simpson
CONSULTING ENGINEERS

8 Friday Street
Henley-on-Thames
Oxfordshire
RG9 1AH
Tel: +44 (0)1491 576 221
Email: mail@simpsoneng.com
www.simpsoneng.com

# SURFACE WATER DRAINAGE STATEMENT

*FOR PROPOSED RESIDENTIAL DEVELOPMENT*

*BRAMPTON ABBOTTS*

*ROSS-ON-WYE*

PREPARED FOR: Mr A. West

JOB NO: 14452

DATE: 27.09.19

## DOCUMENT HISTORY

| Revision | Description | Date |
|---|---|---|
| - | First issue. | 08.02.17 |
| A | Updated to accommodate revised site layout | 30.03.17 |
| B | Updated following Herefordshire County Council Comments. Alternative surface water discharge method proposed. | 25.04.17 |
| C | Surface water drainage strategy updated following meetings with Herefordshire County Council Drainage Engineer | 29.08.17 |
| D | Site Layout amended for updated planning submission | 24.06.19 |
| E | Site Layout amended for updated planning submission | 27.09.19 |

## CONTENTS


1. INTRODUCTION..... 3

2. SURFACE WATER MANAGEMENT & DRAINAGE STRATEGY ..... 3

3. CONCLUSIONS..... 7


## APPENDICES


APPENDIX A: SOAKAWAY TEST RESULTS

APPENDIX B: TOPOGRAPHICAL SURVEY

APPENDIX C: IH 124 GREENFIELD RUNOFF RESULTS

APPENDIX D: RAINWATER HARVESTING RESULTS

APPENDIX E: PROPOSED DRAINAGE LAYOUT

APPENDIX F: MICRODRAINAGE DESIGN RESULTS

## 1. INTRODUCTION

1.1 This report has been prepared by Simpson Associates on behalf of Mr A West to outline a surface water drainage strategy for a proposed residential development in Brampton Abbotts, Ross-on-Wye.

## 2. SURFACE WATER MANAGEMENT & DRAINAGE STRATEGY

Surface Water Disposal

2.1 The NPPF Planning Practice Guidance advises that Sustainable Urban Drainage Systems (SUDS) should be used to control surface water runoff close to where it falls as well as to mimic natural drainage as closely as possible with surface runoff discharged as high up the following hierarchy of drainage options as reasonably practicable.

- into the ground (infiltration);
- to a surface water body;
- to a surface water sewer, highway drain, or another drainage system;
- to a combined sewer.

2.2 The methods of disposal are summarised in *Table 1* below with an assessment of each methods suitability also provided.

*Table 1: Surface Water Runoff Destination Assessment*

| Surface Water Runoff Destination | Assessment |
|---|---|
| Into the ground (infiltration) | Infiltration drainage techniques were deemed to be inappropriate by a ground investigation due to the cohesive nature of the underlying soils with soakaway tests failing to establish a suitable infiltration rate. Soakaway test results are included in *Appendix* A. |
| To a surface water body | There nearest watercourse is located approximately 400m away from the site to the south east and therefore direct connection to a surface water body is deemed to be inappropriate. |
| To a surface water sewer, highway drain, or another drainage system | A 225mm Ø surface water drainage system is identified in Ross Road on the Topographical Survey included in *Appendix B,* with connection to the nearby watercourse. Concerns have however been raised over the condition of this sewer and it is therefore proposed to provide a separate surface water sewer within Ross Road with a downstream connection to the 225mm Ø highway drainage system at the point where it leaves the highway. |
| To a combined sewer | A surface water drainage system has been identified in close proximity to the site. Therefore, it is not necessary to consider the discharge of the surface water runoff to a combined sewer. |

2.3 Based on the assessment in *Table 1*, it is considered appropriate to discharge surface water runoff from the development to the 225mm Ø surface water drainage system

identified in Ross Road at the point where it meets the highway, via a new adoptable surface water connection.

Runoff Management

2.4 Surface water runoff from the development should be managed in accordance with the suggested procedures set out in the March 2015 DEFRA Report "Sustainable Drainage Systems: Non-statutory technical standards for sustainable drainage systems."

2.5 The area proposed for development is considered to be greenfield in nature. For developments on greenfield sites Policy S2 of the DEFRA report advises that the peak runoff rate from the development to any highway drain, sewer or surface water body for the 1 in 1 year rainfall event and the 1 in 100 year rainfall event should never exceed the peak greenfield runoff rate for the same event.

2.6 Greenfield rates of runoff have been calculated using the IH124 method of calculation, which is included in the Source Control design facility of the MicroDrainage software Package by XP Solutions. The calculation recommends that greenfield rates should be calculated using an area of 50 Ha in the formula, which should then be adjusted by the ratio of the site area to 50 Ha. The IH124 design results are included in *Appendix C*, while the calculated rates for a variety of storm events up to the 1 in 100 year return period are summarised in *Table 2* below.

*Table 2: Pre-Development Runoff Rates*

| Return Period | Greenfield Runoff Rate for 50 Ha Area (l/s) | Greenfield Runoff Rate for Area of 0.742 Ha (l/s) |
|---|---|---|
| QBAR | 172.7 | 2.6 |
| 1 year | 143.3 | 2.1 |
| 30 year | 338.3 | 5.0 |
| 100 year | 443.8 | 6.6 |

2.7 Policy S4 of the DEFRA report advises that where reasonably practicable, for greenfield development, the runoff volume from the development to any highway drain, sewer or surface water body in the 1 in 100 year, 6 hour rainfall event should never exceed the greenfield runoff volume for the same event.

2.8 Greenfield runoff volumes (QBAR) have been calculated using the Greenfield Runoff Volume Calculator, which is included in the Source Control design facility of the MicroDrainage software Package by XP Solutions. Copies of the design results are included in *Appendix C*, while the calculated volumes for a variety of storm events up to the 1 in 100 year return period are summarised in *Table 2* below.

*Table 3: Greenfield Runoff Volumes*

| Return Period | Greenfield Runoff Volume ($m^3$) |
|---|---|
| 1 year 360 minute | 41.3 |
| 30 year 360 minute | 98.0 |
| 100 year 360 minute | 137.4 |

Sustainable Urban Drainage Systems (SUDS)

2.9 It is proposed to discharge surface water runoff from the development to the existing downstream highway drainage system identified approximately 370m to the south east of the site. Given the known capacity issues with the existing highway discharge, connection is proposed to be made via a new off-site sewer. In order to do so it has been established that it will be necessary to control and attenuate excess volumes of surface water runoff from the development to the maximum allowable discharge rates shown in *Table 1*, above.

2.10 Surface water runoff from the existing site understood to sheet flow in an easterly/ south easterly direction towards existing property and the highway. The proposed cut off ditch which runs along the eastern boundary of the site diverts overland flows away from adjacent properties. The positive drainage system will therefore offer a reduction on flood risk to sensitive downstream receptors compared to the existing situation.

2.11 The proposed surface water sewer within the highway will offer further betterment over the existing situation as the overland flows naturally drain towards the highway will now be diverted underground and directed towards the receiving ordinary watercourse.

2.12 Within the drainage strategy it is necessary to consider the use of SUDS to achieve this balance. SUDS encompass a wide range of drainage techniques intended to minimise the rate of discharge, volume and environmental impact of runoff and include; green roofs / rainwater harvesting; soakaways / infiltration systems; infiltration trenches and filter drains; permeable paving; swales and basins; ponds and wetlands. *Table 4* below provides an assessment of each methods suitability.

*Table 4: SUDS Assessment*

| System | Assessment |
|---|---|
| Green Roofs | The development would comprise of residential houses with pitched roof profiles, which are appropriate to the site and its context. Therefore, the use of green roofs is not considered suitable for the management of surface water runoff. |
| Rainwater Harvesting | The Rainwater Harvesting Calculator included in the MicroDrainage software package by XP Solutions has established that the use of rainwater harvesting would not significantly contribute to a reduction in surface water runoff volumes. On this basis rainwater harvesting has not been considered as part of the surface water drainage strategy for the development. The rainwater harvesting assessment is included in *Appendix D*. |
| Soakaway / Infiltration Systems / Infiltration Trenches | Infiltration drainage techniques are deemed to be inappropriate due to the cohesive nature of the underlying soils. On this basis infiltration drainage techniques have not been considered as part of the surface water drainage strategy for the development. |
| Permeable Pavements | Driveways and parking bays could be considered suitable for porous construction to intercept, retain and treat precipitation and to help to reduce the runoff rates and volumes discharged from the site in comparison to the existing situation. |
| Swales, basins, ponds and wetlands. | Given the nature of the available surface water drainage connection and following consultation with Welsh Water, the use of open SUDS features is not considered appropriate to the proposed development site, which is located at the head of the proposed adoptable drainage run. Gravel filter strips have been provided to treat the run-off from the private drives. |

2.13 Based on the assessment in *Table 3*, a surface water drainage scheme has been developed for the site and is shown on the proposed drainage layout included in *Appendix E* with a description of the proposals provided below.

- The plan shows the site to be drained via a network of surface water sewers.

- Roof water runoff from buildings would discharge to the network of surface water sewers via roof gutters and rainwater downpipes and a traditional network of below ground pipework.

- Driveways and parking bays would discharge via gravel filter strips which would be wrapped in an impermeable geomembrane and would discharge to the network of surface water sewers via collector pipes.

- The network of surface water sewers is shown to convey surface water to a series of attenuation tanks located along the site's southern boundary. The 30 year adoptable attenuation tank, supplemented by the 30-100 year private attenuation tank, would store and attenuate excess surface water runoff from the development prior to discharging via a flow control chamber to the existing highway drainage system via a new off-site surface water sewer in Ross Road.

- The flow control chamber is shown to be fitted with a Hydrobrake flow control device, which would limit surface water flows to a maximum rate of 5 l/s, which has been agreed with the drainage officer and is governed by the minimum practicable orifice size to reduce the risk of blockage.

Hydraulic Analysis

2.14 The source control facility in the MicroDrainage software Package by XP Solutions has been used to design the surface water drainage scheme with design results included in *Appendix F* for a variety of storm events up to and including the 1 in 100 year storm return period, including a 40% allowance for increased rainfall the predicted effects of climate change.

2.15 *Table 4* below compares the maximum rate of discharge analysed for each storm event to the peak greenfield rates determined in *Table 2*.

*Table 5: Comparison of Discharge Rates & Volumes*

| Return Period | Greenfield | | Post Development (including 40% allowance for climate change) | |
|---|---|---|---|---|
| | Peak Runoff Rate (l/s) | 6 hr Runoff Volume ($m^3$) | Peak Runoff Rate (l/s) | 6 hr Runoff Volume ($m^3$) |
| 1 year | 2.1 | 41.3 | 4.7 | 14.0 |
| 30 year | 5.0 | 98.0 | 5.0 | 49.2 |
| 100 year | 6.6 | 136.4 | 5.0 | 76.1 |

2.1 The Hydrobrake flow control devices have been sized to a minimum practical orifice diameter of 100mm resulting in a discharge rate of 5 l/s, as agreed with the local drainage officer. The above table therefore confirms that the surface water drainage scheme would comply with Policy S3 of the DEFRA Report as the peak runoff rate

from the development for the 1 in 1 year rainfall event and the 1 in 100 year rainfall event would be as close as reasonably practicable to the greenfield runoff rate from the development for the same rainfall event and where practicable would also not exceed the rate of discharge from the development site prior to redevelopment for that event.

2.2 *Table 5* shows that the surface water drainage scheme would discharge at a greater volume than the equivalent pre-development volume for the 1 in 100-year 6-hour rainfall event with 40% allowance for climate change. However, Policy S6 of the DEFRA Report advises that where it is not reasonably practicable to constrain the volume of runoff to any drain, sewer or surface water body, the runoff volume must be discharged at a rate that does not adversely affect flood risk. Surface water runoff from the development has been limited as far as practicable, in line with guidance provided by the Lead Local Flood Authority. On this basis, it is considered that the runoff volume would be discharged at a rate that does not adversely affect flood risk.

