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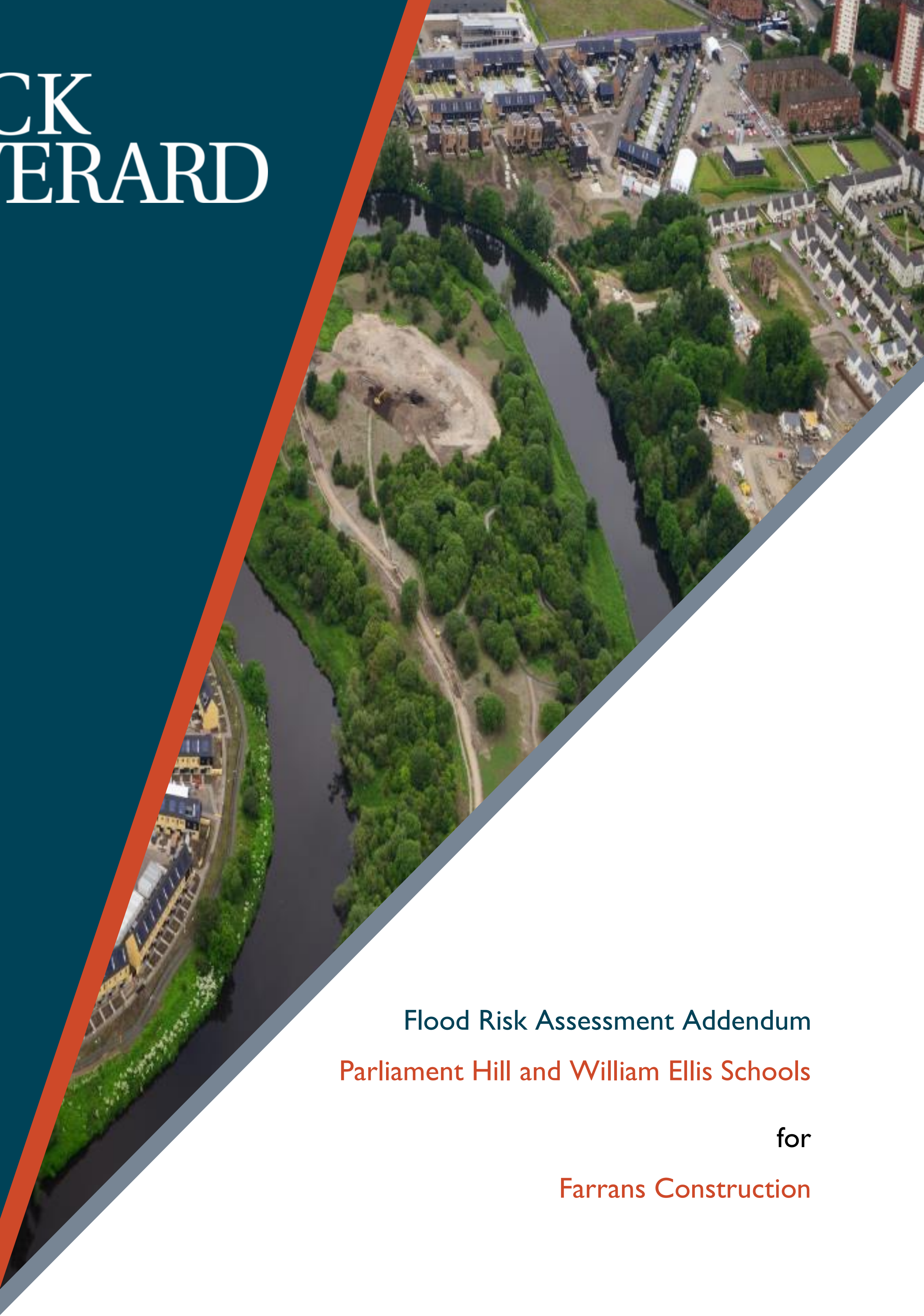


Flood Risk Assessment Addendum

Parliament Hill and William Ellis Schools

for

Farrans Construction

Issue Number 02
September 2017

Document History

Issue	Date	Comment	Author	Chk'd
01	31/08/17		EST	ART
02	September 2017	Minor amendments and addition of App C	EST	EST

Contents

1.0 Introduction

1.1 General

Pick Everard has been instructed by Farrans Construction to provide and addendum to a previous Flood Risk Assessment (FRA) for the proposed development of Parliament Hill and William Ellis Schools. The original FRA was undertaken by Pick Everard in June 2014, REF: 140423/R00, and was approved under planning permission 2014/7683/P. As part of that planning application information was subsequently submitted and approved under Condition 21(SUDs). That information will be submitted again for completeness with this assessment.

The addendum is required due to changes in the proposed development, which have reduced the footprint of the new build. Please see the Design and Access Statement for the full details of the revised proposals.

This assessment will only evaluate elements of the previous FRA that are different due to the proposed changes to the development or updates in legislation. Therefore this report should be read in conjunction with Pick Everard Report 140423/R001 dated June 2014, which is included in Appendix C.

The original assessment referred to the following documents:

- 'Core Strategy 2010 – 2025' London Borough of Camden 2010
- 'Camden Development Policies 2010 – 2025' London Borough of Camden 2010
- 'Floods in Camden' Report of the Floods Scrutiny Panel, London Borough of Camden 2003
- 'Surface Water Management Plan for the London Borough of Camden', Halcrow 2011
- 'Camden Flood Risk Management Strategy' London Borough of Camden 2013
- 'The History of the River Fleet' UCL River Fleet Restoration Team 2009

It should be noted that some of these documents have been updated as follows:

- The Camden Plan June 2017 – replaces the core strategy and Camden Development Policies
- London Borough of Camden Strategic Flood Risk Assessment – July 2014

3.0 Site Setting

3.1 Site Description and Layout

The site comprises two schools, Parliament Hill and William Ellis, which are adjacent and located immediately to the west of Highgate Road in Camden. It is approximately centred on 528358, 186013.

The site location is shown in Figure 1 and the existing site layout is presented in Appendix 1 of the 2014 FRA report.

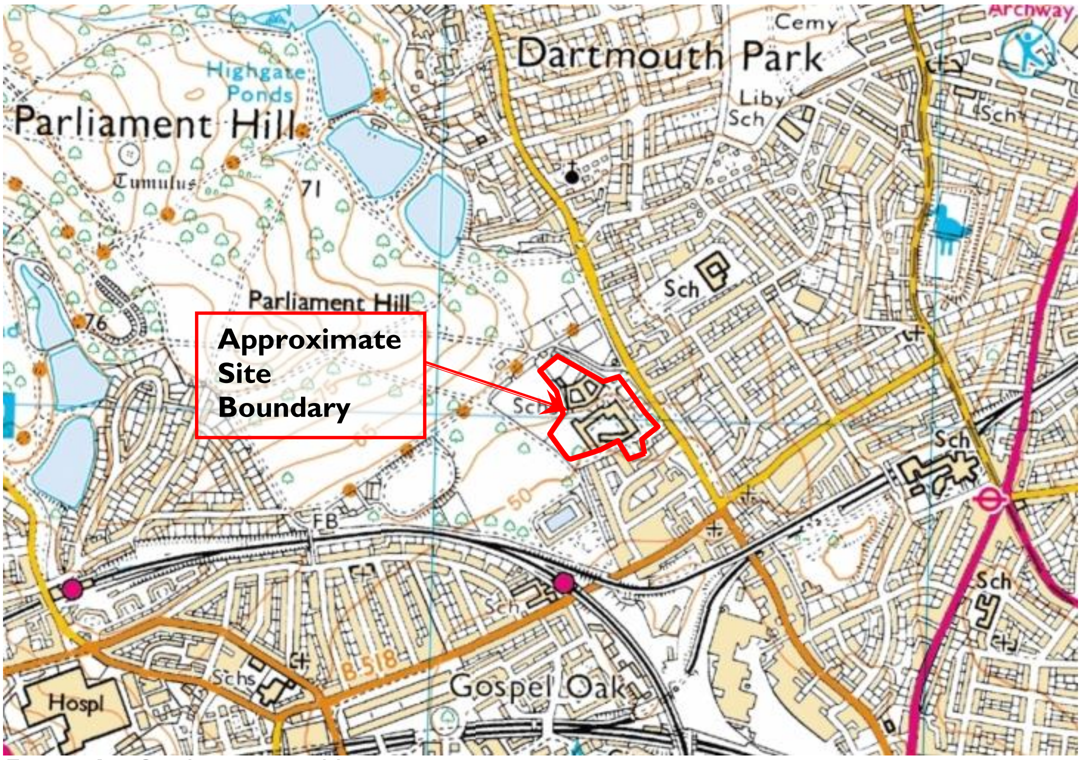


Figure 1 – Site Location and Layout

Parliament Hill School occupies the southern part of the site and covers approximately 25080m^2, while William Ellis School, which occupies the northern part of the site, covers approximately 10490m^2.

Both schools consist of single and multi-storey buildings and a mixture of soft and hard landscaping.

The site is bounded to the north and west by parkland, to the south by flats with gardens and to the east by Highgate Road, beyond which is housing with gardens. Surrounding land use consists predominantly of housing and public parkland.

3.2 Proposed Development

The proposed developments comprise demolition of some school buildings, construction of new school buildings, new sports facilities and car parking. The proposed masterplan of the development is shown in Figure 2, below;

Figure 2 – Proposed Development

The works will not change the classification of the site use, which is classed as more vulnerable, as defined in the NPPF Technical Guidance.

3.3 Geology and Hydrogeology

The site is underlain by London Clay, which the Environment Agency classifies as unproductive strata in terms of water supply. No superficial deposits are indicated. The site is not within a Groundwater Source Protection Zone and there are none within 1km.

3.4 Topography

A topographical survey undertaken for Gardiner and Theobold in October 2013 indicates that Ground elevations range from 49.0m AOD in the south-west of the site to a maximum of 57.87m AOD in the north. The ground generally rises gently to the north, although there are parts of the site where slopes are slightly steeper where areas of flat ground have been created to accommodate buildings.

4.0 Surface Water Management

4.1 General

The following is an assessment of surface water drainage from the site and the implications for the proposed development.

Run-off calculations have been based on rainfall events with return periods of 1, 30 and 100 years. These return periods have been chosen because they represent key events in terms of risk assessment and drainage design. The 1 year event represents the storm intensity that is likely to be experienced on an annual basis. The 30 year storm represents a common design standard for surface drainage systems, while the 100 year storm is the usual design standard for developments in terms of safety and drainage.

4.2 Existing Site Drainage

Approximately 2.3ha of the total site area is currently occupied by buildings and hard standing from which drainage is expected to be by run-off to a subsurface network of pipes connected to the public sewer system. The remainder of the site is occupied by grass playing fields and soft landscaping where drainage is expected to be mainly by infiltration.

It should be noted that we have not undertaken a survey of the site drainage

4.2.1 Existing and proposed Run-Off Rates

The minimum requirement of the NPPF / BREEAM is that run-off from new development does not exceed pre-development rates for all storms up to the 1:100 year event, when accounting for an increase in storm intensity as a result of climate change. The London Plan and the London Borough of Camden's Planning Policy Guidance CC3 (from the Camden Local Plan) have more stringent conditions, requiring run-off for new developments to be attenuated to Greenfield rates, or as close as possible.

The development comprises approximately 8,150m^2 of hard standing to replace approximately 11,900m^2 of hard-standing, which represents an overall decrease. However in order to take into account the predicted increase in run-off rates resulting from the effects of climate change and to achieve the attenuation required by the North London SFRA and Planning Guidance attenuation measures will be required, such as flow control and infiltration or storage structures.

An estimate of the current rates of run-off has been made using the Institute of Hydrology Report No. 124 (IoH 124) methodology. The Greenfield run-off rates for the total area of hard surfaces of the new developments are presented in the table below and the calculations are included in Appendix A.

