of runoff as a result of the development and criteria "Part 6A" cannot be satisfied via infiltration or other SuDS techniques (as listed below), please provide an explanation below (evidence to support the reasoning should be provided in the hydrological report): | | |
| | **Soakaways:** | | |
| | **Porous/Pervious paving:** | | |
| | **Rainwater re-use harvesting:** | | |

| | |
|---|---|
| | **Green Roof:** |
| | **Other surface infiltration techniques:** |

| **Part 6B: Volume of Runoff** | | | |
|---|---|---|---|
| 14. | Where it has not been possible to reduce all of the additional volume by infiltration or other SuDS techniques, the volume of runoff should be discharged in accordance with one of the following rates of runoff, whichever is the higher. Please tick one of the boxes below to confirm the level of flow control that has been achieved: | | |
| | A. The peak discharge rate has been reduced to pre development 1 year peak flow rate | | ☐ |
| | Please state the pre development 1-year peak flow rate: | | l/s |
| | **Or:** | | |
| | B. The peak discharge rate has been reduced to the site's estimated mean annual flood flow rate (Qbar). | | ☐ |
| | Please state Qbar: | | l/s |
| | **Or:** | | |
| | C. The peak discharge rate has been reduced to 2l/s/ha. | | ☐ |
| | Please state the peak discharge rate at 2l/s/ha: | | |
| | **Or:** | | |
| | D. The limiting discharge rate requires a flow rate of less than 5l/s at a discharge point, therefore a flow rate of up to 5l/s has been used | | ☐ |

| **Part 7: Designing for Local Drainage System failure** | | |
|---|---|---|
| 15. | Tick here to confirm that the consequences of system failure caused by extreme rainfall, lack of maintenance, blockage or other causes, have been considered and evaluated fully and there will be no increased risk to dwellings either on or off site.[8] | ☒ |

| **Section C - To be completed by the Appropriately Qualified Professional** | | |
|---|---|---|
| **Awarding of Credits** | | |
| **Part 8: Water Quality Criteria** | | |
| 16. | A. Tick here to confirm that there will be no discharge from the developed site for rainfall depths up to 5 mm. Please provide a brief explanation below describing how the runoff from rainfall depths up to 5 mm will be prevented from leaving the site:<br><br>Geocellular and concrete ring soakaways, together with permeable paved areas have been used to absorb all run-off from impermeable areas | ☒ |
| | B. Tick here to confirm that the runoff from all hard surfaces shall receive an appropriate level of treatment in accordance with the SuDS Manual to minimise the risk of pollution to the receiving watercourse. Please provide a brief explanation below describing how the hard surfaces will receive an appropriate level of treatment: | ☒ |

[8] Refer to the technical guide for details on the evidence that would be required to demonstrate that this has been considered fully.

| | | |
|---|---|---|
| | The permeable paving will provide a level of treatment for run-off from parking/ access areas. Geocellular soakaways will drain all roof areas via silt traps. A trapped gulley will accept run-off from the communal bin/ bike store and discharge to a concrete ring soakaway.. | |

| Section D - To be completed by the Appropriately Qualified Professional | | |
|---|---|---|
| **Part 9: Confirmation** | | |
| 17. | The following declaration should be signed by the appropriately qualified professional responsible for ensuring that the development meets the SUR 1 mandatory criteria and the necessary criteria to allow the awarding of credits, where applicable. | |
| | I confirm that the information provided in this document is truthful and accurate at the time of completion. | |
| | **Name of Appropriately Qualified Professional:** | Mr RTF Clark |
| | **Signature of Appropriately Qualified Professional:** | [redacted] |
| | **Date:** | 30 March 2012 |