Exceedance

2.3 In the event that the capacity of the surface water drainage network was exceeded, proposed site levels would allow surface water to be channelled off-site in a south-easterly direction to the lower lying undeveloped fields to the south away from any neighbouring properties via the proposed drainage cut off ditch. The proposed scheme will therefore reduce flood risk to the sensitive downstream receptors. Further to this the finished floor levels of all proposed dwellings would be raised above surrounding levels so there would be no risk of buildings being affected by such overland flows.

## 3. CONCLUSIONS

3.1 The use of infiltration drainage techniques is not considered appropriate, it is therefore proposed to discharge surface water to the existing highway drainage system in Ross Road via a new off-site surface water sewer.

3.2 It is proposed to attenuate surface water flows to an agreed rate of 5l/s using a attenuation tanks, which would ensure that excess surface water is stored on site for all storm return periods up to and including the 1 in 100 year event (with 40% allowance for climate change).

3.3 The proposed drainage scheme would offer a reduction on flood risk to sensitive downstream receptors by diverting flows away from adjacent properties and the existing highway drainage system.

3.4 In terms of surface water drainage strategy it is concluded that the development can be occupied and operated safely and that there will be no increase in the level of surface water flood risk to the site or neighbouring property as a result of the development. There is no drainage related reason why planning consent should not be granted.

# APPENDIX A
# SOAKAWAY TEST RESULTS

Enzygo Geoenvironmental Limited
The Byre, Woodend Lane
Cromhall, Gloucestershire GL12 8AA

**Tel:** 01454 269237
**www.enzygo.com**

Gareth Crowther
Simpson Associates
8 Friday Street
Henley-on-Thames
RG9 1AH

CRM.413.329

6th December 2016

Sent via email gareth.crowther@simpsoneng.com

Dear Gareth

**Land of Church Road, Brampton Abbotts, Ros-On-Wye.**

Enzygo undertook soakaway testing at the above-named site on the 28th November 2016. Three trial pits were excavated to a depth of between 2m and 2.1m below ground level (BGL) and the tests undertaken from depths of between 0.8m and 1.02m bgl.

A tractor towed water bowser was used for the water supply with a large outlet valve. Trail pit sides remained stable and vertical during excavation and soakaway testing.

A single cycle of testing were carried out in each trail pit. The infiltration rates were calculated and the results summarised in table 1, 2 and 3. Soakaway sheets are also provided.

Yours sincerely,

[redacted]

Greg Parr
**Site Engineer**

Table 1

| Exploratory Hole | Depth (m bgl) | Test No | Soil Infiltration Rate (m/s) | Design Soil Infiltration Rate (m/s) |
|---|---|---|---|---|
| Soakaway 1 | 2 | 1 | N/A | Insufficient Uptake |

Table 2

| Exploratory Hole | Depth (m bgl) | Test No | Soil Infiltration Rate (m/s) | Design Soil Infiltration Rate (m/s) |
|---|---|---|---|---|
| Soakaway 2 | 2 | 1 | N/A | Insufficient Uptake |

Table 3

| Exploratory Hole | Depth (m bgl) | Test No | Soil Infiltration Rate (m/s) | Design Soil Infiltration Rate (m/s) |
|---|---|---|---|---|
| Soakaway 3 | 2.1 | 1 | N/A | Insufficient Uptake |


Key

- Site Boundary
- Soakaway Location (SA)
  (SA1 - SA3)

enzygo
environmental consultants
Samuel House, 5 Fox Valley Way, Stocksbridge, Sheffield, S36 2AA

CLIENT: Simpson Associates

SCALE: 1:500@A3

PROJECT REF: CRM.413.329

DRAWN: MG

CHECKED: GP

DATE: Dec 2016

PROJECT: Brampton Abbotts

TITLE: Site Location Plan

FIGURE NO: CRM.413.329.GE.D.001

enzygo

| | | | |
|---|---|---|---|
| Site..... | Brampton Abbotts, Ross-On-Wye | Soakaway Number..... | SA1 |
| Job Number..... | CRM.413.329 | Length..... | 1.40 m |
| Date of Test..... | 28.11.16 | Width..... | 0.60 m |
| | | Depth..... | 2.00 m |
| | | Groundwater Level..... | Dry m |

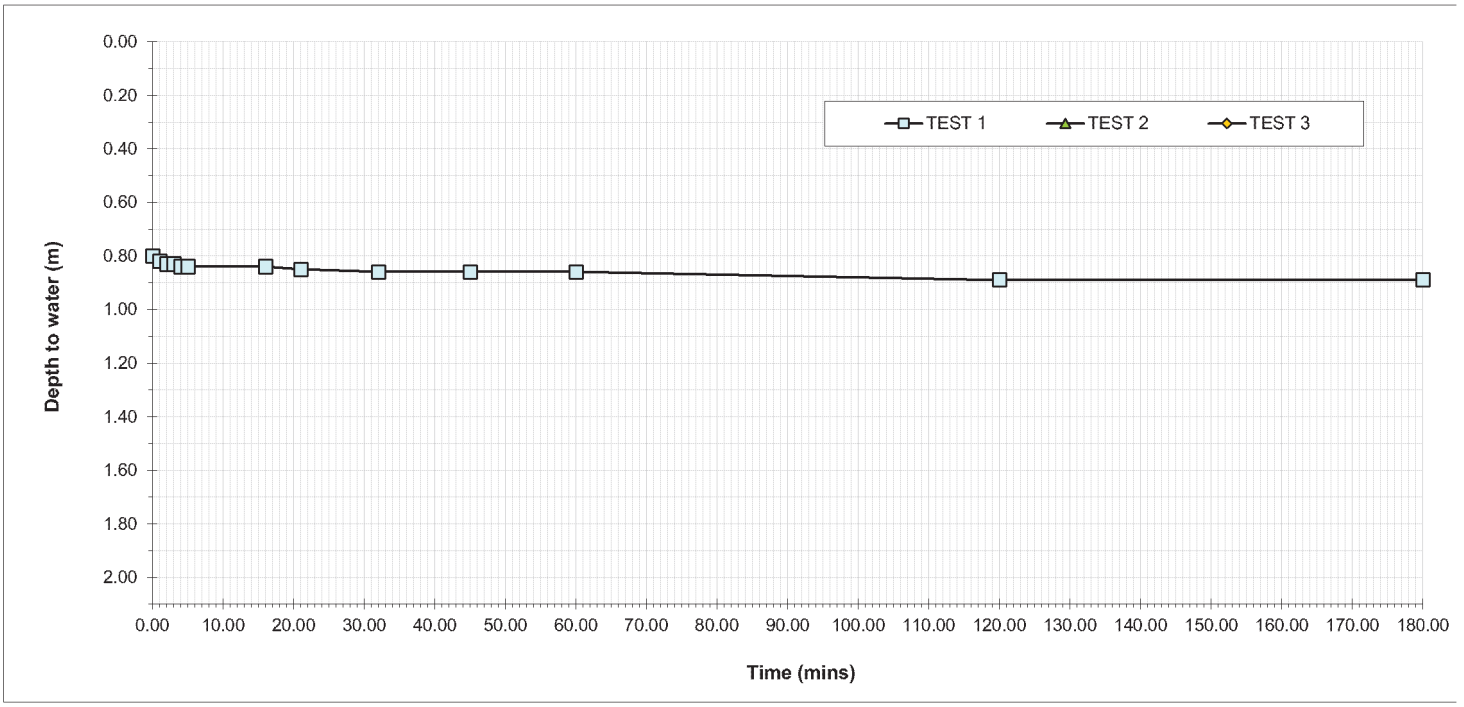
**SOIL INFILTRATION RATE TEST**
**See B.R.E. Digest 365, 1991, Soakaway Design.**

Remarks -
GL
Grass over reddish brown silty SAND with rootlets.
0.75m
Reddish brown sandy silty CLAY with occasional bands of light greenish grey fine sand and silt from 1.10m.
2.00m
End of trial pit.

| TEST 1 | |
|---|---|
| Time(min) | Depth to Water (m) |
| 0.0 | 0.80 |
| 1.0 | 0.82 |
| 2.0 | 0.83 |
| 3.0 | 0.83 |
| 4.0 | 0.84 |
| 5.0 | 0.84 |
| 16.0 | 0.84 |
| 21.0 | 0.85 |
| 32.0 | 0.86 |
| 45.0 | 0.86 |
| 60.0 | 0.86 |
| 120.0 | 0.89 |
| 180.0 | 0.89 |
| 0.00 | 0.00 |
| 0.00 | 0.00 |
| 0.00 | 0.00 |
| 0.00 | 0.00 |

| | | |
|---|---|---|
| Effective Storage Depth | m | 1.20 |
| 75% Effective Storage Depth | m | 0.90 |
| (i.e. depth below GL) | m | **1.10** |
| 25% Effective Storage Depth | m | 0.30 |
| (i.e. depth below GL) | m | **1.70** |
| Effective Storage Depth 75%-25% | m | 0.60 |
| Time to fall to 75% effective depth | mins | |
| Time to fall to 25% effective depth | mins | |
| V (75%-25%) | m3 | 0.50 |
| a (50%) | m2 | 3.24 |
| t (75%-25%) | mins | 0.00 |
| **SOIL INFILTRATION RATE** | m/s | **#DIV/0!** |

**DESIGN SOIL INFILTRATION RATE, f** **Insufficient Uptake** **m/s**




| Compiled By: | Date: | Checked By: | Date: | Approved By: | Date: |
|---|---|---|---|---|---|
| M. Ward | 05.12.16 | R.Hamilton | 05.12.16 | S.Rhodes | 05.12.16 |