Storm Return Period (years)	Greenfield Run-Off Rate (l/s)
1	3.08
30	8.33
100	11.55

***Table 1** – Greenfield run-off rates*

4.2.3 Storage and Flow Requirements

An estimate of the storage requirement for 1:30 and 1:100 year storms has been calculated based on limiting run-off from the total area of hard surfaces of the proposed development areas to Greenfield rates. However attenuating to the 1:1 year Greenfield rate would result in a discharge rate of less than 5l/s which is generally considered as the minimum flow rate necessary for the effective functioning of a piped drainage system. In this case, storage volumes have been estimated for a minimum rate of 5l/s with an allowance for

An estimate of the storage requirements for 1:30 and 1:100 year storms has been calculated using the WinDes Quick Storage Estimate. The estimated storage volumes are presented for allowable discharge rates corresponding to a 30% improvement on the existing 1year peak run-off rates. The calculations are included in Appendix B.

Attenuation Scenario	Allowable Discharge Rate (l/s)	Estimated Storage Requirement for 1:30 year event (m^3)	Estimated Storage Requirement for 1:100 year event (m^3)
Minimum achievable greenfield 1:1yr rate	5	234-318	452-592

***Table 2** – Estimated storage requirements*

The calculations in this report are indicative and should not be used for design purposes. The required run-off rates and storage volumes should be optimised during the detailed design stage.

The figures indicate that a up to 592m^3 of rainwater will need to be infiltrated and / or stored on-site in order to achieve a 20% improvement for a 1:100 year storm event. Furthermore, up to 318m^3 of this volume should be available within the site drainage infrastructure, to ensure the system does not result in surface flooding during a 1:30 year event.

4.3 Potential Solutions

A detailed drainage strategy will accompany the application titled ‘Surface Water Drainage Design Strategy For Parliament Hill School, William Ellis School & La Swap Sixth Form College’, prepared by Doran Consulting.

NPPF Technical Guidance and the Environment Agency generally require that new drainage incorporates Sustainable Drainage Systems (SUDS) measures where possible, to reduce and control surface water run-off. The London Plan and Camden’s Planning Guidance CC3 goes further in requiring SUDS unless there are practical reasons for not doing so.

A SUDS hierarchy provided in the London Plan and Camden Planning Guidance CC3 identifies the storage of rainwater for later use (rainwater harvesting) as the preferred solution followed by infiltration measures, such as permeable paving. Storage in open features such as ponds for gradual release is then regarded as the next most preferable measure. Storage in underground attenuation tanks is seen as the least desirable solution.

5.0 Conclusions and Recommendations

5.1 Development Suitability

The site is located within Flood Zone 1 and as such the current and proposed developments are considered suitable for this location.

The site is adjacent to an area which experienced surface water flooding in 1975 and 2002, but the site itself was not flooded and was not surrounded by floodwater. The risk to the site from surface water flooding is therefore considered to be low.

There is a residual risk from flooding from the Highgate Ponds. Although such an event is considered unlikely, the consequences could be significant. The alleviation works planned by the Corporation of London will significantly reduce the likelihood of such an event. The risk of flooding to the site from the ponds is currently considered low, but this will be significantly reduced once the works have been completed.

Considering the overall risks from surface water flooding and the risks of flooding from the ponds, the site is considered to be suitable for the proposed developments.

5.2 Development Safety

Although the risks of flooding to the site are low, in order to manage residual risks related to the failure of the Highgate Pond dams, it is recommended that use is made of any available flood warning information services, and that a plan is developed which details the response to such an event.

5.3 Surface Water Management

In order to limit run-off from the hard surfaces of the proposed development areas to Greenfield run-off rates whilst taking into account future predicted increases in storm intensity as a result of climate change, it has been estimated that the new developments will need the capacity to infiltrate or store up to 592m^3. Up to 318m^3 of this volume should be available in the site drainage infrastructure to avoid surface flooding during a 1:30 year storm.

A detailed drainage strategy will accompany the application titled 'Surface Water Drainage Design Strategy For Parliament Hill School, William Ellis School & La Swap Sixth Form College', prepared by Doran Consulting.

In accordance with the SUDS hierarchy design of the site drainage strategy should give preference to rainwater storage for later use followed by infiltration measures. It should be noted that Camden's development policies require new developments to include green/brown roofs wherever these are suitable.

Geological mapping indicates that the site is underlain by low permeability London Clay which may not be suitable for infiltration measures. However this should be confirmed by appropriate field tests.

Should SUDS measures alone be unable to handle the required volumes any shortfall in the acquired attenuation may be achieved by underground storage structures as a last resort.

It should be noted that the calculations included in this report are indicative and should not be used for design purposes.

The relevant service provider should be contacted prior to development to agree any new connections or changes in discharge rates to the public sewer.

Appendix A

Greenfield Run-Off Calculations

Greenfield runoff estimation for sites

www.uksuds.com | Greenfield runoff tool

HR Wallingford — Working with water

Calculated by:	Emelye Kenyon
Site name:	PHWES
Site location:	PHWES

This is an estimation of the greenfield runoff rate limits that are needed to meet normal best practice criteria in line with Environment Agency guidance "Preliminary rainfall runoff management for developments", W5-074/A/TR1/1 rev. E (2012) and the SuDS Manual, C753 (Ciria, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site coordinates

Latitude:	51.55846° N
Longitude:	0.15051° W
Reference:	6088207
Date:	2017-08-31T12:44:02

Methodology	IH124

Site characteristics

Total site area (ha)	0.815

Methodology

Qbar estimation method	Calculate from SPR and SAAR
SPR estimation method	Calculate from SOIL type

	Default	Edited
SOIL type	4	4
HOST class	---	---
SPR/SPRHOST	0.47	0.47

Hydrological characteristics

	Default	Edited
SAAR (mm)	652	652
Hydrological region	6	6
Growth curve factor: 1 year	0.85	0.85
Growth curve factor: 30 year	2.3	2.3
Growth curve factor: 100 year	3.19	3.19

Notes:

(1) Is Q_{BAR} < 2.0 l/s/ha?

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consents are usually set at 5.0l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set in which case blockage work must be addressed by using appropriate drainage elements

(3) Is SPR/SPRHOST ≤ 0.3?

Greenfield runoff rates

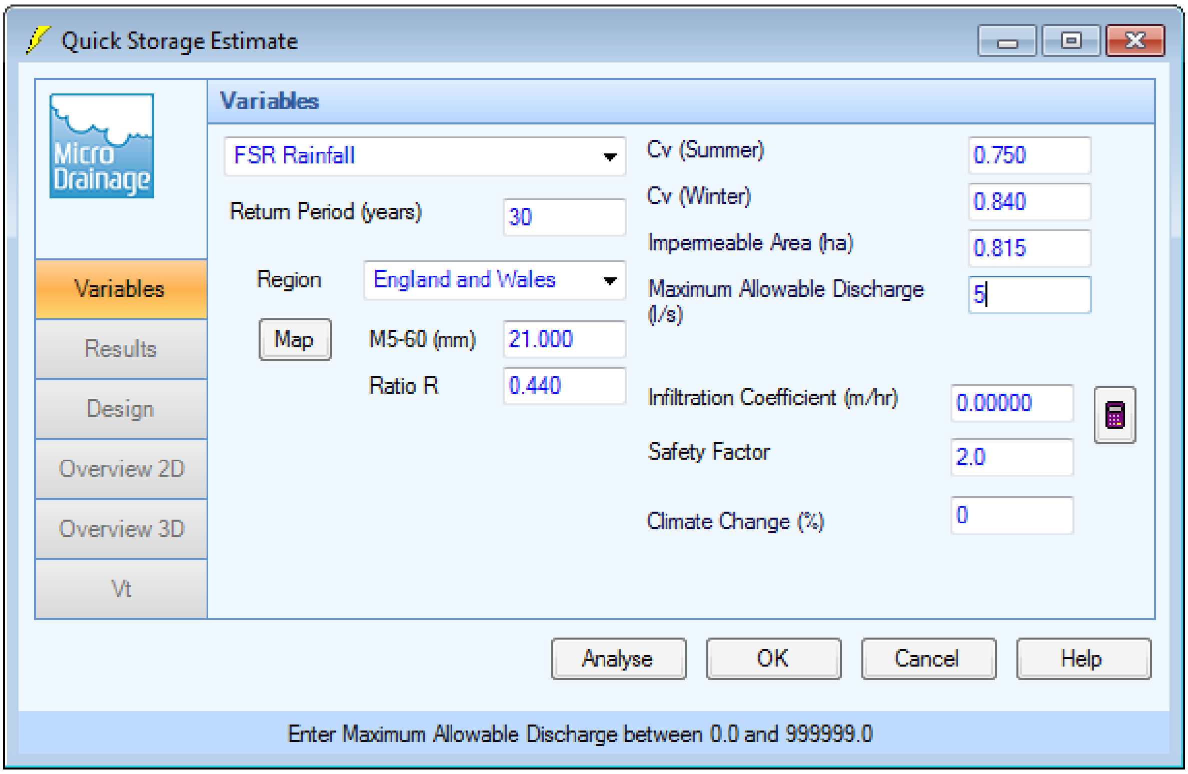
	Default	Edited
Qbar (l/s)	3.62	3.62
1 in 1 year (l/s)	3.08	3.08
1 in 30 years (l/s)	8.33	8.33
1 in 100 years (l/s)	11.55	11.55