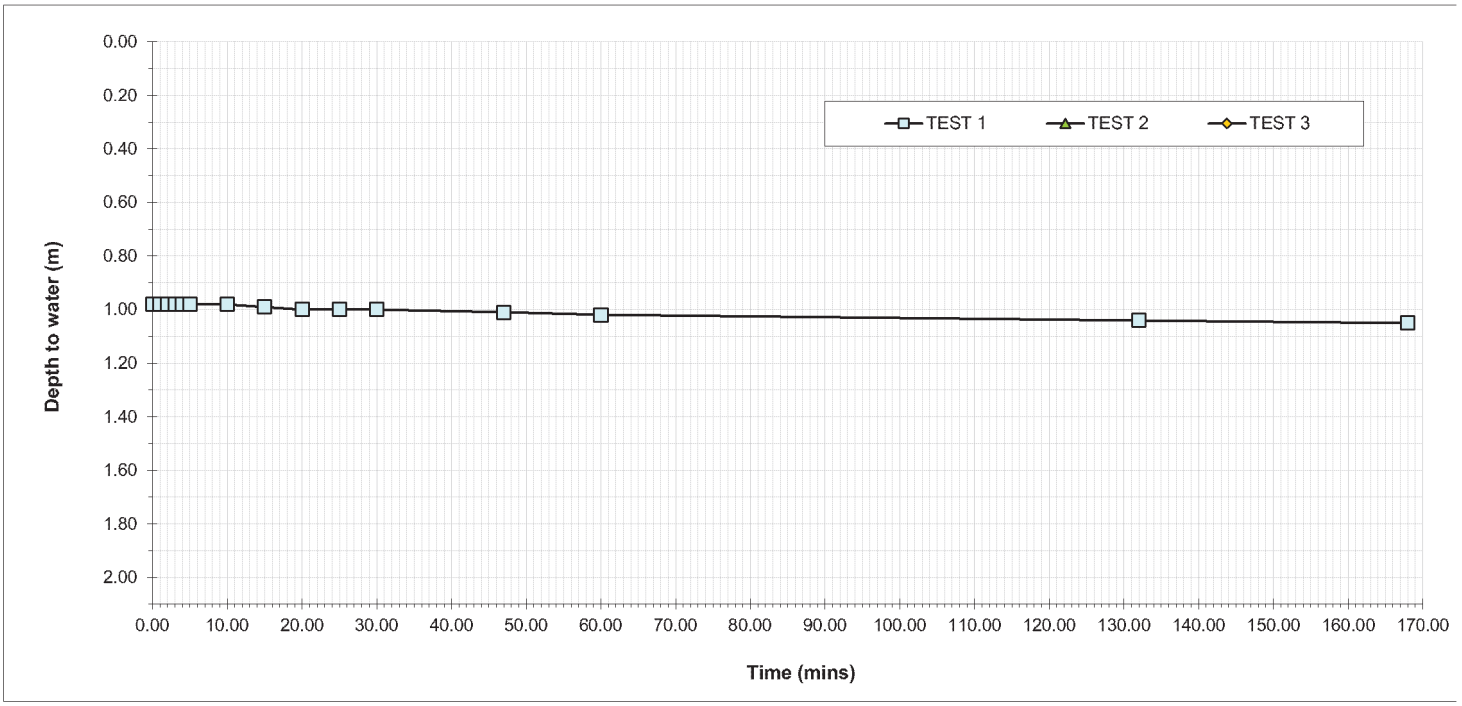
| | | |
|---|---|---|
| enzygo | Site..... Brampton Abbotts, Ross-On-Wye<br>Job Number..... CRM.413.329<br>Date of Test..... 28.11.16 | Soakaway Number..... SA2<br>Length..... 1.70 m<br>Width..... 0.60 m<br>Depth..... 2.00 m<br>Groundwater Level..... Dry m |

**SOIL INFILTRATION RATE TEST**
**See B.R.E. Digest 365, 1991, Soakaway Design.**

Remarks -
GL
Grass over reddish brown silty SAND with rootlets.
0.60m
Reddish brown sandy silty CLAY with rare bands of light greenish grey fine sand and silt from 0.60m.
1.60m
Reddish brown gravelly clayey SAND with frequent angular flat cobbles of weak sandstone. Gravel is angular and subangular, fine to coarse sandstone.
2.00m
End of trial pit.

| | | TEST 1 | TEST 2 | TEST 3 |
|---|---|---|---|---|
| | | Time(min) / Depth to Water (m) | | |
| | | 0.0 / 0.98 | | |
| | | 1.0 / 0.98 | | |
| | | 2.0 / 0.98 | | |
| | | 3.0 / 0.98 | | |
| | | 4.0 / 0.98 | | |
| | | 5.0 / 0.98 | | |
| | | 10.0 / 0.98 | | |
| | | 15.0 / 0.99 | | |
| | | 20.0 / 1.00 | | |
| | | 25.0 / 1.00 | | |
| | | 30.0 / 1.00 | | |
| | | 47.0 / 1.01 | | |
| | | 60.0 / 1.02 | | |
| | | 132.00 / 1.04 | | |
| | | 168.00 / 1.05 | | |
| | | 0.00 / 0.00 | | |
| | | 0.00 / 0.00 | | |
| Effective Storage Depth | m | 1.02 | | |
| 75% Effective Storage Depth | m | 0.77 | | |
| (i.e. depth below GL) | m | **1.24** | | |
| 25% Effective Storage Depth | m | 0.26 | | |
| (i.e. depth below GL) | m | **1.75** | | |
| Effective Storage Depth 75%-25% | m | 0.51 | | |
| Time to fall to 75% effective depth | mins | | | |
| Time to fall to 25% effective depth | mins | | | |
| V (75%-25%) | m3 | 0.52 | | |
| a (50%) | m2 | 3.37 | | |
| t (75%-25%) | mins | 0.00 | | |
| **SOIL INFILTRATION RATE** | m/s | **#DIV/0!** | | |

**DESIGN SOIL INFILTRATION RATE, f** **Insufficient Uptake** **m/s**



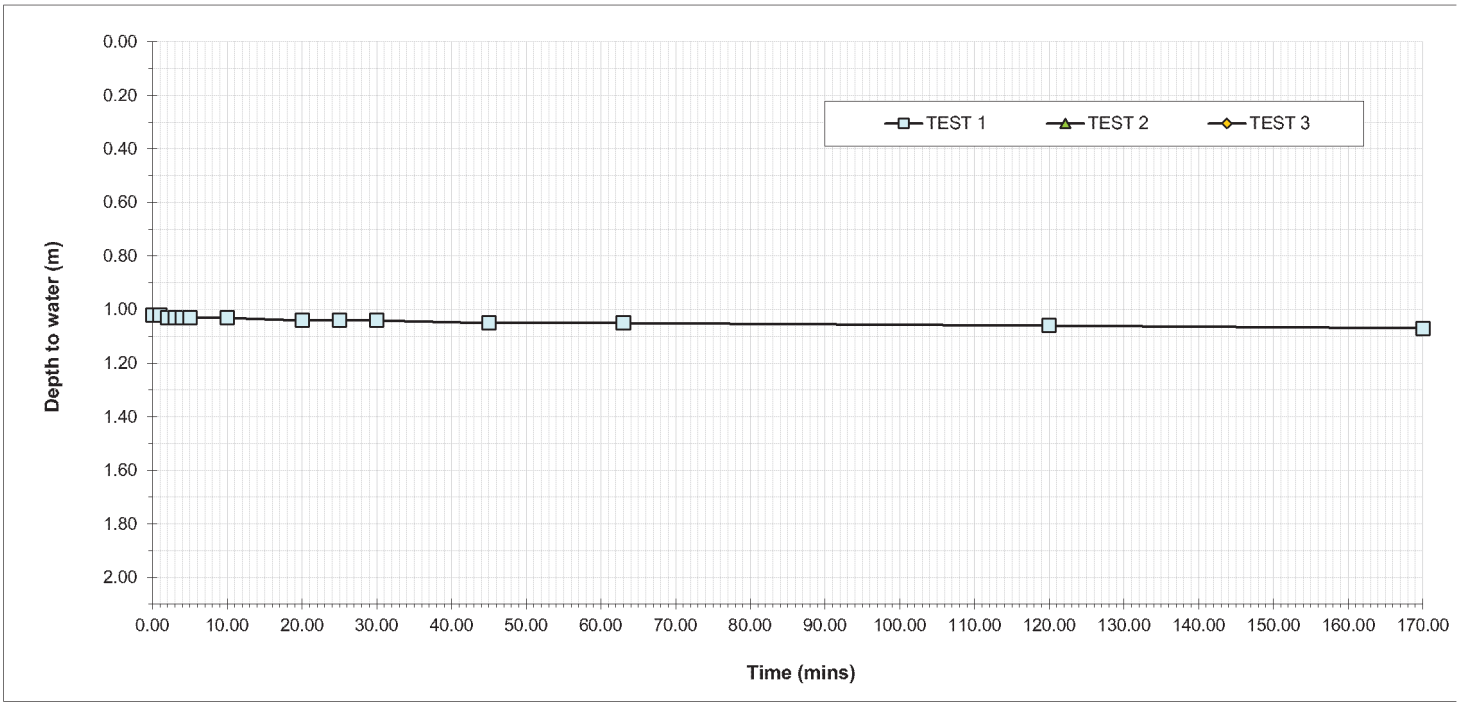

| Compiled By: | Date: | Checked By: | Date: | Approved By: | Date: |
|---|---|---|---|---|---|
| M. Ward [redacted] | 01.12.16 | R.Hamilton [redacted] | 01.12.16 | S.Rhodes [redacted] | 01.12.16 |

| | | |
|---|---|---|
| enzygo | Site..... Brampton Abbotts, Ross-On-Wye<br>Job Number..... CRM.413.329<br>Date of Test..... 28.11.16 | Soakaway Number..... SA3<br>Length..... 1.40 m<br>Width..... 0.60 m<br>Depth..... 2.10 m<br>Groundwater Level..... Dry m |

**SOIL INFILTRATION RATE TEST**
**See B.R.E. Digest 365, 1991, Soakaway Design.**

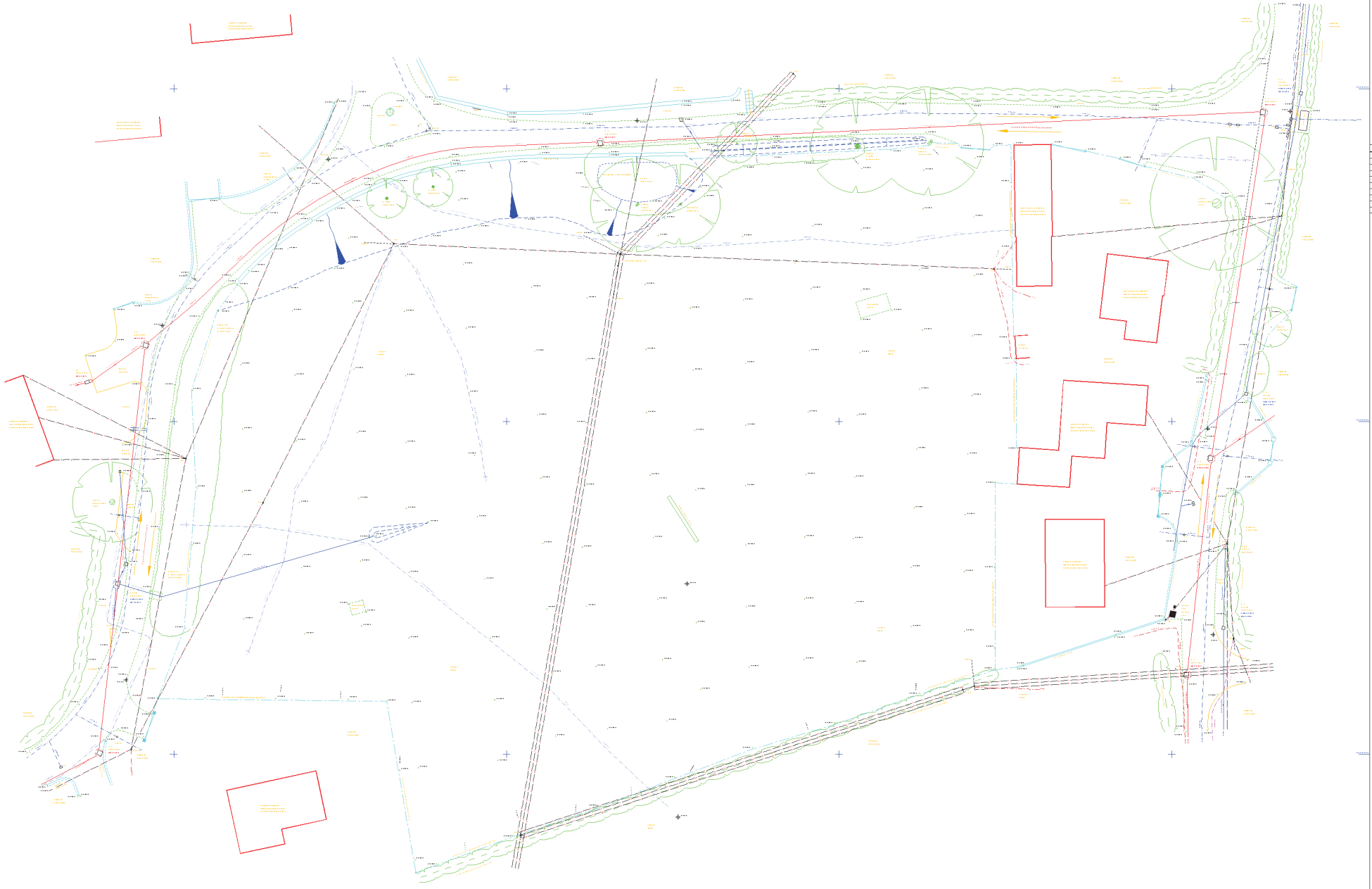
| Remarks - | | TEST 1 | | TEST 2 | TEST 3 |
|---|---|---|---|---|---|
| GL | | Time(min) | Depth to Water (m) | | |
| Grass over reddish brown silty SAND with rootlets. | | 0.0 | 1.02 | | |
| 0.80m | | 1.0 | 1.02 | | |
| Reddish brown sandy silty CLAY with rare bands of light greenish grey fine sand and silt. Becoming slightly sandy with depth. | | 2.0 | 1.03 | | |
| 2.00m | | 3.0 | 1.03 | | |
| End of trial pit. | | 4.0 | 1.03 | | |
| | | 5.0 | 1.03 | | |
| | | 10.0 | 1.03 | | |
| | | 20.0 | 1.04 | | |
| | | 25.0 | 1.04 | | |
| | | 30.0 | 1.04 | | |
| | | 45.0 | 1.05 | | |
| | | 63.0 | 1.05 | | |
| | | 120.0 | 1.06 | | |
| | | 170.00 | 1.07 | | |
| | | 0.00 | 0.00 | | |
| | | 0.00 | 0.00 | | |
| | | 0.00 | 0.00 | | |
| Effective Storage Depth | m | | 1.08 | | |
| 75% Effective Storage Depth | m | | 0.81 | | |
| (i.e. depth below GL) | m | | **1.29** | | |
| 25% Effective Storage Depth | m | | 0.27 | | |
| (i.e. depth below GL) | m | | **1.83** | | |
| Effective Storage Depth 75%-25% | m | | 0.54 | | |
| Time to fall to 75% effective depth | mins | | | | |
| Time to fall to 25% effective depth | mins | | | | |
| V (75%-25%) | m3 | | 0.45 | | |
| a (50%) | m2 | | 3.00 | | |
| t (75%-25%) | mins | | 0.00 | | |
| **SOIL INFILTRATION RATE** | m/s | | **#DIV/0!** | | |

**DESIGN SOIL INFILTRATION RATE, f** **Insufficient Uptake** **m/s**




| Compiled By: | Date: | Checked By: | Date: | Approved By: | Date: |
|---|---|---|---|---|---|
| M. Ward [redacted] | 01.12.16 | R.Hamilton [redacted] | 01.12.16 | S.Rhodes [redacted] | 01.12.16 |

# APPENDIX B
# TOPOGRAPHICAL SURVEY



## NOTES

## UTILITY NOTES

NORTH

**MIDLAND SURVEY LTD**

TOPOGRAPHICAL (LAND) SURVEYORS / UTILITY SURVEYORS
BUILDING MEASUREMENT SURVEYORS / 3D LASER SCANNING

# APPENDIX C
# IH124 GREENFIELD RUNOFF RESULTS

## IH 124 Mean Annual Flood

Input

| | | | |
|---|---|---|---|
| Return Period (years) | 100 | Soil | 0.400 |
| Area (ha) | 50.000 | Urban | 0.000 |
| SAAR (mm) | 709 | Region Number | Region 4 |

| **Results** | **l/s** |
|---|---|
| QBAR Rural | 172.7 |
| QBAR Urban | 172.7 |
| Q100 years | 443.8 |
| Q1 year | 143.3 |
| Q2 years | 154.8 |
| Q5 years | 212.4 |
| Q10 years | 257.3 |
| Q20 years | 306.9 |
| Q25 years | 324.3 |
| Q30 years | 338.3 |
| Q50 years | 380.2 |
| Q100 years | 443.8 |
| Q200 years | 521.5 |
| Q250 years | 547.4 |
| Q1000 years | 718.3 |

## Greenfield Runoff Volume

FSR Data

| | |
|---|---|
| Return Period (years) | 1 |
| Storm Duration (mins) | 360 |
| Region | England and Wales |
| M5-60 (mm) | 19.100 |
| Ratio R | 0.366 |
| Areal Reduction Factor | 1.00 |
| Area (ha) | 0.742 |
| SAAR (mm) | 719 |
| CWI | 107.452 |
| Urban | 0.000 |
| SPR | 30.000 |

Results

| | |
|---|---|
| Percentage Runoff (%) | 25.61 |
| Greenfield Runoff Volume ($m^3$) | 41.327 |

## Greenfield Runoff Volume

FSR Data

| | |
|---|---|
| Return Period (years) | 30 |
| Storm Duration (mins) | 360 |
| Region | England and Wales |
| M5-60 (mm) | 19.100 |
| Ratio R | 0.366 |
| Areal Reduction Factor | 1.00 |
| Area (ha) | 0.742 |
| SAAR (mm) | 719 |
| CWI | 107.452 |
| Urban | 0.000 |
| SPR | 30.000 |

Results

| | |
|---|---|
| Percentage Runoff (%) | 27.54 |
| Greenfield Runoff Volume ($m^3$) | 98.001 |

## Greenfield Runoff Volume

FSR Data

| | |
|---|---|
| Return Period (years) | 100 |
| Storm Duration (mins) | 360 |
| Region | England and Wales |
| M5-60 (mm) | 19.100 |
| Ratio R | 0.366 |
| Areal Reduction Factor | 1.00 |
| Area (ha) | 0.742 |
| SAAR (mm) | 719 |
| CWI | 107.452 |
| Urban | 0.000 |
| SPR | 30.000 |

Results

| | |
|---|---|
| Percentage Runoff (%) | 29.56 |
| Greenfield Runoff Volume ($m^3$) | 136.435 |

# APPENDIX D
# RAINWATER HARVESTING ASSESSMENT

## Rainwater Harvesting

### Annual Demand

| | |
|---|---|
| Daily requirement per person (l) | 30.0 |
| Number of persons | 3 |

### Annual Yield

| | |
|---|---|
| Collection area (m²) | 71 |
| Runoff Coefficient | 1.000 |
| AAR (mm) | 725 |
| Hydraulic Filter Efficiency | 0.90 |
| Depression Storage (mm) | 0.4 |
| Number of Rainfall Events/Year | 150 |

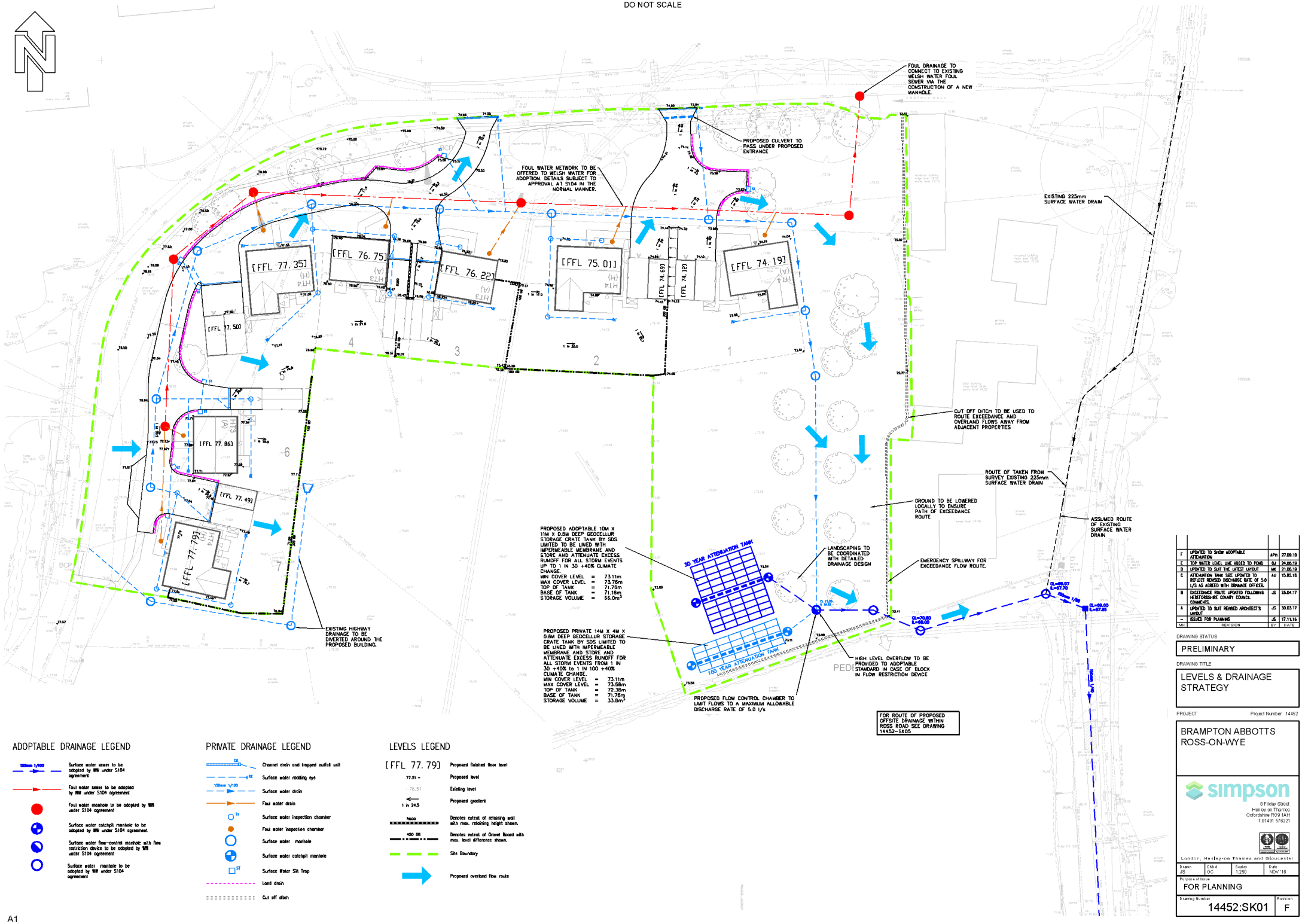
### Feasibility

| | |
|---|---|
| Annual non-potable water demand (l) | 32850.0 |
| Annual rainfall yield (l) | 42493.5 |

Rainfall yield exceeds demand, rainwater harvesting is not feasible for storm water control under BS8515:2009+A1:2013 detailed design approach. Detailed approach using continuous analysis is required.