Appendix B

WinDes Calculations

1:30 Year

Input



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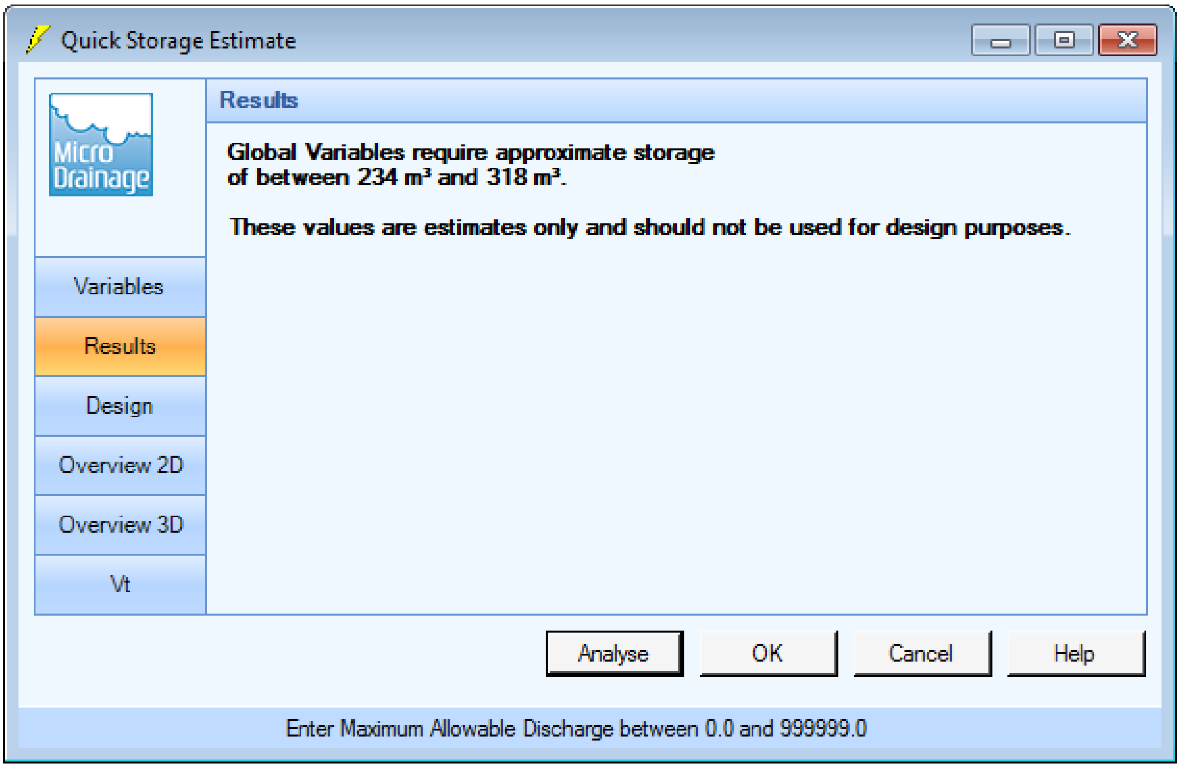
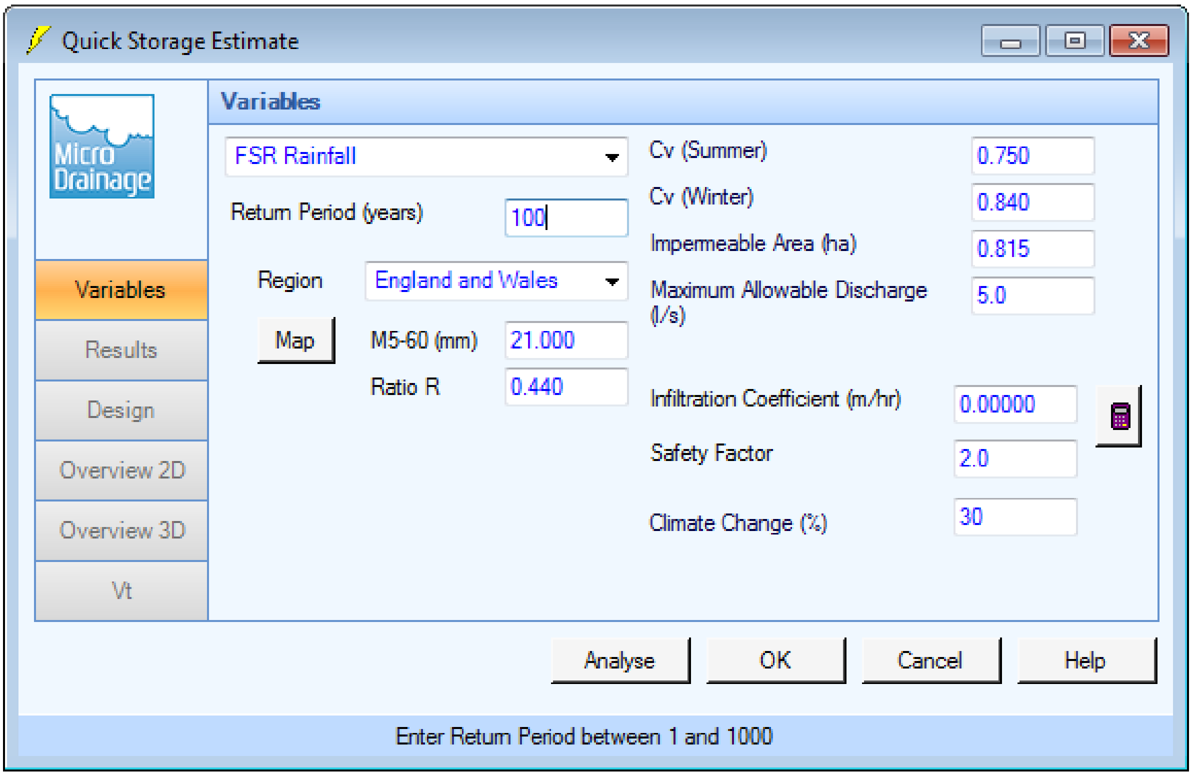


1:100 Year

Input



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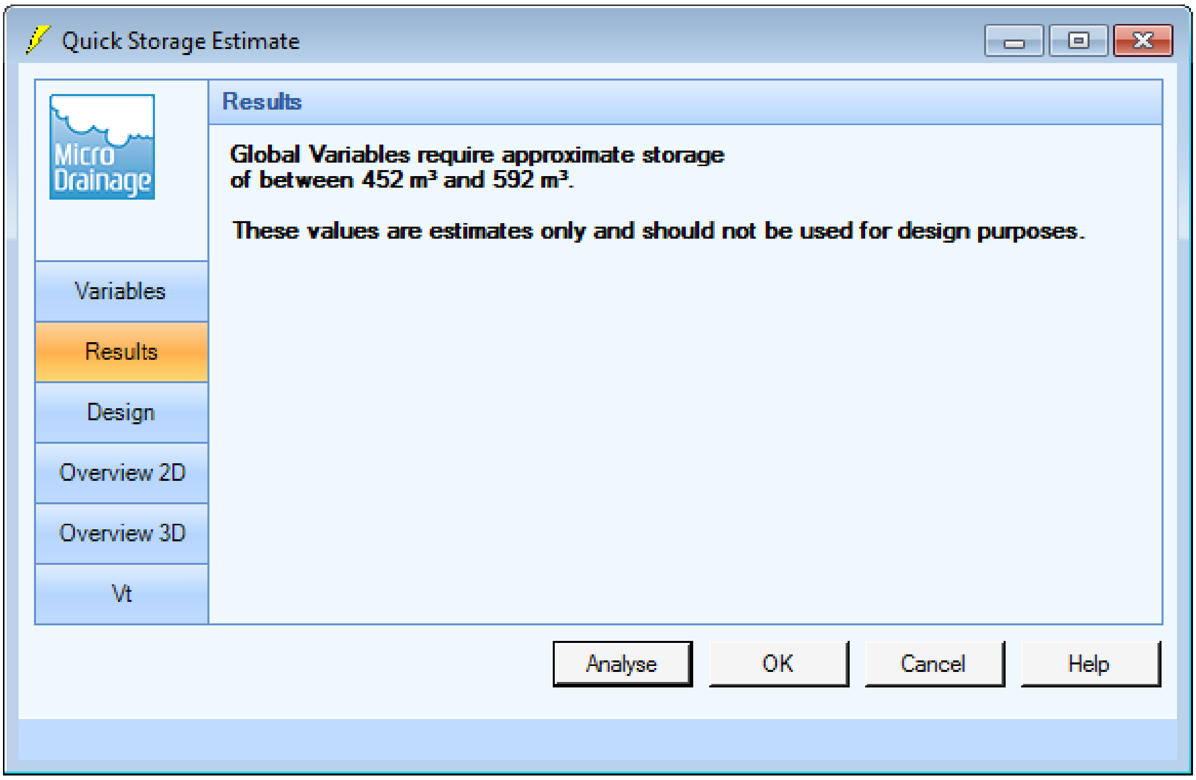

Appendix C

Previous FRA Report Ref: 140423/R001

FLOOD RISK ASSESSMENT

Parliament Hill and William Ellis Schools

For

Astudio Ltd

18 June 2014

Architects
Consulting Engineers
Project Managers
Surveyors

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FLOOD RISK ASSESSMENT

Parliament Hill and William Ellis Schools
For
Astudio Ltd

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Report Reference: **140423/R001** Date: **18 June 2014**

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CONTENTS

1. INTRODUCTION

1.1. General

Pick Everard have been instructed by Astudio to carry out a Flood Risk Assessment (FRA) for the proposed developments at Parliament Hill and William Ellis Schools within the London Borough of Camden. Although the schools are separate sites, they are adjacent to each other and for the purposes of this report have been treated as a single site covering approximately 3.56ha.

This assessment will evaluate the flood risk to the site and the potential impact of the development on the local hydrology. The assessment will also include recommendations, where appropriate, to mitigate or compensate for the impact of the development on flooding.

Our assessment has been carried out in accordance with the requirements of the National Planning Policy Framework Technical Guidance on Flood Risk, the North London SFRA, the London Plan and BREEAM 2011. We have also referred to the following documents and taken into account any guidance therein:

- 'Core Strategy 2010 – 2025' London Borough of Camden 2010
- 'Camden Development Policies 2010 – 2025' London Borough of Camden 2010
- *'Floods in Camden'* Report of the Floods Scrutiny Panel, London Borough of Camden 2003
- *'Surface Water Management Plan for the London Borough of Camden'*, Halcrow 2011
- *'Camden Flood Risk Management Strategy'* London Borough of Camden 2013
- *'The History of the River Fleet'* UCL River Fleet Restoration Team 2009

Additionally, we have discussed our FRA with an officer in the London Borough of Camden's planning department.

Pick Everard have many qualified engineers and consultants with a wealth of experience in undertaking Flood Risk Assessments, designing surface drainage systems, flow modelling and calculations, and designing flood alleviation measures. As such, Pick Everard meet the requirements of an 'Appropriate Consultant', for the purposes of BREEAM.

1.2. Policy Context

The National Planning Policy Framework (NPPF) requires new development to be steered towards areas with the lowest probability of flooding. This decision making process is referred to as the 'Sequential Test', and is closely linked to the Flood Zones, which are defined by the level of risk associated with flooding from rivers or the sea. A site located within Flood Zone 3 has a greater than 1% annual probability of flooding from these sources, while in Flood Zone 2 the annual probability of flooding is between 0.1 – 1%. All land outside Zones 2 and 3 falls into Flood Zone 1.

Development in Zones 2 & 3 is discouraged, and should only be considered where there are no reasonably available sites in a lower risk zone. Certain types of development should not be permitted in higher risk flood zones, while others should only be allowed if certain conditions are met (known as the Exception Test). The suitability of a particular type of development for a specific flood zone will be dependent on its flood risk vulnerability classification. For example, residential housing is classed as ‘more vulnerable’, while commercial development is classed as ‘less vulnerable’.

In terms of flood risk, there are no restrictions on the type of development which is considered appropriate for Zone 1.

Most developments in Flood Zones 2 & 3 require some assessment of flood risk to support the planning application. The detail and scope of any assessment should be proportional to the scale and vulnerability of the development.

For sites in Flood Zone 1, flood risk assessments are generally required for developments over 1ha in size to assess the potential of the development to increase flood risk elsewhere and to address the vulnerability of the site to other forms of flooding. The focus of such an assessment is generally the management of surface water run-off. Planning policy commonly requires that, as a minimum, run-off rates do not increase post development.

2. SITE SETTING

2.1. Site Description and Location

The site comprises two schools, Parliament Hill and William Ellis, which are adjacent to each other, and located immediately to the west of Highgate Road in Camden. It is approximately centred on 528358, 186013.

Parliament Hill School occupies the southern part of the site and covers approximately 25080m^2, while William Ellis School, which occupies the northern part of the site, covers approximately 10490m^2.

Both schools consist of single and multi-storey buildings and a mixture of soft and hard landscaping.

The site is bounded to the north and west by parkland, to the south by flats with gardens and to the east by Highgate Road beyond which is housing with gardens. Surrounding land use consists predominantly of housing and public parkland.

The site location is shown in Figure 1 and the existing site layout is presented in Appendix 1.

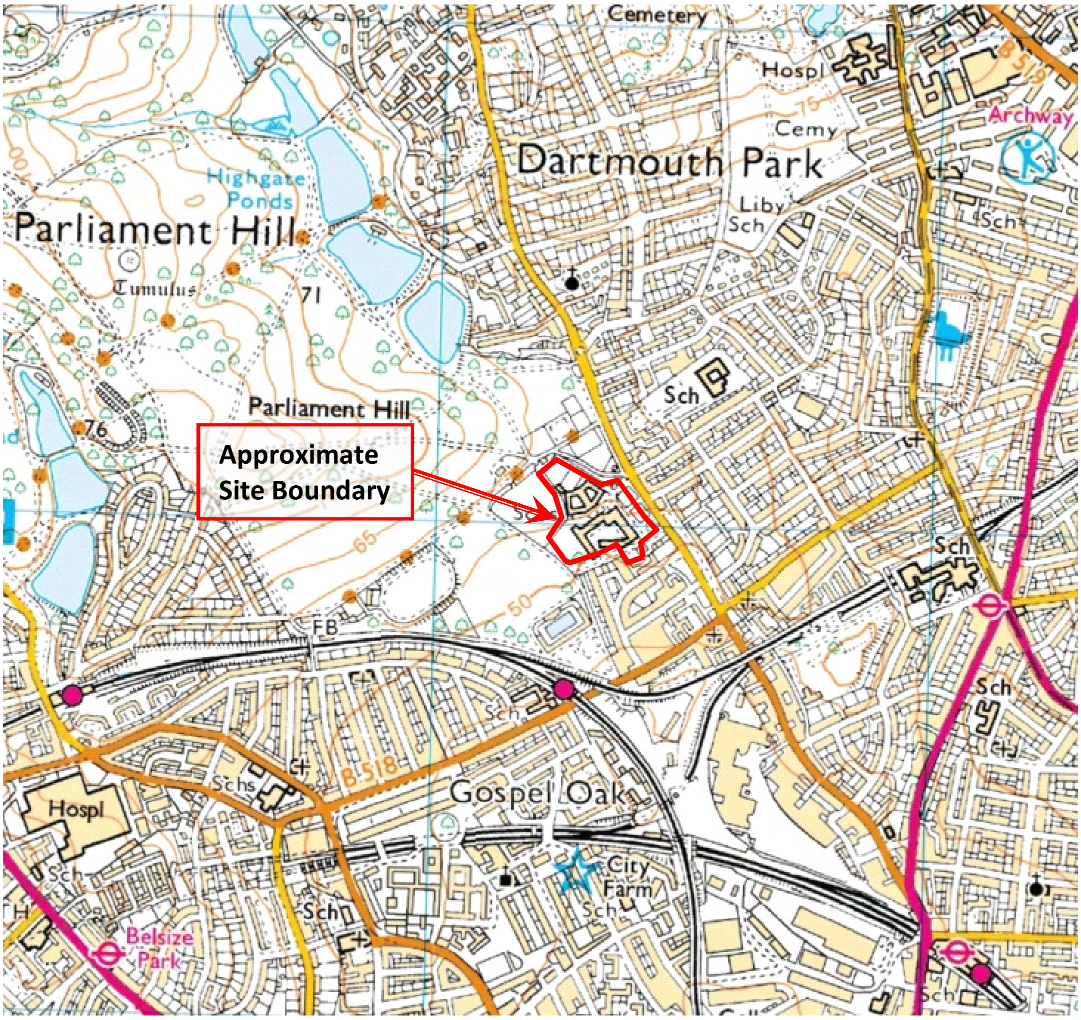


Figure 1 - Site location map

2.2. Proposed Development

The proposed developments comprise a number of different works at various locations across the two school sites. Most are within the Parliament Hill School site and comprise the following main elements:

- Demolition of some of the existing buildings, most of which are within the Parliament Hill School campus.
- Construction of a new car park
- Significant extensions to two existing school buildings
- Construction of a new free standing sixth form building covering approximately 975m^2
- Construction of a new dining hall and kitchen
- Hard and soft landscaping

The proposed works within the William Ellis School site comprise

- A new free standing building
- Hard and soft landscaping

The proposed developments consist of approximately 8000m^2 of hard surfaces, comprising buildings and hardstanding. Demolition of a number of existing buildings and the creation of some new areas of soft landscaping mean that the proposals will not result in an overall increase in the total area occupied by hard surfaces. The works will not change the classification of the site use, which is classed as more vulnerable, as defined in the NPPF Technical Guidance.

Drawings of the proposed site layout are presented in Appendix 2.

2.3. Geology and Hydrogeology

The site is underlain by London Clay which the Environment Agency classifies as unproductive strata in terms of water supply. No superficial deposits are indicated.

The site is not within a Groundwater Source Protection Zone, and there are none within 1km.

2.4. Topology

A topographical survey undertaken for Gardiner and Theobold in October 2013 indicates that Ground elevations range from 49.0m AOD in the south-west of the site to a maximum of 57.87m AOD in the north. The ground generally rises gently to the north, although there are parts of the site where slopes are slightly steeper where areas of flat ground have been created to accommodate buildings.

3. HYDROLOGY

3.1. Nearest Watercourses

The nearest water feature is Highgate No 1 Pond which is located approximately 400m to the north. It is the southernmost member of the Highgate Ponds, a chain of interconnected earth banked ponds located on the eastern edge of Hampstead Heath.

The ponds discharge underground to the former River Fleet, one of London's 'Lost Rivers' which was culverted in the mid 19th century to become part of the sewer network, and is located approximately 250m to the east of the site. The site is within the catchment of this former river.

3.2. Flood Zone

3.2.1. Environment Agency Flood Map

Flood mapping provided by the Environment Agency indicates that the site is located within Flood Zone 1, which represents land outside the predicted extent of extreme flooding from rivers or the sea, having a less than 0.1% annual probability of flooding from these sources.

3.2.2. Historic Flooding

The available records indicate that Camden has been subjected to a number of intense summer rainfall events which have resulted in localised surface water flooding.

In August 1975, a rain storm which was estimated as a 1 in 100 year event, resulted in surface water flooding of a number of roads, including Highgate Road adjacent to the eastern boundary of the site.

More recently a high intensity rainfall event which occurred in August 2002 again resulted in surface water flooding of a number of roads in the borough. This was caused largely by the sewer system quickly reaching capacity and being unable to drain away the continued rainfall at an adequate rate. On this occasion the Highgate Road was spared, but Lissenden Gardens which is located approximately 15m from the southern boundary of the site was flooded, as was Glenhurst Avenue, 90m to the south. An area of residential land immediately east of Highgate Road was also flooded.

3.3. Development Suitability

The site is located in Flood Zone 1, and the development is therefore considered suitable for the location. Given that the development area is greater than 1ha, a full flood risk assessment is likely to be required to support the planning process.

The following assessment is therefore based on the requirements of the NPPF and associated flood risk policy guidance.

4. FLOOD RISK TO THE SITE

4.1. Flooding Mechanisms

4.1.1. Fluvial / Tidal Flooding

The site is located in Flood Zone 1 and is not therefore expected to experience fluvial or tidal flooding.

4.1.2. Groundwater Flooding

Groundwater flooding generally occurs where permeable deposits are present close to the surface. Geological mapping indicates that only low permeability London Clay is present beneath the site and that there are no permeable deposits on or near the site.

The Strategic Flood Risk Assessment (SFRA) notes that there are no recorded incidents of groundwater flooding having affected properties within the borough of Camden.

Mapping provided by the Environment agency indicates that the site is not within an area which is considered to be vulnerable to groundwater flooding.

Given the available information, the risks from groundwater flooding on the site are considered to be low.

4.1.3. Pluvial Flooding

Pluvial flooding may occur where intense rainfall results in an accumulation of water due to a combination of run-off entering the site from adjacent land and the inability of the site to drain at a sufficient rate, either by natural or man-made mechanisms of the on-site drainage system.

As already discussed in Section 3.2.2, a number of intense summer rain storms have resulted in surface water flooding in Camden. These events have resulted in flooding on Highgate Road immediately to the east of the site and on Lissenden Gardens to the south. However none of the available records indicate that the site itself was affected.

Environment Agency Mapping indicates that there is a low risk of pluvial flooding affecting the site, as indicated in Figure 2.

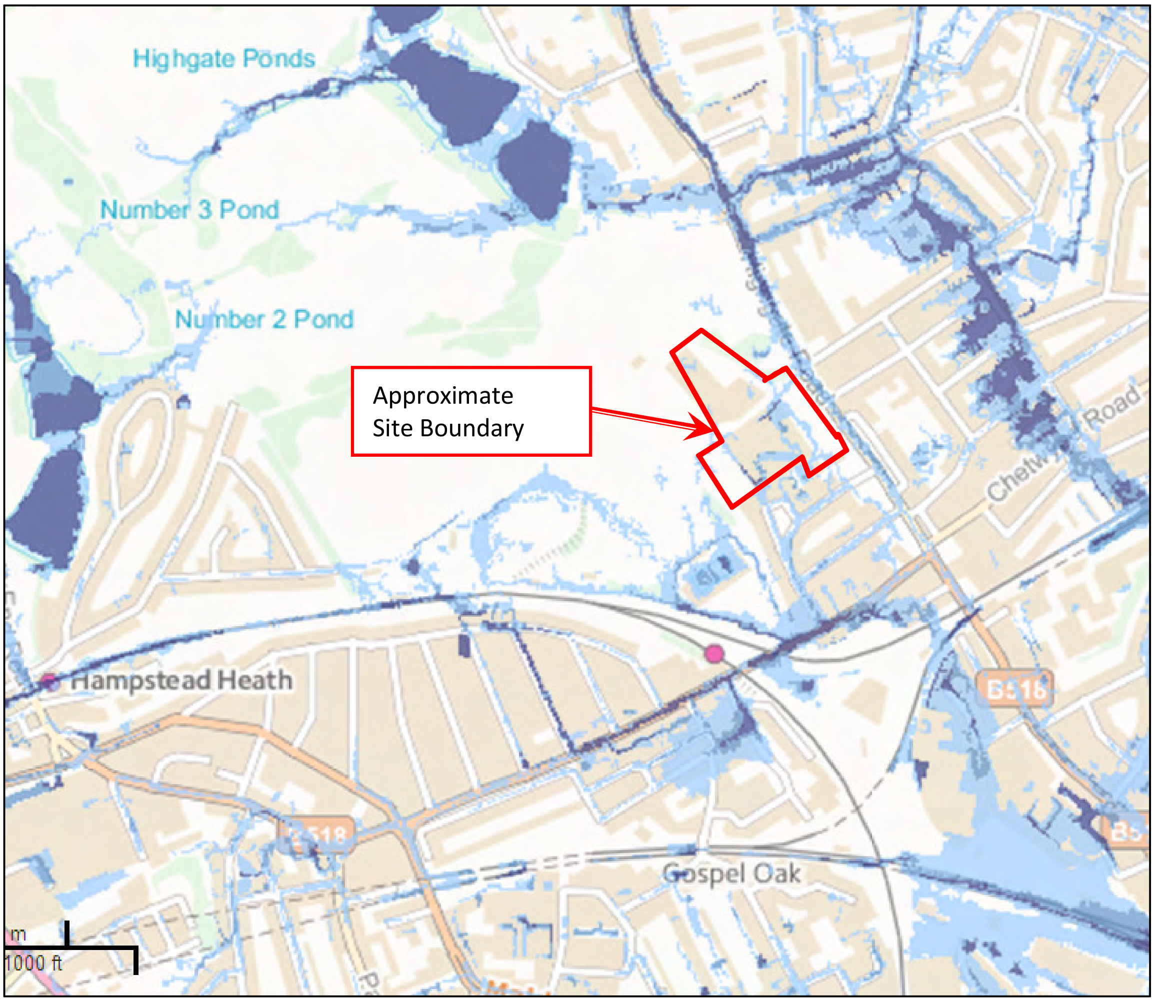


Figure 2 – Environment Agency map showing surface water flooding risk

According to the North London SFRA, the site is within an area which is at medium risk of flooding from overland flow and combined sewer flooding. However, considering all the available information, the risks posed to the site by pluvial flooding are considered to be low.

4.1.4. Sewer Flooding

The exact locations of sewer flooding events are not known as only partial postcode data of these incidents is made publicly available. The Camden SWMP notes that, within the postcode area in which the site is located, over 300 properties have been affected by sewer flooding in the period from 2003 to 2013.