# APPENDIX E
# PROPOSED DRAINAGE LAYOUT

DO NOT SCALE




## ADOPTABLE DRAINAGE LEGEND

- Surface water sewer to be adopted by WW under S104 agreement
- Foul water sewer to be adopted by WW under S104 agreement
- Foul water manhole to be adopted by WW under S104 agreement
- Surface water catchpit manhole to be adopted by WW under S104 agreement
- Surface water flow-control manhole with flow restriction device to be adopted by WW under S104 agreement
- Surface water manhole to be adopted by WW under S104 agreement

## PRIVATE DRAINAGE LEGEND

- Channel drain and trapped outfall unit
- Surface water rodding eye
- Surface water drain
- Foul water drain
- Surface water inspection chamber
- Foul water inspection chamber
- Surface water manhole
- Surface water catchpit manhole
- Surface Water Silt Trap
- Land drain
- Cut off ditch

## LEVELS LEGEND

- [FFL 77.79] Proposed finished floor level
- 77.51 + Proposed level
- 76.51 Existing level
- 1 in 24.5 Proposed gradient
- R600 Denotes extent of retaining wall with max. retaining height shown.
- 450 GB Denotes extent of Gravel Board with max. level difference shown.
- Site Boundary
- Proposed overland flow route

| MK | REVISION | BY | DATE |
|---|---|---|---|
| F | UPDATED TO SHOW ADOPTABLE ATTENUATION | APH | 27.09.19 |
| E | TOP WATER LEVEL LINE ADDED TO POND | SJ | 24.05.19 |
| D | UPDATED TO SUIT THE LATEST LAYOUT | MK | 21.05.19 |
| C | ATTENUATION TANK SIZE UPDATED TO REFLECT REVISED DISCHARGE RATE OF 5.0 l/S AS AGREED WITH DRAINAGE OFFICER. | AU | 15.05.18 |
| B | EXCEEDANCE ROUTE UPDATED FOLLOWING HERTFORDSHIRE COUNTY COUNCIL COMMENTS. | JS | 25.04.17 |
| A | UPDATED TO SUIT REVISED ARCHITECTS LAYOUT | JS | 30.03.17 |
| – | ISSUED FOR PLANNING | JS | 17.11.16 |

DRAWING STATUS

PRELIMINARY

DRAWING TITLE

LEVELS & DRAINAGE STRATEGY

PROJECT — Project Number 14452

BRAMPTON ABBOTTS
ROSS-ON-WYE

simpson
9 Friday Street
Henley on Thames
Oxfordshire RG9 1AH
T 01491 576221
London, Henley-on Thames and Gloucester

| Drawn | Ckd | Scales | Date |
|---|---|---|---|
| JS | SC | 1:250 | NOV '16 |

Purpose of Issue

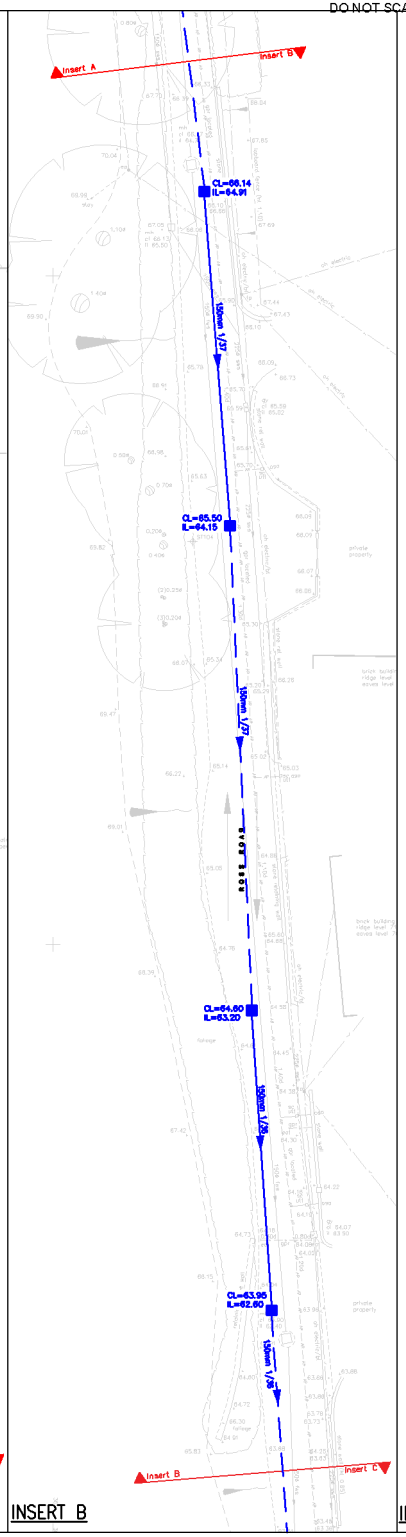
FOR PLANNING

| Drawing Number | Revision |
|---|---|
| 14452:SK01 | F |

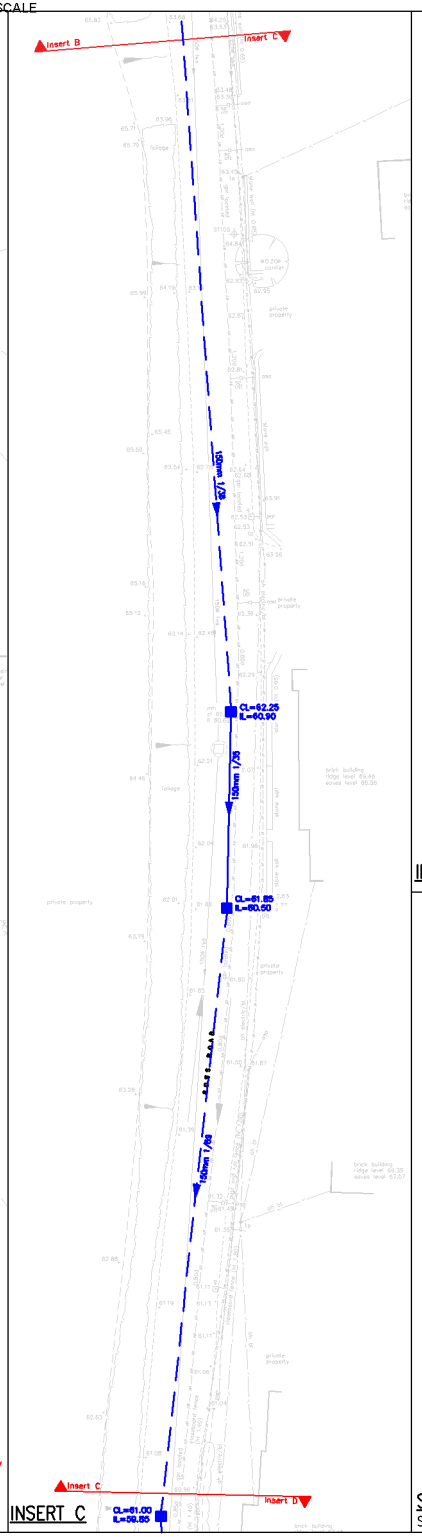
A1

DO NOT SCALE

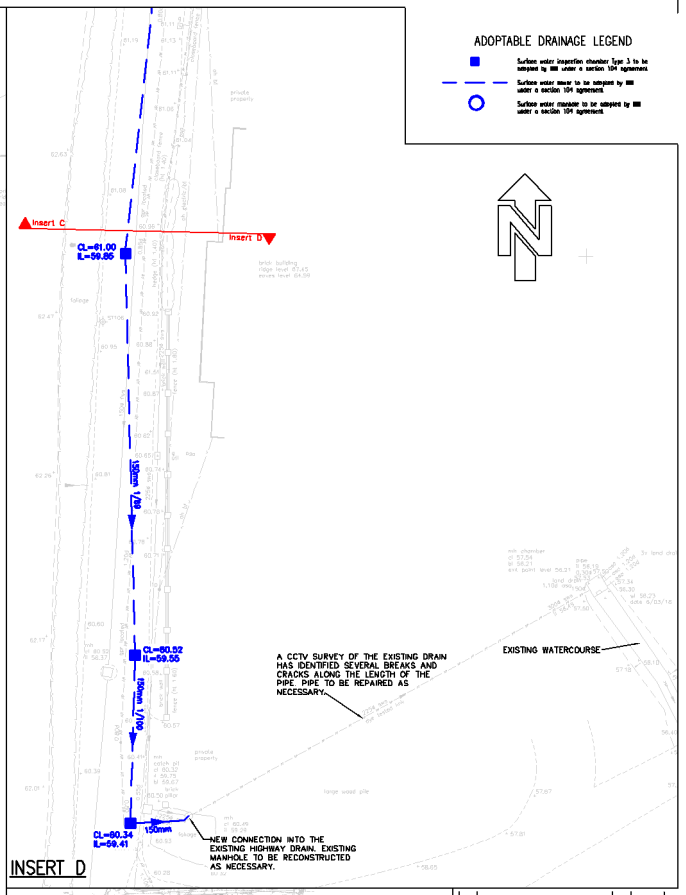

INSERT A




INSERT B



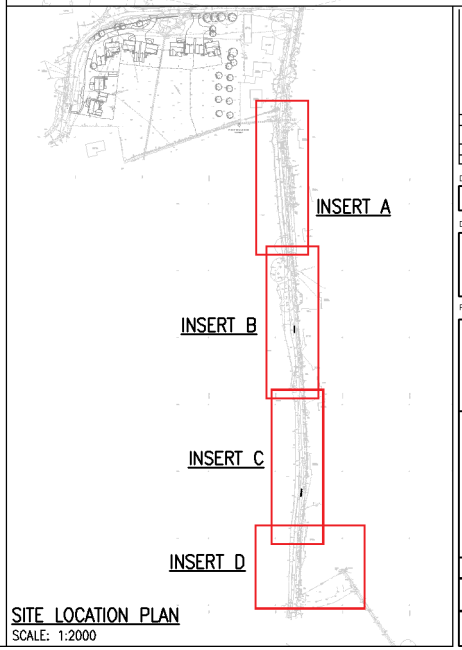

INSERT C




INSERT D

ADOPTABLE DRAINAGE LEGEND

- Surface water inspection chamber Type 3 to be adopted by WW under a section 104 agreement
- Surface water sewer to be adopted by WW under a section 104 agreement
- Surface water chamber to be adopted by WW under a section 104 agreement




SITE LOCATION PLAN
SCALE: 1:2000

| | | | |
|---|---|---|---|
| B | UPDATED DRAINAGE LEGEND | APH | 27.09.18 |
| A | AMENDED TO SUIT LATEST ON-SITE DRAINAGE PROPOSALS | MK | 24.06.19 |
| – | INITIAL ISSUE | AU | 16.05.18 |
| MK | REVISION | BY | DATE |

DRAWING STATUS
PRELIMINARY

DRAWING TITLE
PROPOSED OFFSITE DRAINAGE CONNECTION

PROJECT Project Number 14452
BRAMPTON ABBOTTS
ROSS-ON-WYE

simpson
9 Friday Street
Henley on Thames
Oxfordshire RG9 1AH
T:01491 576221
London, Henley-on Thames and Gloucester

| Drawn | Chkd | Scales | Date |
|---|---|---|---|
| AU | ADC | 1:200@A1 | MAY 18 |

Purpose of Issue
FOR PLANNING

Drawing Number 14452:SK05
Revision B

A1

# APPENDIX F
# MICRODRAINAGE DESIGN RESULTS

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

Half Drain Time : 142 minutes.

| Storm Event | Max Level (m) | Max Depth (m) | Max Infiltration (l/s) | Max Control (l/s) | Max Σ Outflow (l/s) | Max Volume (m³) | Status |
|---|---|---|---|---|---|---|---|
| 15 min Summer | 71.591 | 0.431 | 0.0 | 5.0 | 5.0 | 42.2 | O K |
| 30 min Summer | 71.720 | 0.560 | 0.0 | 5.0 | 5.0 | 54.8 | O K |
| 60 min Summer | 71.931 | 0.771 | 0.0 | 5.0 | 5.0 | 66.4 | O K |
| 120 min Summer | 72.075 | 0.915 | 0.0 | 5.0 | 5.0 | 72.7 | O K |
| 180 min Summer | 72.077 | 0.917 | 0.0 | 5.0 | 5.0 | 72.8 | O K |
| 240 min Summer | 72.047 | 0.887 | 0.0 | 5.0 | 5.0 | 71.5 | O K |
| 360 min Summer | 71.956 | 0.796 | 0.0 | 5.0 | 5.0 | 67.4 | O K |
| 480 min Summer | 71.834 | 0.674 | 0.0 | 5.0 | 5.0 | 62.0 | O K |
| 600 min Summer | 71.743 | 0.583 | 0.0 | 5.0 | 5.0 | 57.1 | O K |
| 720 min Summer | 71.695 | 0.535 | 0.0 | 5.0 | 5.0 | 52.4 | O K |
| 960 min Summer | 71.608 | 0.448 | 0.0 | 5.0 | 5.0 | 43.9 | O K |
| 1440 min Summer | 71.472 | 0.312 | 0.0 | 5.0 | 5.0 | 30.5 | O K |
| 2160 min Summer | 71.353 | 0.193 | 0.0 | 4.7 | 4.7 | 18.9 | O K |
| 2880 min Summer | 71.295 | 0.135 | 0.0 | 4.3 | 4.3 | 13.2 | O K |
| 4320 min Summer | 71.259 | 0.099 | 0.0 | 3.4 | 3.4 | 9.7 | O K |
| 5760 min Summer | 71.242 | 0.082 | 0.0 | 2.7 | 2.7 | 8.0 | O K |
| 7200 min Summer | 71.233 | 0.073 | 0.0 | 2.3 | 2.3 | 7.1 | O K |
| 8640 min Summer | 71.227 | 0.067 | 0.0 | 2.0 | 2.0 | 6.5 | O K |
| 10080 min Summer | 71.222 | 0.062 | 0.0 | 1.8 | 1.8 | 6.0 | O K |
| 15 min Winter | 71.646 | 0.486 | 0.0 | 5.0 | 5.0 | 47.6 | O K |

| Storm Event | Rain (mm/hr) | Flooded Volume (m³) | Discharge Volume (m³) | Time-Peak (mins) |
|---|---|---|---|---|
| 15 min Summer | 122.474 | 0.0 | 45.5 | 18 |
| 30 min Summer | 82.355 | 0.0 | 61.2 | 32 |
| 60 min Summer | 52.892 | 0.0 | 78.8 | 62 |
| 120 min Summer | 32.827 | 0.0 | 97.9 | 120 |
| 180 min Summer | 24.479 | 0.0 | 109.5 | 150 |
| 240 min Summer | 19.741 | 0.0 | 117.8 | 182 |
| 360 min Summer | 14.507 | 0.0 | 129.8 | 252 |
| 480 min Summer | 11.659 | 0.0 | 139.1 | 316 |
| 600 min Summer | 9.833 | 0.0 | 146.6 | 380 |
| 720 min Summer | 8.551 | 0.0 | 153.0 | 444 |
| 960 min Summer | 6.853 | 0.0 | 163.5 | 570 |
| 1440 min Summer | 5.007 | 0.0 | 179.2 | 808 |
| 2160 min Summer | 3.650 | 0.0 | 196.1 | 1148 |
| 2880 min Summer | 2.913 | 0.0 | 208.6 | 1496 |
| 4320 min Summer | 2.116 | 0.0 | 227.2 | 2204 |
| 5760 min Summer | 1.684 | 0.0 | 241.3 | 2936 |
| 7200 min Summer | 1.410 | 0.0 | 252.5 | 3672 |
| 8640 min Summer | 1.220 | 0.0 | 262.2 | 4384 |
| 10080 min Summer | 1.080 | 0.0 | 270.7 | 5120 |
| 15 min Winter | 122.474 | 0.0 | 51.0 | 18 |

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

| Storm Event | Max Level (m) | Max Depth (m) | Max Infiltration (l/s) | Max Control (l/s) | Max Σ Outflow (l/s) | Max Volume (m³) | Status |
|---|---|---|---|---|---|---|---|
| 30 min Winter | 71.837 | 0.677 | 0.0 | 5.0 | 5.0 | 62.2 | O K |
| 60 min Winter | 72.138 | 0.978 | 0.0 | 5.0 | 5.0 | 75.5 | O K |
| 120 min Winter | 72.312 | 1.152 | 0.0 | 5.0 | 5.0 | 83.2 | O K |
| 180 min Winter | 72.310 | 1.150 | 0.0 | 5.0 | 5.0 | 83.1 | O K |
| 240 min Winter | 72.272 | 1.112 | 0.0 | 5.0 | 5.0 | 81.4 | O K |
| 360 min Winter | 72.152 | 0.992 | 0.0 | 5.0 | 5.0 | 76.1 | O K |
| 480 min Winter | 72.007 | 0.847 | 0.0 | 5.0 | 5.0 | 69.7 | O K |
| 600 min Winter | 71.812 | 0.652 | 0.0 | 5.0 | 5.0 | 61.1 | O K |
| 720 min Winter | 71.706 | 0.546 | 0.0 | 5.0 | 5.0 | 53.4 | O K |
| 960 min Winter | 71.572 | 0.412 | 0.0 | 5.0 | 5.0 | 40.4 | O K |
| 1440 min Winter | 71.392 | 0.232 | 0.0 | 4.8 | 4.8 | 22.8 | O K |
| 2160 min Winter | 71.284 | 0.124 | 0.0 | 4.2 | 4.2 | 12.1 | O K |
| 2880 min Winter | 71.259 | 0.099 | 0.0 | 3.4 | 3.4 | 9.7 | O K |
| 4320 min Winter | 71.237 | 0.077 | 0.0 | 2.5 | 2.5 | 7.5 | O K |
| 5760 min Winter | 71.226 | 0.066 | 0.0 | 2.0 | 2.0 | 6.5 | O K |
| 7200 min Winter | 71.220 | 0.060 | 0.0 | 1.7 | 1.7 | 5.8 | O K |
| 8640 min Winter | 71.215 | 0.055 | 0.0 | 1.4 | 1.4 | 5.3 | O K |
| 10080 min Winter | 71.211 | 0.051 | 0.0 | 1.3 | 1.3 | 5.0 | O K |

| Storm Event | Rain (mm/hr) | Flooded Volume (m³) | Discharge Volume (m³) | Time-Peak (mins) |
|---|---|---|---|---|
| 30 min Winter | 82.355 | 0.0 | 68.6 | 32 |
| 60 min Winter | 52.892 | 0.0 | 88.3 | 60 |
| 120 min Winter | 32.827 | 0.0 | 109.6 | 116 |
| 180 min Winter | 24.479 | 0.0 | 122.7 | 166 |
| 240 min Winter | 19.741 | 0.0 | 131.9 | 188 |
| 360 min Winter | 14.507 | 0.0 | 145.4 | 268 |
| 480 min Winter | 11.659 | 0.0 | 155.8 | 348 |
| 600 min Winter | 9.833 | 0.0 | 164.3 | 416 |
| 720 min Winter | 8.551 | 0.0 | 171.4 | 480 |
| 960 min Winter | 6.853 | 0.0 | 183.2 | 606 |
| 1440 min Winter | 5.007 | 0.0 | 200.7 | 824 |
| 2160 min Winter | 3.650 | 0.0 | 219.6 | 1124 |
| 2880 min Winter | 2.913 | 0.0 | 233.7 | 1472 |
| 4320 min Winter | 2.116 | 0.0 | 254.5 | 2196 |
| 5760 min Winter | 1.684 | 0.0 | 270.3 | 2936 |
| 7200 min Winter | 1.410 | 0.0 | 282.8 | 3648 |
| 8640 min Winter | 1.220 | 0.0 | 293.6 | 4400 |
| 10080 min Winter | 1.080 | 0.0 | 303.2 | 5080 |

## Rainfall Details

| | | | |
|---|---|---|---|
| Rainfall Model | FSR | Winter Storms | Yes |
| Return Period (years) | 100 | Cv (Summer) | 0.750 |
| Region | England and Wales | Cv (Winter) | 0.840 |
| M5-60 (mm) | 18.700 | Shortest Storm (mins) | 15 |
| Ratio R | 0.350 | Longest Storm (mins) | 10080 |
| Summer Storms | Yes | Climate Change % | +40 |

## Time Area Diagram

Total Area (ha) 0.199

| Time (mins) From: | To: | Area (ha) |
|---|---|---|
| 0 | 4 | 0.199 |

## Model Details

Storage is Online Cover Level (m) 73.110

## Complex Structure

### Cellular Storage

Invert Level (m) 71.160 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.89
Infiltration Coefficient Side (m/hr) 0.00000

| Depth (m) | Area (m²) | Inf. Area (m²) | Depth (m) | Area (m²) | Inf. Area (m²) |
|---|---|---|---|---|---|
| 0.000 | 110.0 | 0.0 | 0.601 | 0.0 | 0.0 |
| 0.600 | 110.0 | 0.0 | | | |

### Cellular Storage

Invert Level (m) 71.760 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.79
Infiltration Coefficient Side (m/hr) 0.00000

| Depth (m) | Area (m²) | Inf. Area (m²) | Depth (m) | Area (m²) | Inf. Area (m²) |
|---|---|---|---|---|---|
| 0.000 | 56.0 | 0.0 | 0.601 | 0.0 | 0.0 |
| 0.600 | 56.0 | 0.0 | | | |

### Hydro-Brake® Optimum Outflow Control

| | |
|---|---|
| Unit Reference | MD-SHE-0103-5000-1200-5000 |
| Design Head (m) | 1.200 |
| Design Flow (l/s) | 5.0 |
| Flush-Flo™ | Calculated |
| Objective | Minimise upstream storage |
| Application | Surface |
| Sump Available | Yes |
| Diameter (mm) | 103 |
| Invert Level (m) | 71.160 |
| Minimum Outlet Pipe Diameter (mm) | 150 |
| Suggested Manhole Diameter (mm) | 1200 |

| Control Points | Head (m) | Flow (l/s) |
|---|---|---|
| Design Point (Calculated) | 1.200 | 5.0 |
| Flush-Flo™ | 0.354 | 5.0 |
| Kick-Flo® | 0.745 | 4.0 |
| Mean Flow over Head Range | - | 4.4 |

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

## Hydro-Brake® Optimum Outflow Control

| Depth (m) | Flow (l/s) | Depth (m) | Flow (l/s) | Depth (m) | Flow (l/s) | Depth (m) | Flow (l/s) |
|---|---|---|---|---|---|---|---|
| 0.100 | 3.4 | 1.200 | 5.0 | 3.000 | 7.7 | 7.000 | 11.5 |
| 0.200 | 4.7 | 1.400 | 5.4 | 3.500 | 8.3 | 7.500 | 11.8 |
| 0.300 | 5.0 | 1.600 | 5.7 | 4.000 | 8.8 | 8.000 | 12.2 |
| 0.400 | 5.0 | 1.800 | 6.0 | 4.500 | 9.3 | 8.500 | 12.6 |
| 0.500 | 4.9 | 2.000 | 6.3 | 5.000 | 9.8 | 9.000 | 12.9 |
| 0.600 | 4.7 | 2.200 | 6.6 | 5.500 | 10.2 | 9.500 | 13.3 |
| 0.800 | 4.1 | 2.400 | 6.9 | 6.000 | 10.7 | | |
| 1.000 | 4.6 | 2.600 | 7.2 | 6.500 | 11.1 | | |

## Summary of Results for 30 year Return Period (+40%)

Half Drain Time : 104 minutes.