4.1.5. Flooding From Artificial Sources

Three of the Highgate Ponds, including Highgate No 1 pond which is closest to the site, are classified as raised reservoirs and are therefore subject to the Reservoir Act 1975. The ponds are interconnected and are therefore considered as a single system. Mapping provided by the Environment Agency indicates that the site is at risk of flooding from the ponds, with predicted floodwater depths of up to 0.3m and velocities of less than 0.5m per second. The Environment Agency website indicates that the risk designation of the ponds is yet to be determined.

However it is considered that although such an event would be unlikely, the potential impacts could be severe. Figure 3, based on Environment Agency mapping, indicates the maximum extent of the predicted flooding.

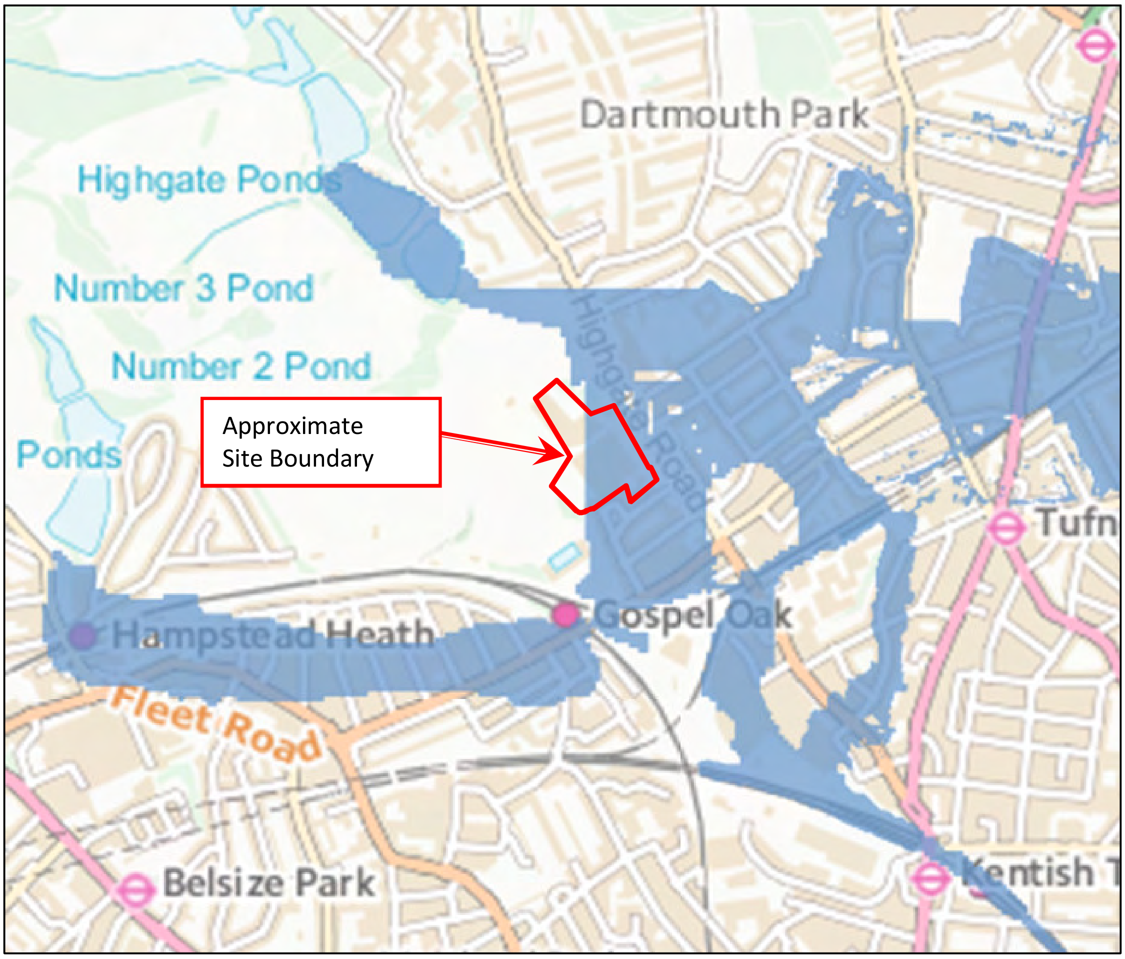


Figure 3 – Environment Agency map showing the risk of flooding from reservoirs. The blue areas indicate the maximum predicted extent of flood water.

The City of London Corporation, which manages the ponds, has undertaken a number of detailed surveys on them over the past few years and produced a number of flood risk studies to assess the impact of a dam failure. It has identified that there is insufficient spillway capacity, which in an extreme rainfall event, could result in uncontrolled overtopping leading to erosion of the earth dams and a potential breach. This could potentially flood a significant area of Camden including the proposed development site.

Limited overtopping occurred as a result of the rainfall events of August 1975 and August 2002, referred to in Section 3.2.2, but did not directly result in the flooding of any roads or property.

Based on the findings of the surveys and assessments, the Corporation is now planning an engineering scheme which is intended to reduce the likelihood of dam failure to negligible levels and ultimately reduce the risk of downstream flooding to an acceptably low level. The proposed scheme is likely to be completed in 2016.

Given the above, it is considered that the risk of flooding to the site from the pond is low, but this will be significantly reduced once the works have been completed.

There are considered to be no other artificial sources of flooding which pose a risk to the site.

4.1.6. Critical Drainage Areas

A number of Critical Drainage Areas (CDA) have been identified in Camden's SWMP. CDAs are classified as discrete geographical areas in which multiple sources of flood risk (fluvial, groundwater, pluvial and sewer) often cause flooding in one or more Local Flood Risk Zones (LFRZ) during severe weather, affecting property, infrastructure and people.

The site is within a CDA in which more than 7 properties have been identified as being at risk of flooding from floodwater having a depth of 0.5m or more. The predicted extent of the area which may be affected by flooding, the Local Flood Risk Zone, is indicated in Figure 4 and is adjacent to the east of the site. It is identified to be at risk from surface water flooding as well there being a residual risk of inundation from the Highgate Ponds.

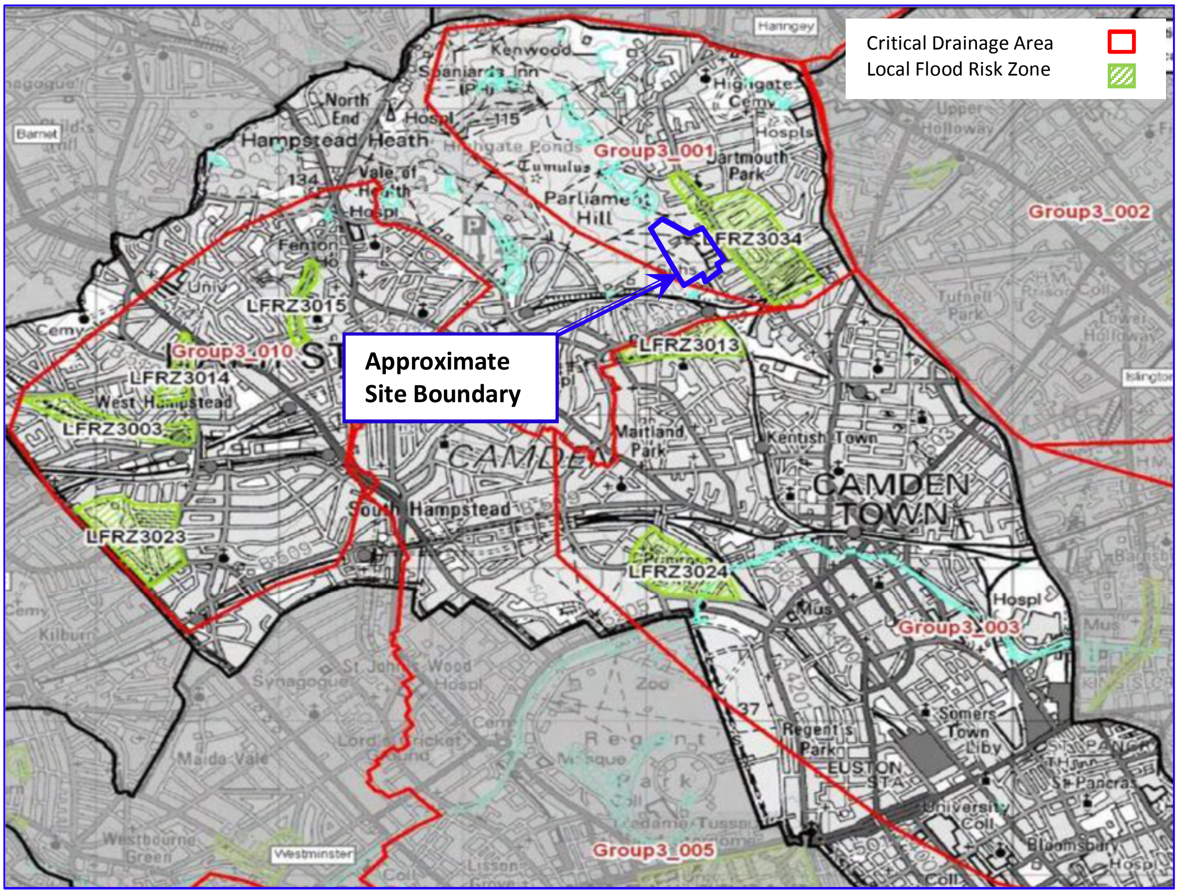


Figure 4 –Extract of mapping from the London Borough of Camden's Surface Water Management Plan showing the boundaries of CDAs and Local Flood Risk Zones

4.2. Floodwater Depth and Velocity

A residual risk of flooding from the Highgate Ponds has been identified. Predicted flood water depths on site of up to 0.3m with maximum velocities of 0.5m/s are indicated on Environment Agency mapping.

4.3. Effects of the Development on the Flood Plain

The development is outside the predicted extent of fluvial or tidal flooding and therefore is not expected to have a significant impact on the floodplain, except through the management of surface water run-off, which is discussed in Section 5.

4.4. Development Safety

As noted in Section 4.1.5, there is considered to be a residual risk of flooding to the site from the Highgate Ponds. The Environment Agency predicts that floodwater depths of up to 0.3m with velocities of up to 0.5m/s would result from such an event. These conditions are considered to present a danger to most people in terms of the Defra FD2321 Flood Risks to People Guidance Document.

In the unlikely event of the site being flooded by the Highgate Ponds, mapping indicates that the south and east of the site and land to the south and east would be flooded. Dry egress to pedestrians would be available to the west and north-west of the site. The development should ensure that safe pedestrian access is in place from this direction to facilitate continued site operation. Access by emergency vehicles from Highgate Road to the east of the site may still be possible, as they would likely be able to cope with the predicted floodwater depths.

The City of London Corporation has installed water level monitoring systems in the ponds and a weather monitoring system which are able to give advance warning of potential overtopping and dam failure. An emergency plan has been developed by the Corporation in the event of a dam failure.

It is suggested that the schools make use of any flood alert service provided by the London Borough of Camden or the City of London Corporation. They should consult both authorities in formulating an evacuation and emergency plan, or if one is already in place, it should be updated to take into account the proposed developments.

Areas adjacent to the site have been affected by surface water flooding resulting from intense Summer Rainfall events in 1975 and 2002. The site was not flooded during these events, although it is possible that during the 1975 floods when Highgate Road flooded, access to the main entrances of the schools would have been impeded. Surface water flooding of adjacent roads would not be expected to pose a significant safety risk to the schools.

The site is outside the extent of predicted fluvial or tidal flooding and therefore there are not considered to be any significant safety risks related to this type of flooding.

The Environment Agency flood mapping indicates that the site is not on a 'dry island', an area outside the floodplain surrounded by land that is within the floodplain, and therefore should not be cut-off during a flood event.