| Storm Event | Max Level (m) | Max Depth (m) | Max Infiltration (l/s) | Max Control (l/s) | Max Σ Outflow (l/s) | Max Volume (m³) | Status |
|---|---|---|---|---|---|---|---|
| 15 min Summer | 71.488 | 0.328 | 0.0 | 5.0 | 5.0 | 32.1 | O K |
| 30 min Summer | 71.577 | 0.417 | 0.0 | 5.0 | 5.0 | 40.8 | O K |
| 60 min Summer | 71.646 | 0.486 | 0.0 | 5.0 | 5.0 | 47.5 | O K |
| 120 min Summer | 71.676 | 0.516 | 0.0 | 5.0 | 5.0 | 50.5 | O K |
| 180 min Summer | 71.674 | 0.514 | 0.0 | 5.0 | 5.0 | 50.4 | O K |
| 240 min Summer | 71.661 | 0.501 | 0.0 | 5.0 | 5.0 | 49.0 | O K |
| 360 min Summer | 71.622 | 0.462 | 0.0 | 5.0 | 5.0 | 45.2 | O K |
| 480 min Summer | 71.581 | 0.421 | 0.0 | 5.0 | 5.0 | 41.2 | O K |
| 600 min Summer | 71.542 | 0.382 | 0.0 | 5.0 | 5.0 | 37.4 | O K |
| 720 min Summer | 71.505 | 0.345 | 0.0 | 5.0 | 5.0 | 33.8 | O K |
| 960 min Summer | 71.441 | 0.281 | 0.0 | 5.0 | 5.0 | 27.6 | O K |
| 1440 min Summer | 71.354 | 0.194 | 0.0 | 4.7 | 4.7 | 19.0 | O K |
| 2160 min Summer | 71.289 | 0.129 | 0.0 | 4.3 | 4.3 | 12.6 | O K |
| 2880 min Summer | 71.266 | 0.106 | 0.0 | 3.6 | 3.6 | 10.3 | O K |
| 4320 min Summer | 71.243 | 0.083 | 0.0 | 2.7 | 2.7 | 8.1 | O K |
| 5760 min Summer | 71.232 | 0.072 | 0.0 | 2.2 | 2.2 | 7.0 | O K |
| 7200 min Summer | 71.224 | 0.064 | 0.0 | 1.9 | 1.9 | 6.3 | O K |
| 8640 min Summer | 71.219 | 0.059 | 0.0 | 1.6 | 1.6 | 5.8 | O K |
| 10080 min Summer | 71.215 | 0.055 | 0.0 | 1.5 | 1.5 | 5.4 | O K |
| 15 min Winter | 71.530 | 0.370 | 0.0 | 5.0 | 5.0 | 36.2 | O K |

| Storm Event | Rain (mm/hr) | Flooded Volume (m³) | Discharge Volume (m³) | Time-Peak (mins) |
|---|---|---|---|---|
| 15 min Summer | 94.759 | 0.0 | 35.2 | 18 |
| 30 min Summer | 63.095 | 0.0 | 46.9 | 32 |
| 60 min Summer | 40.269 | 0.0 | 60.0 | 60 |
| 120 min Summer | 24.964 | 0.0 | 74.4 | 96 |
| 180 min Summer | 18.667 | 0.0 | 83.5 | 130 |
| 240 min Summer | 15.114 | 0.0 | 90.1 | 164 |
| 360 min Summer | 11.184 | 0.0 | 100.1 | 232 |
| 480 min Summer | 9.030 | 0.0 | 107.7 | 298 |
| 600 min Summer | 7.644 | 0.0 | 114.0 | 362 |
| 720 min Summer | 6.669 | 0.0 | 119.3 | 426 |
| 960 min Summer | 5.373 | 0.0 | 128.2 | 548 |
| 1440 min Summer | 3.957 | 0.0 | 141.6 | 780 |
| 2160 min Summer | 2.910 | 0.0 | 156.3 | 1124 |
| 2880 min Summer | 2.338 | 0.0 | 167.4 | 1472 |
| 4320 min Summer | 1.715 | 0.0 | 184.2 | 2204 |
| 5760 min Summer | 1.376 | 0.0 | 197.1 | 2936 |
| 7200 min Summer | 1.159 | 0.0 | 207.5 | 3672 |
| 8640 min Summer | 1.008 | 0.0 | 216.5 | 4384 |
| 10080 min Summer | 0.896 | 0.0 | 224.4 | 5048 |
| 15 min Winter | 94.759 | 0.0 | 39.4 | 18 |

## Summary of Results for 30 year Return Period (+40%)

| Storm Event | Max Level (m) | Max Depth (m) | Max Infiltration (l/s) | Max Control (l/s) | Max Σ Outflow (l/s) | Max Volume (m³) | Status |
|---|---|---|---|---|---|---|---|
| 30 min Winter | 71.633 | 0.473 | 0.0 | 5.0 | 5.0 | 46.3 | O K |
| 60 min Winter | 71.717 | 0.557 | 0.0 | 5.0 | 5.0 | 54.6 | O K |
| 120 min Winter | 71.755 | 0.595 | 0.0 | 5.0 | 5.0 | 58.3 | O K |
| 180 min Winter | 71.747 | 0.587 | 0.0 | 5.0 | 5.0 | 57.5 | O K |
| 240 min Winter | 71.725 | 0.565 | 0.0 | 5.0 | 5.0 | 55.3 | O K |
| 360 min Winter | 71.663 | 0.503 | 0.0 | 5.0 | 5.0 | 49.2 | O K |
| 480 min Winter | 71.597 | 0.437 | 0.0 | 5.0 | 5.0 | 42.8 | O K |
| 600 min Winter | 71.535 | 0.375 | 0.0 | 5.0 | 5.0 | 36.7 | O K |
| 720 min Winter | 71.480 | 0.320 | 0.0 | 5.0 | 5.0 | 31.3 | O K |
| 960 min Winter | 71.393 | 0.233 | 0.0 | 4.9 | 4.9 | 22.8 | O K |
| 1440 min Winter | 71.296 | 0.136 | 0.0 | 4.3 | 4.3 | 13.3 | O K |
| 2160 min Winter | 71.258 | 0.098 | 0.0 | 3.4 | 3.4 | 9.6 | O K |
| 2880 min Winter | 71.242 | 0.082 | 0.0 | 2.7 | 2.7 | 8.1 | O K |
| 4320 min Winter | 71.227 | 0.067 | 0.0 | 2.0 | 2.0 | 6.6 | O K |
| 5760 min Winter | 71.219 | 0.059 | 0.0 | 1.6 | 1.6 | 5.7 | O K |
| 7200 min Winter | 71.213 | 0.053 | 0.0 | 1.4 | 1.4 | 5.2 | O K |
| 8640 min Winter | 71.209 | 0.049 | 0.0 | 1.2 | 1.2 | 4.8 | O K |
| 10080 min Winter | 71.206 | 0.046 | 0.0 | 1.0 | 1.0 | 4.5 | O K |

| Storm Event | Rain (mm/hr) | Flooded Volume (m³) | Discharge Volume (m³) | Time-Peak (mins) |
|---|---|---|---|---|
| 30 min Winter | 63.095 | 0.0 | 52.5 | 32 |
| 60 min Winter | 40.269 | 0.0 | 67.2 | 60 |
| 120 min Winter | 24.964 | 0.0 | 83.4 | 114 |
| 180 min Winter | 18.667 | 0.0 | 93.5 | 142 |
| 240 min Winter | 15.114 | 0.0 | 101.0 | 180 |
| 360 min Winter | 11.184 | 0.0 | 112.1 | 252 |
| 480 min Winter | 9.030 | 0.0 | 120.6 | 322 |
| 600 min Winter | 7.644 | 0.0 | 127.7 | 388 |
| 720 min Winter | 6.669 | 0.0 | 133.6 | 450 |
| 960 min Winter | 5.373 | 0.0 | 143.6 | 568 |
| 1440 min Winter | 3.957 | 0.0 | 158.6 | 780 |
| 2160 min Winter | 2.910 | 0.0 | 175.1 | 1124 |
| 2880 min Winter | 2.338 | 0.0 | 187.5 | 1472 |
| 4320 min Winter | 1.715 | 0.0 | 206.3 | 2192 |
| 5760 min Winter | 1.376 | 0.0 | 220.7 | 2928 |
| 7200 min Winter | 1.159 | 0.0 | 232.4 | 3608 |
| 8640 min Winter | 1.008 | 0.0 | 242.5 | 4328 |
| 10080 min Winter | 0.896 | 0.0 | 251.3 | 5136 |

## Rainfall Details

| | | | |
|---|---|---|---|
| Rainfall Model | FSR | Winter Storms | Yes |
| Return Period (years) | 30 | Cv (Summer) | 0.750 |
| Region | England and Wales | Cv (Winter) | 0.840 |
| M5-60 (mm) | 18.700 | Shortest Storm (mins) | 15 |
| Ratio R | 0.350 | Longest Storm (mins) | 10080 |
| Summer Storms | Yes | Climate Change % | +40 |

## Time Area Diagram

Total Area (ha) 0.199

| Time (mins) From: | To: | Area (ha) |
|---|---|---|
| 0 | 4 | 0.199 |

## Model Details

Storage is Online Cover Level (m) 73.110

## Complex Structure

### Cellular Storage

Invert Level (m) 71.160 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.89
Infiltration Coefficient Side (m/hr) 0.00000

| Depth (m) | Area (m²) | Inf. Area (m²) | Depth (m) | Area (m²) | Inf. Area (m²) |
|---|---|---|---|---|---|
| 0.000 | 110.0 | 0.0 | 0.601 | 0.0 | 0.0 |
| 0.600 | 110.0 | 0.0 | | | |

### Cellular Storage

Invert Level (m) 71.760 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.79
Infiltration Coefficient Side (m/hr) 0.00000

| Depth (m) | Area (m²) | Inf. Area (m²) | Depth (m) | Area (m²) | Inf. Area (m²) |
|---|---|---|---|---|---|
| 0.000 | 56.0 | 0.0 | 0.601 | 0.0 | 0.0 |
| 0.600 | 56.0 | 0.0 | | | |

### Hydro-Brake® Optimum Outflow Control

| | |
|---|---|
| Unit Reference | MD-SHE-0103-5000-1200-5000 |
| Design Head (m) | 1.200 |
| Design Flow (l/s) | 5.0 |
| Flush-Flo™ | Calculated |
| Objective | Minimise upstream storage |
| Application | Surface |
| Sump Available | Yes |
| Diameter (mm) | 103 |
| Invert Level (m) | 71.160 |
| Minimum Outlet Pipe Diameter (mm) | 150 |
| Suggested Manhole Diameter (mm) | 1200 |

| Control Points | Head (m) | Flow (l/s) |
|---|---|---|
| Design Point (Calculated) | 1.200 | 5.0 |
| Flush-Flo™ | 0.354 | 5.0 |
| Kick-Flo® | 0.745 | 4.0 |
| Mean Flow over Head Range | - | 4.4 |

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

## Hydro-Brake® Optimum Outflow Control

| Depth (m) | Flow (l/s) | Depth (m) | Flow (l/s) | Depth (m) | Flow (l/s) | Depth (m) | Flow (l/s) |
|---|---|---|---|---|---|---|---|
| 0.100 | 3.4 | 1.200 | 5.0 | 3.000 | 7.7 | 7.000 | 11.5 |
| 0.200 | 4.7 | 1.400 | 5.4 | 3.500 | 8.3 | 7.500 | 11.8 |
| 0.300 | 5.0 | 1.600 | 5.7 | 4.000 | 8.8 | 8.000 | 12.2 |
| 0.400 | 5.0 | 1.800 | 6.0 | 4.500 | 9.3 | 8.500 | 12.6 |
| 0.500 | 4.9 | 2.000 | 6.3 | 5.000 | 9.8 | 9.000 | 12.9 |
| 0.600 | 4.7 | 2.200 | 6.6 | 5.500 | 10.2 | 9.500 | 13.3 |
| 0.800 | 4.1 | 2.400 | 6.9 | 6.000 | 10.7 | | |
| 1.000 | 4.6 | 2.600 | 7.2 | 6.500 | 11.1 | | |

## Summary of Results for 1 year Return Period (+40%)

Half Drain Time : 41 minutes.