5. SURFACE WATER MANAGEMENT

5.1. General

The following is an assessment of surface water drainage from the site and the implications for the proposed development.

Run-off calculations have been based on rainfall events with return periods of 1, 30 and 100 years. These return periods have been chosen because they represent key events in terms of risk assessment and drainage design. The 1 year event represents the storm intensity that is likely to be experienced on an annual basis. The 30 year storm represents a common design standard for surface drainage systems, while the 100 year storm is the usual design standard for developments in terms of safety and drainage.

It should be noted that any new connections to the public sewer or any change in the discharge from the site should be agreed with the relevant service provider.

5.2. Existing Site Drainage

Approximately 2.3ha of the total site area is currently occupied by buildings and hard standing from which drainage is expected to be by run-off to a subsurface network of pipes connected to the public sewer system. The remainder of the site is occupied by grass playing fields and soft landscaping where drainage is expected to be mainly by infiltration.

It should be noted that we have not undertaken a survey of the site drainage.

5.3. Run-off from the Proposed Development

The minimum requirement of the NPPF / BREEAM is that run-off from new development does not exceed pre-development rates for all storms up to the 1:100 year event, when accounting for an increase in storm intensity as a result of climate change. The London Plan and the London Borough of Camden's Planning Policy Guidance CPG3 have more stringent conditions, requiring run-off for new developments to be attenuated to 50% of pre-development rates, as a minimum. However, where a new development is located within a CDA, as this site is, then the SFRA states that the 'preferred standard' of the London Plan should apply which requires 100% attenuation of the developed site's surface water run-off.

Post development, approximately 2.2ha of the site area will be occupied by hard surfaces, which represents a small overall decrease compared to the existing area of hard surfacing. However in order to take into account the predicted increase in run-off rates resulting from the effects of climate change and to achieve the attenuation required by the North London SFRA and Planning Guidance, attenuation measures will be required, such as flow control and infiltration or storage structures.

Given the site location within a CDA, the general principle should be to limit run-off from all areas of new development to Greenfield rates, wherever possible.

The proposed developments are in a number of different locations across the site and will have a total area of hard surfacing of approximately 8000m^2. An estimate of the maximum storage volume required has therefore been based on attenuating run off from this area to Greenfield rates.

An estimate of the Greenfield rates of run-off for the site has been made using the Institute of Hydrology Report No. 124 (IoH 124) methodology, the model outputs from which are presented in Appendix 3. The Greenfield run-off rates for the total area of hard surfaces of the new developments are presented in the table below.

Storm Return Period (years)	Greenfield Run-off Rate for the site (l/s)
1	2.72
30	7.12
100	10.08

Table 1 – Greenfield Run-off Rates

5.3.1. Storage and Flow Requirements

An estimate of the storage requirement for 1:30 and 1:100 year storms has been calculated based on limiting run-off from the total area of hard surfaces of the proposed development areas to Greenfield rates.

Attenuating to the 1:1 year Greenfield rate would result in a discharge rate of less than 5l/s which is generally considered as the minimum flow rate necessary for the effective functioning of a piped drainage system. In this case, storage volumes have been estimated for a minimum rate of 5l/s.

The full model storage calculation outputs are presented in Appendix 4.

Attenuation Scenario	Allowable Discharge Rate (l/s)	Estimated Storage Requirement for 1:30 year event (m^3)	Estimated Storage Requirement for 1:100 year event (m^3)
Attenuation to 1:1 year Greenfield rate for areas to be developed	5.0	288 - 529	400 - 773
Attenuation to 1:30 year Greenfield rate for areas to be developed	7.12	263 - 472	367 - 703
Attenuation to 1:100 year Greenfield rate for areas to be developed	10.08	237 - 420	336 – 638

Table 2 – Estimated Storage Requirements

The calculations in this report are indicative and should not be used for design purposes. The required run-off rates and storage volumes should be optimised during the detailed design stage.

By way of an example, should run-off be limited to the minimum acceptable discharge rate of 5 l/s (for all events up to the 1 in 100 year storm), the figures indicate that up to 773m^3 of floodwater will need to be stored or infiltrated on site in order to attenuate run-off to the required rate. Furthermore up to 529m^3 of this will need to be available in the site drainage infrastructure, to ensure there is no surface flooding during a 1:30 storm.

These estimated storage volumes assume that drainage from all of the proposed development areas discharge from the same outlet. In reality this is unlikely, and the contribution from each proposed development area may be drained independently, and will likely connect to the existing drainage infrastructure in different locations.

5.4. Potential Drainage Solutions

The detailed drainage strategy will be completed separately to this report.

NPPF Technical Guidance and the Environment Agency generally require that new drainage incorporates Sustainable Drainage Systems (SUDS) measures where possible, to reduce and control surface water run-off. The London Plan and Camden's Planning Guidance CPG23 goes further in requiring SUDS unless there are practical reasons for not doing so.

A SUDS hierarchy provided in the London Plan and Camden Planning Guidance CPG23 identifies the storage of rainwater for later use (rainwater harvesting) as the preferred solution followed by infiltration measures, such as permeable paving. Storage in open features such as ponds for gradual release is then regarded as the next most preferable measure. Storage in underground attenuation tanks is seen as the least desirable solution.

The North London SFRA assesses the general suitability of a number of SUDS measures for Camden's environmental circumstances and identifies pervious pavements, green roofs and bioretention to generally be the most appropriate. However given the size of the site and the landscaped grounds, it is considered that a larger range of SUDS measures may be suitable for the proposed development. A combination of different SUDS measures is often used to achieve the necessary attenuation and may also provide a number of other environmental and amenity benefits. The available options are discussed below.

5.4.1. Green and Brown Roofs

It is recommended that consideration is given to incorporating green or brown roofs in the new buildings, as these measures deal with run-off as close to the source as possible, and will reduce the capacity required of any downstream attenuation measures. They may also deliver other environmental benefits such as reducing the urban heat island effect and increase biodiversity. Camden's Development Policy DP22 requires green and brown roofs to be included in new developments wherever these are suitable. Consideration should therefore be given to these features at the design stage.

5.4.2. Rainwater Harvesting

The collection of rainwater for later use not only provides attenuation but is also an environmental opportunity in limiting the demand for water. Rainwater harvesting could be incorporated into the new buildings and integrated into a grey water recycling system which could, for example, provide water for toilet flushing and the irrigation of landscaped areas. Camden's Development Policy DP23.5 requires grey water harvesting systems to be included in all major developments. Such systems could be integrated with a rainwater harvesting system. However, it is recognised that these measures will not count towards the volume of storage required.

5.4.3. Soakaways

Given that the site is underlain by low permeability London Clay, infiltration measures such as soakaways may not be suitable. However, this would need to be confirmed by appropriate field tests.

5.4.4. Permeable Paving

Permeable paving with a permeable sub-base for the storage of water may be possible in car parking areas and beneath hard landscaping. This could be designed to filter out entrained pollutants and may therefore discharge treated water directly to storage ponds or soakaways.

5.4.5. Swales and Filter Strips

These may be used alongside access roads and pathways and are best suited to draining small areas of car parking or hard landscaping. They may be readily integrated into soft landscaped areas. They are able to filter out pollutants in the run-off and like permeable paving, may be used as a pre-treatment measure.

5.4.6. Ponds and Basins

Site restrictions related to topography and available space may limit the potential for ponds and basins. However, soft landscaping will be present that provides opportunities for such features which may not only contribute towards the required attenuation, but also deliver amenity and biodiversity benefits. Any ponds could be topped up with water collected by the rainwater harvesting measures.

5.4.7. Bio-retention Areas

These consist of shallow landscaped areas containing engineered soil which drain surface water by filtration. They are effective in removing pollutants and could therefore be used in car park areas.

5.4.8. Allowing Surface Water Flooding of Designated Areas

For storms in excess of the 1:30 year event, surface flooding of non-sensitive areas of the site, such as landscaped areas may be acceptable. Flooding of buildings and access routes should not occur for storms up to the 1:100 year event.

5.4.9. Other Attenuation Measures

Should SUDS measures alone be unable to handle the required volumes, as a last resort, the necessary attenuation may be achieved by underground storage structures.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. Development Suitability

The site is located within Flood Zone 1 and as such the current and proposed developments are considered suitable for this location.

The site is adjacent to an area which experienced surface water flooding in 1975 and 2002, but the site itself was not flooded and was not surrounded by floodwater. The risk to the site from surface water flooding is therefore considered to be low.

There is a residual risk from flooding from the Highgate Ponds. Although such an event is considered unlikely, the consequences could be significant. The alleviation works planned by the Corporation of London will significantly reduce the likelihood of such an event. The risk of flooding to the site from the ponds is currently considered low, but this will be significantly reduced once the works have been completed.

Considering the overall risks from surface water flooding and the risks of flooding from the ponds, the site is considered to be suitable for the proposed developments.

6.2. Development Safety

Although the risks of flooding to the site are low, in order to manage residual risks related to the failure of the Highgate Pond dams, it is recommended that use is made of any available flood warning information services, and that a plan is developed which details the response to such an event.

6.3. Surface Water Management

In order to limit run-off from the hard surfaces of the proposed development areas to Greenfield run-off rates, while taking into account future predicted increases in storm intensity as a result of climate change, it has been estimated that the new developments will need the capacity to infiltrate or store up to 773m^3. Up to 529m^3 of this volume should be available in the site drainage infrastructure to avoid surface flooding during a 1:30 year storm.

Given the location of the site in a Critical Drainage Area and the susceptibility of neighbouring roads to surface water flooding, Camden Council requires source control measures to be implemented as detailed in its SWMP. If SUDS cannot be deployed then there should be good reasons for not doing so which should be demonstrated to the Council.

In accordance with the SUDS hierarchy, when designing the site drainage strategy, preference should be given to rainwater storage for later use followed by infiltration measures. It should be noted that Camden’s development policies require new developments to include green/brown roofs wherever these are suitable.

Geological mapping indicates that the site is underlain by low permeability London Clay which may not be suitable for infiltration measures. However this should be confirmed by appropriate field tests.

Should SUDS measures alone be unable to handle the required volumes, as a last resort, any shortfall in the acquired attenuation may be achieved by underground storage structures.

It should be noted that the calculations included in this report are indicative and should not be used for design purposes.

The relevant service provider should be contacted prior to development, to agree any new connections or changes in discharge rates to the public sewer.

APPENDIX 1

Existing Site Layout

01 Existing Site Plan
1:1000

KEY

SITE BOUNDARY

EXISTING BUILDING TO BE DEMOLISHED

0 10 20 30 40 50
Scale 1:1000

rev	description	date	dr by	ap by
A	DRAFT STAGE C ISSUE	09/01/2014	FG	CR
original by FG		09.01.2014	FG	

ASTUDIO architecture

Elizabeth House - Tower Building - 10th Floor - 11 York Road - London SE1 7NX - UK

Client
LB CAMDEN

Project
PARLIAMENT HILL SCHOOL

Drawing
EXISTING SITE PLAN

Scale
1:1000@A1

Project number
13009

Issue status

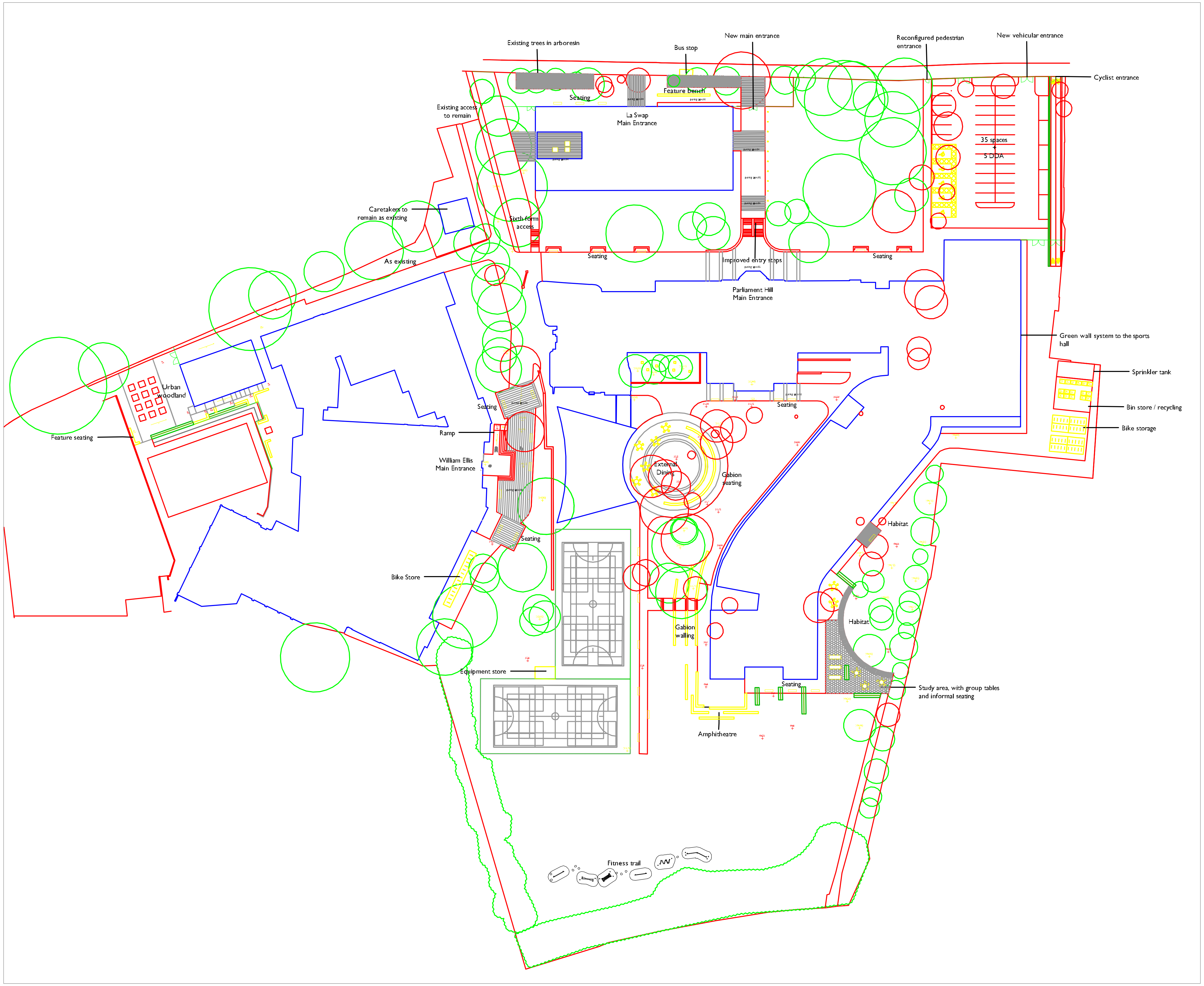
Drawing number

PHS	A	PL-00-GA	0500	A
ORIGINATOR	CODE 1	CODE 2	CODE 3	REV

Disclaimer

APPENDIX 2

Proposed Site Layout



1:1000 @ a3

0 10 20 30 40 60 80 100m

London 0207 38 78 560
Newcastle 0191 24 24 224

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Scale 1:500

Hardworks

- Pedestrain Macadam - Buff
- Dense Bitumen Macadam
- Concrete paving
- Tarmacadam

Softworks

- Proposed tree
- Proposed orchard tree
- Woodland planting
- Grass
- Meadow
- Shrub/ herbaceous planting

Furniture

- Cycle hoop
- Cycle shelter
- Seating
- Gate
- Play boulder
- Walls

Site

- (24.00) Existing level
- 23.25 Proposed level
- Site boundary
- Site secure line

Rev	Amendments	Date	Drwn	Chkd
01	First Issue	10.12.13	CLS	PC

Project
Parliament Hill & William Ellis

Drawing Title
Landscape Layout

Project No. 1151 | Scale @ A1 1:500 | Project Status Planning

Drawing No. L-1151-GAP 01 | Revision 01

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APPENDIX 3

Model Output Calculations

ICP SUDS Mean Annual Flood

Input

Return Period (years)	30	Soil	0.450
Area (ha)	1.000	Urban	0.000
SAAR (mm)	639	Region Number	Region 6

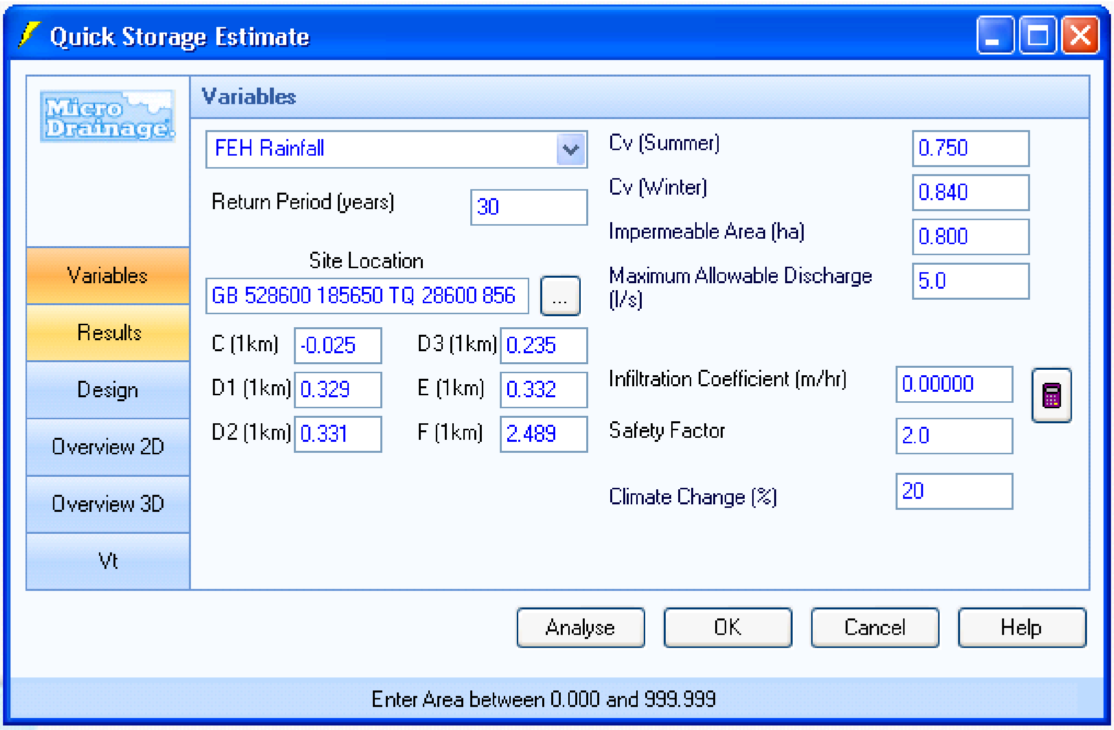
Results	**l/s**
QBAR Rural	3.9
QBAR Urban	3.9
Q30 years	8.9
Q1 year	3.4
Q30 years	8.9
Q100 years	12.6

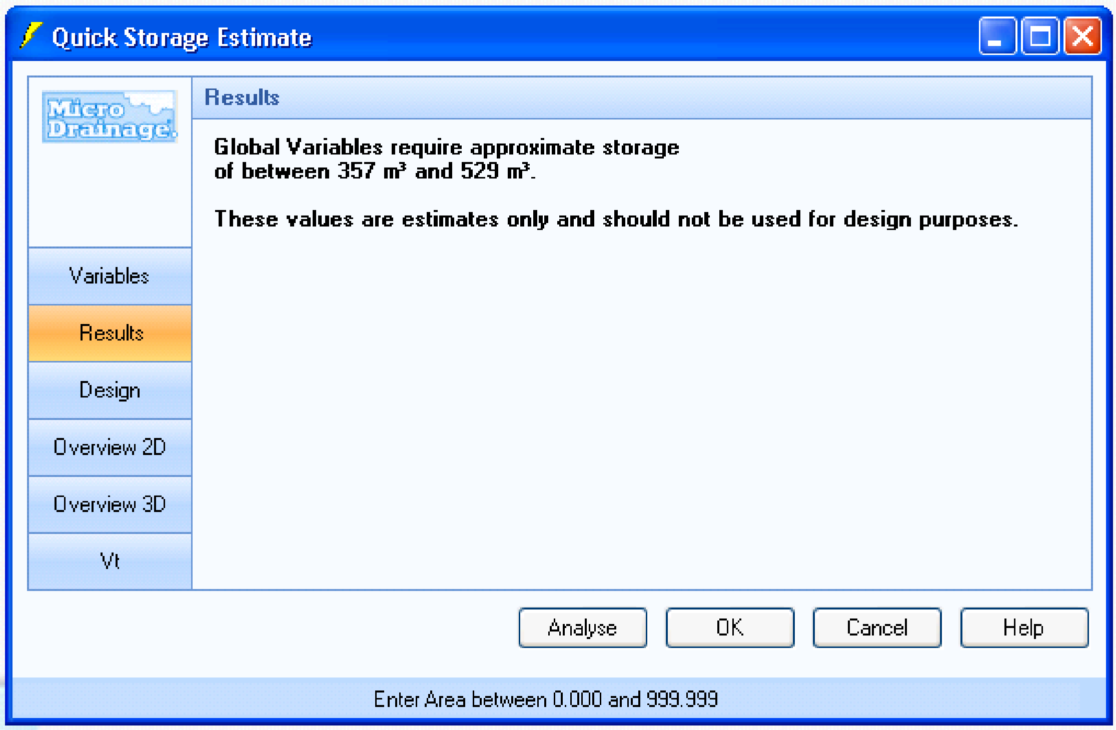
APPENDIX 4

WinDes Storage Calculations

FEH Rainfall Data

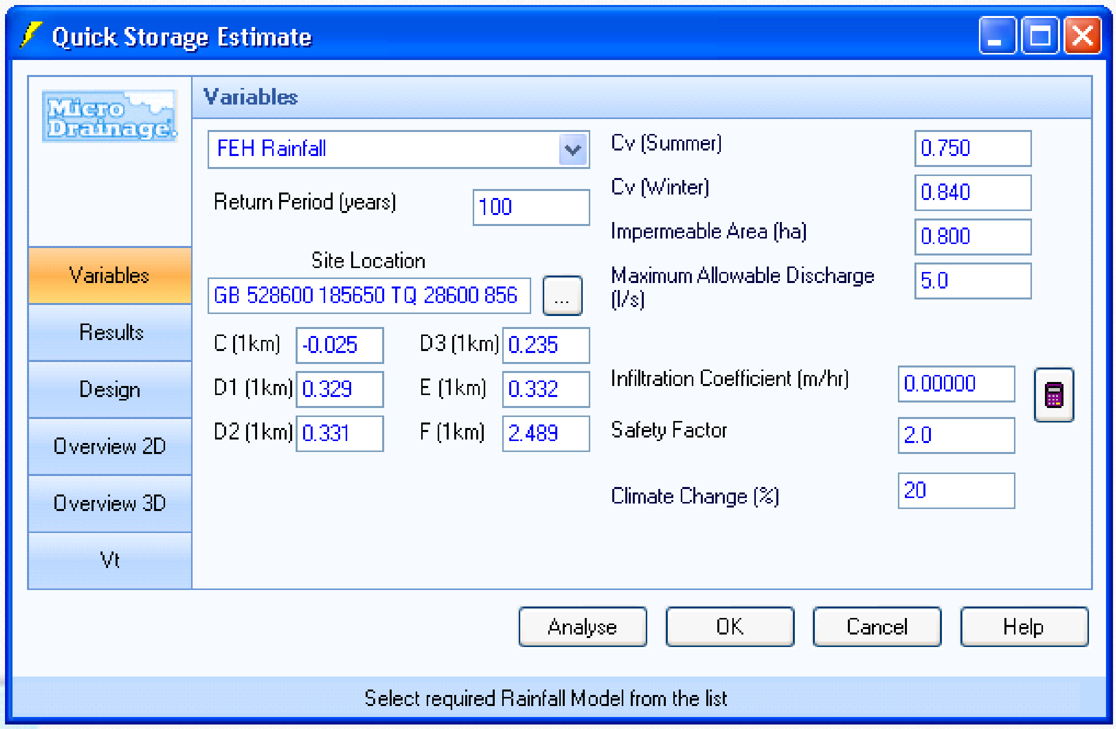
1:30 Year Return Period - Discharge Rate Attenuated to 5l/s