| Storm Event | Max Level (m) | Max Depth (m) | Max Infiltration (l/s) | Max Control (l/s) | Max Σ Outflow (l/s) | Max Volume (m³) | Status |
|---|---|---|---|---|---|---|---|
| 15 min Summer | 71.286 | 0.126 | 0.0 | 4.2 | 4.2 | 12.4 | O K |
| 30 min Summer | 71.312 | 0.152 | 0.0 | 4.5 | 4.5 | 14.9 | O K |
| 60 min Summer | 71.333 | 0.173 | 0.0 | 4.6 | 4.6 | 17.0 | O K |
| 120 min Summer | 71.343 | 0.183 | 0.0 | 4.6 | 4.6 | 17.9 | O K |
| 180 min Summer | 71.340 | 0.180 | 0.0 | 4.6 | 4.6 | 17.6 | O K |
| 240 min Summer | 71.332 | 0.172 | 0.0 | 4.6 | 4.6 | 16.8 | O K |
| 360 min Summer | 71.314 | 0.154 | 0.0 | 4.5 | 4.5 | 15.0 | O K |
| 480 min Summer | 71.297 | 0.137 | 0.0 | 4.3 | 4.3 | 13.4 | O K |
| 600 min Summer | 71.284 | 0.124 | 0.0 | 4.2 | 4.2 | 12.2 | O K |
| 720 min Summer | 71.275 | 0.115 | 0.0 | 3.9 | 3.9 | 11.3 | O K |
| 960 min Summer | 71.262 | 0.102 | 0.0 | 3.5 | 3.5 | 10.0 | O K |
| 1440 min Summer | 71.245 | 0.085 | 0.0 | 2.9 | 2.9 | 8.4 | O K |
| 2160 min Summer | 71.233 | 0.073 | 0.0 | 2.3 | 2.3 | 7.1 | O K |
| 2880 min Summer | 71.225 | 0.065 | 0.0 | 1.9 | 1.9 | 6.3 | O K |
| 4320 min Summer | 71.215 | 0.055 | 0.0 | 1.5 | 1.5 | 5.4 | O K |
| 5760 min Summer | 71.210 | 0.050 | 0.0 | 1.2 | 1.2 | 4.8 | O K |
| 7200 min Summer | 71.206 | 0.046 | 0.0 | 1.0 | 1.0 | 4.5 | O K |
| 8640 min Summer | 71.203 | 0.043 | 0.0 | 0.9 | 0.9 | 4.2 | O K |
| 10080 min Summer | 71.200 | 0.040 | 0.0 | 0.8 | 0.8 | 3.9 | O K |
| 15 min Winter | 71.302 | 0.142 | 0.0 | 4.4 | 4.4 | 13.9 | O K |

| Storm Event | Rain (mm/hr) | Flooded Volume (m³) | Discharge Volume (m³) | Time-Peak (mins) |
|---|---|---|---|---|
| 15 min Summer | 38.710 | 0.0 | 14.3 | 16 |
| 30 min Summer | 25.668 | 0.0 | 19.0 | 27 |
| 60 min Summer | 16.619 | 0.0 | 24.7 | 44 |
| 120 min Summer | 10.573 | 0.0 | 31.5 | 78 |
| 180 min Summer | 8.082 | 0.0 | 36.1 | 112 |
| 240 min Summer | 6.675 | 0.0 | 39.8 | 146 |
| 360 min Summer | 5.070 | 0.0 | 45.3 | 208 |
| 480 min Summer | 4.155 | 0.0 | 49.5 | 268 |
| 600 min Summer | 3.561 | 0.0 | 53.0 | 326 |
| 720 min Summer | 3.140 | 0.0 | 56.1 | 386 |
| 960 min Summer | 2.574 | 0.0 | 61.3 | 508 |
| 1440 min Summer | 1.947 | 0.0 | 69.6 | 748 |
| 2160 min Summer | 1.472 | 0.0 | 79.1 | 1104 |
| 2880 min Summer | 1.207 | 0.0 | 86.4 | 1468 |
| 4320 min Summer | 0.913 | 0.0 | 97.9 | 2204 |
| 5760 min Summer | 0.749 | 0.0 | 107.3 | 2936 |
| 7200 min Summer | 0.643 | 0.0 | 115.1 | 3648 |
| 8640 min Summer | 0.567 | 0.0 | 121.8 | 4368 |
| 10080 min Summer | 0.509 | 0.0 | 127.4 | 5080 |
| 15 min Winter | 38.710 | 0.0 | 16.0 | 16 |

## Summary of Results for 1 year Return Period (+40%)

| Storm Event | Max Level (m) | Max Depth (m) | Max Infiltration (l/s) | Max Control (l/s) | Max Σ Outflow (l/s) | Max Volume (m³) | Status |
|---|---|---|---|---|---|---|---|
| 30 min Winter | 71.333 | 0.173 | 0.0 | 4.6 | 4.6 | 16.9 | O K |
| 60 min Winter | 71.353 | 0.193 | 0.0 | 4.7 | 4.7 | 18.9 | O K |
| 120 min Winter | 71.357 | 0.197 | 0.0 | 4.7 | 4.7 | 19.3 | O K |
| 180 min Winter | 71.346 | 0.186 | 0.0 | 4.7 | 4.7 | 18.2 | O K |
| 240 min Winter | 71.332 | 0.172 | 0.0 | 4.6 | 4.6 | 16.8 | O K |
| 360 min Winter | 71.303 | 0.143 | 0.0 | 4.4 | 4.4 | 14.0 | O K |
| 480 min Winter | 71.282 | 0.122 | 0.0 | 4.1 | 4.1 | 11.9 | O K |
| 600 min Winter | 71.269 | 0.109 | 0.0 | 3.7 | 3.7 | 10.6 | O K |
| 720 min Winter | 71.259 | 0.099 | 0.0 | 3.4 | 3.4 | 9.7 | O K |
| 960 min Winter | 71.246 | 0.086 | 0.0 | 2.9 | 2.9 | 8.4 | O K |
| 1440 min Winter | 71.232 | 0.072 | 0.0 | 2.2 | 2.2 | 7.0 | O K |
| 2160 min Winter | 71.221 | 0.061 | 0.0 | 1.7 | 1.7 | 5.9 | O K |
| 2880 min Winter | 71.214 | 0.054 | 0.0 | 1.4 | 1.4 | 5.3 | O K |
| 4320 min Winter | 71.206 | 0.046 | 0.0 | 1.1 | 1.1 | 4.5 | O K |
| 5760 min Winter | 71.202 | 0.042 | 0.0 | 0.9 | 0.9 | 4.1 | O K |
| 7200 min Winter | 71.198 | 0.038 | 0.0 | 0.8 | 0.8 | 3.7 | O K |
| 8640 min Winter | 71.196 | 0.036 | 0.0 | 0.7 | 0.7 | 3.5 | O K |
| 10080 min Winter | 71.194 | 0.034 | 0.0 | 0.6 | 0.6 | 3.3 | O K |

| Storm Event | Rain (mm/hr) | Flooded Volume (m³) | Discharge Volume (m³) | Time-Peak (mins) |
|---|---|---|---|---|
| 30 min Winter | 25.668 | 0.0 | 21.3 | 29 |
| 60 min Winter | 16.619 | 0.0 | 27.7 | 48 |
| 120 min Winter | 10.573 | 0.0 | 35.3 | 86 |
| 180 min Winter | 8.082 | 0.0 | 40.4 | 120 |
| 240 min Winter | 6.675 | 0.0 | 44.5 | 154 |
| 360 min Winter | 5.070 | 0.0 | 50.8 | 216 |
| 480 min Winter | 4.155 | 0.0 | 55.5 | 274 |
| 600 min Winter | 3.561 | 0.0 | 59.4 | 334 |
| 720 min Winter | 3.140 | 0.0 | 62.9 | 394 |
| 960 min Winter | 2.574 | 0.0 | 68.7 | 512 |
| 1440 min Winter | 1.947 | 0.0 | 77.9 | 750 |
| 2160 min Winter | 1.472 | 0.0 | 88.6 | 1104 |
| 2880 min Winter | 1.207 | 0.0 | 96.8 | 1468 |
| 4320 min Winter | 0.913 | 0.0 | 109.7 | 2204 |
| 5760 min Winter | 0.749 | 0.0 | 120.2 | 2920 |
| 7200 min Winter | 0.643 | 0.0 | 129.0 | 3584 |
| 8640 min Winter | 0.567 | 0.0 | 136.4 | 4296 |
| 10080 min Winter | 0.509 | 0.0 | 142.7 | 5008 |

## Rainfall Details

| | | | |
|---|---|---|---|
| Rainfall Model | FSR | Winter Storms | Yes |
| Return Period (years) | 1 | Cv (Summer) | 0.750 |
| Region | England and Wales | Cv (Winter) | 0.840 |
| M5-60 (mm) | 18.700 | Shortest Storm (mins) | 15 |
| Ratio R | 0.350 | Longest Storm (mins) | 10080 |
| Summer Storms | Yes | Climate Change % | +40 |

## Time Area Diagram

Total Area (ha) 0.199

| Time (mins) From: | To: | Area (ha) |
|---|---|---|
| 0 | 4 | 0.199 |

## Model Details

Storage is Online Cover Level (m) 73.110

## Complex Structure

### Cellular Storage

Invert Level (m) 71.160 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.89
Infiltration Coefficient Side (m/hr) 0.00000

| Depth (m) | Area (m²) | Inf. Area (m²) | Depth (m) | Area (m²) | Inf. Area (m²) |
|---|---|---|---|---|---|
| 0.000 | 110.0 | 0.0 | 0.601 | 0.0 | 0.0 |
| 0.600 | 110.0 | 0.0 | | | |

### Cellular Storage

Invert Level (m) 71.760 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.79
Infiltration Coefficient Side (m/hr) 0.00000

| Depth (m) | Area (m²) | Inf. Area (m²) | Depth (m) | Area (m²) | Inf. Area (m²) |
|---|---|---|---|---|---|
| 0.000 | 56.0 | 0.0 | 0.601 | 0.0 | 0.0 |
| 0.600 | 56.0 | 0.0 | | | |

### Hydro-Brake® Optimum Outflow Control

| | |
|---|---|
| Unit Reference | MD-SHE-0103-5000-1200-5000 |
| Design Head (m) | 1.200 |
| Design Flow (l/s) | 5.0 |
| Flush-Flo™ | Calculated |
| Objective | Minimise upstream storage |
| Application | Surface |
| Sump Available | Yes |
| Diameter (mm) | 103 |
| Invert Level (m) | 71.160 |
| Minimum Outlet Pipe Diameter (mm) | 150 |
| Suggested Manhole Diameter (mm) | 1200 |

| Control Points | Head (m) | Flow (l/s) |
|---|---|---|
| Design Point (Calculated) | 1.200 | 5.0 |
| Flush-Flo™ | 0.354 | 5.0 |
| Kick-Flo® | 0.745 | 4.0 |
| Mean Flow over Head Range | - | 4.4 |

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

## Hydro-Brake® Optimum Outflow Control

| Depth (m) | Flow (l/s) | Depth (m) | Flow (l/s) | Depth (m) | Flow (l/s) | Depth (m) | Flow (l/s) |
|---|---|---|---|---|---|---|---|
| 0.100 | 3.4 | 1.200 | 5.0 | 3.000 | 7.7 | 7.000 | 11.5 |
| 0.200 | 4.7 | 1.400 | 5.4 | 3.500 | 8.3 | 7.500 | 11.8 |
| 0.300 | 5.0 | 1.600 | 5.7 | 4.000 | 8.8 | 8.000 | 12.2 |
| 0.400 | 5.0 | 1.800 | 6.0 | 4.500 | 9.3 | 8.500 | 12.6 |
| 0.500 | 4.9 | 2.000 | 6.3 | 5.000 | 9.8 | 9.000 | 12.9 |
| 0.600 | 4.7 | 2.200 | 6.6 | 5.500 | 10.2 | 9.500 | 13.3 |
| 0.800 | 4.1 | 2.400 | 6.9 | 6.000 | 10.7 | | |
| 1.000 | 4.6 | 2.600 | 7.2 | 6.500 | 11.1 | | |