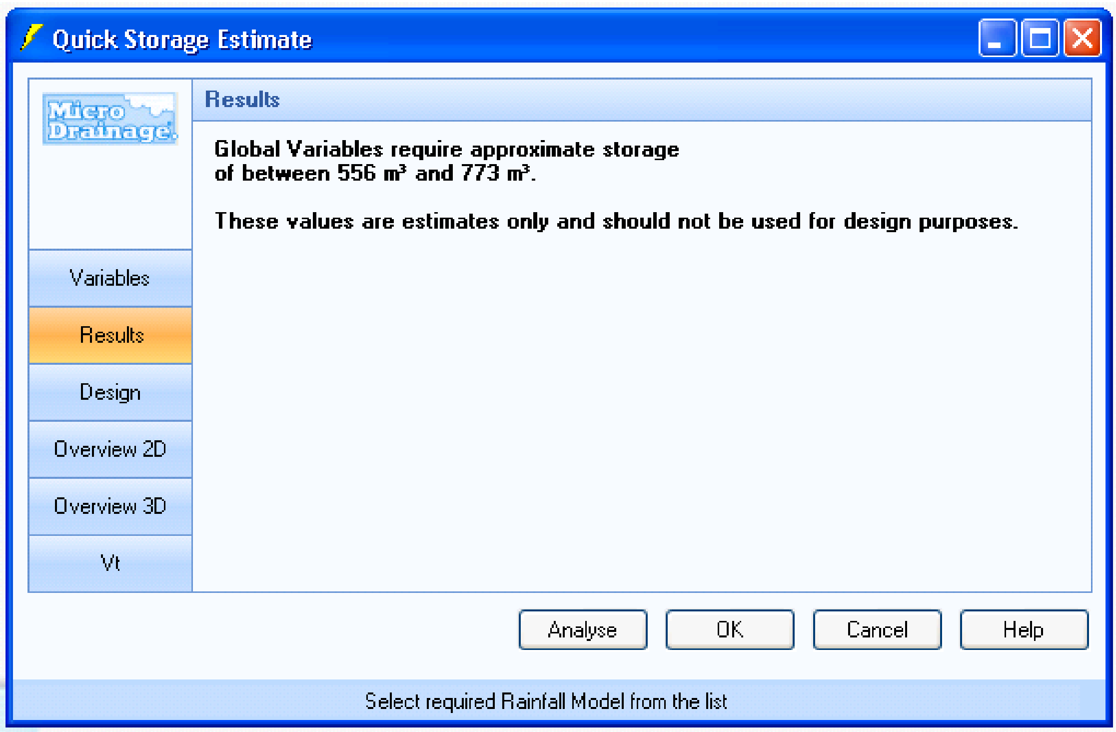




FEH Rainfall Data

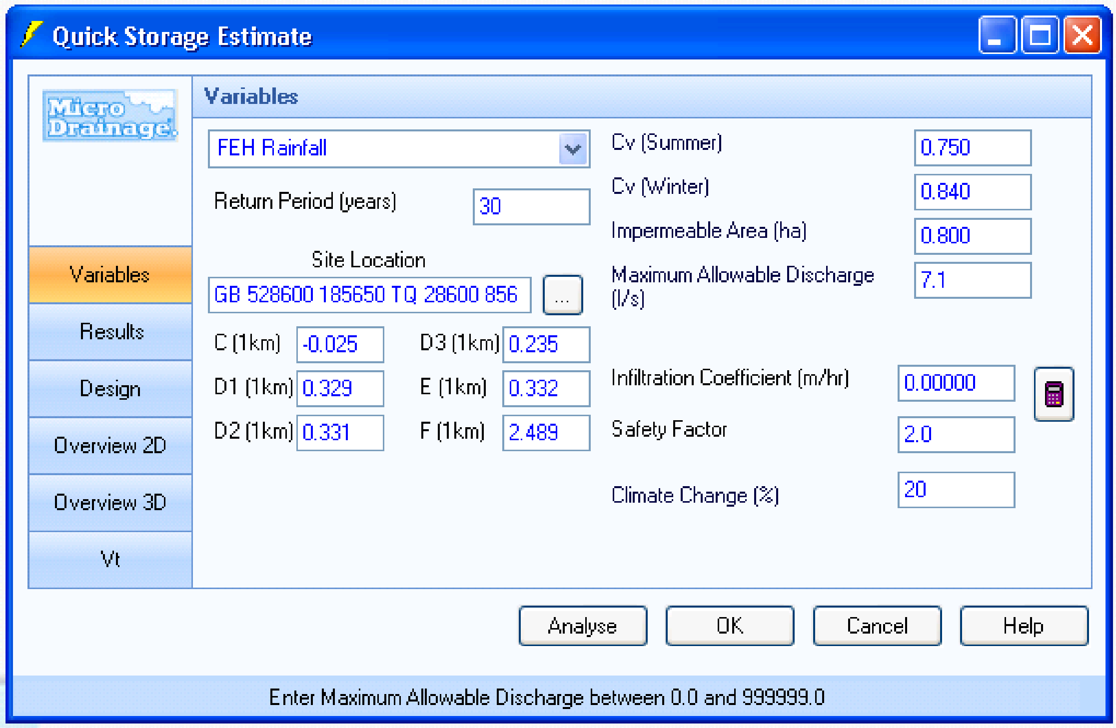
1:100 Year Return Period - Discharge Rate Attenuated to 5l/s

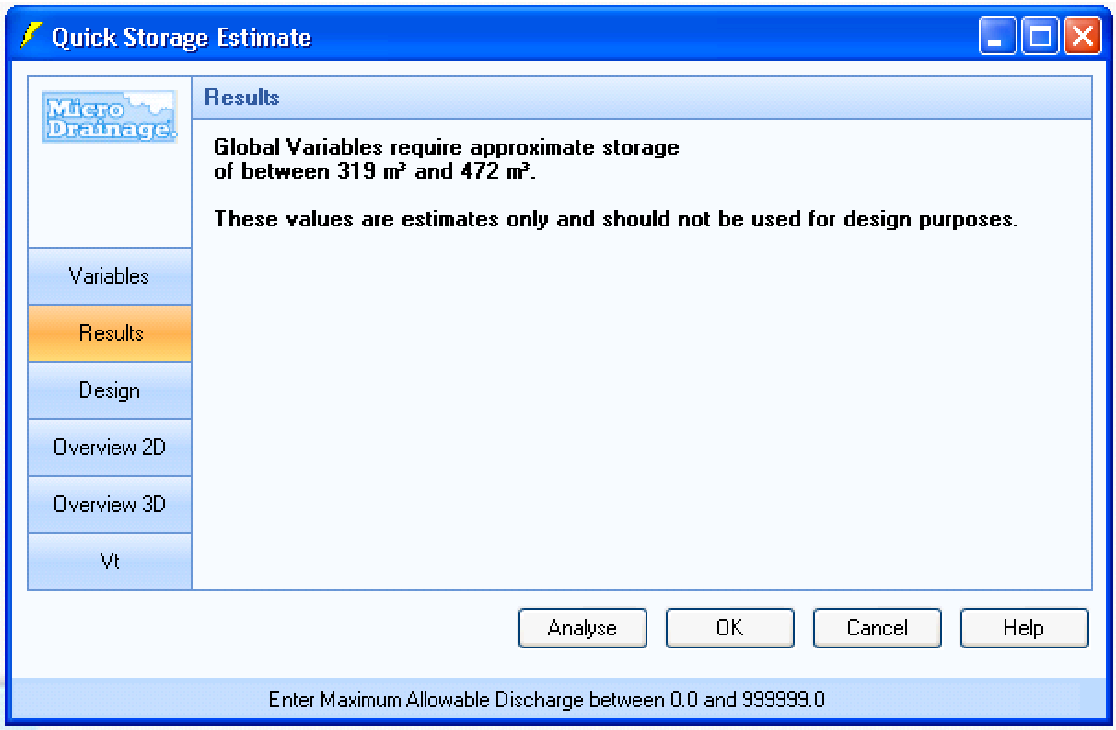




FEH Rainfall Data

1:30 Year Return Period - Discharge Rate Attenuated to 7.1l/s





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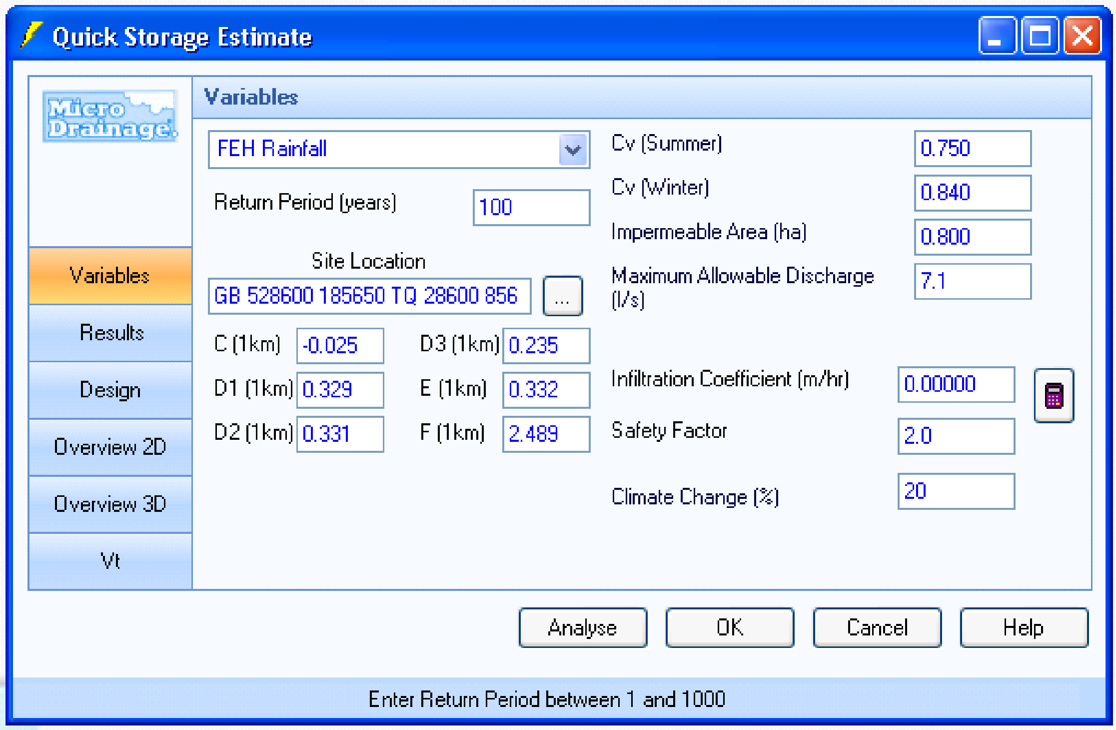
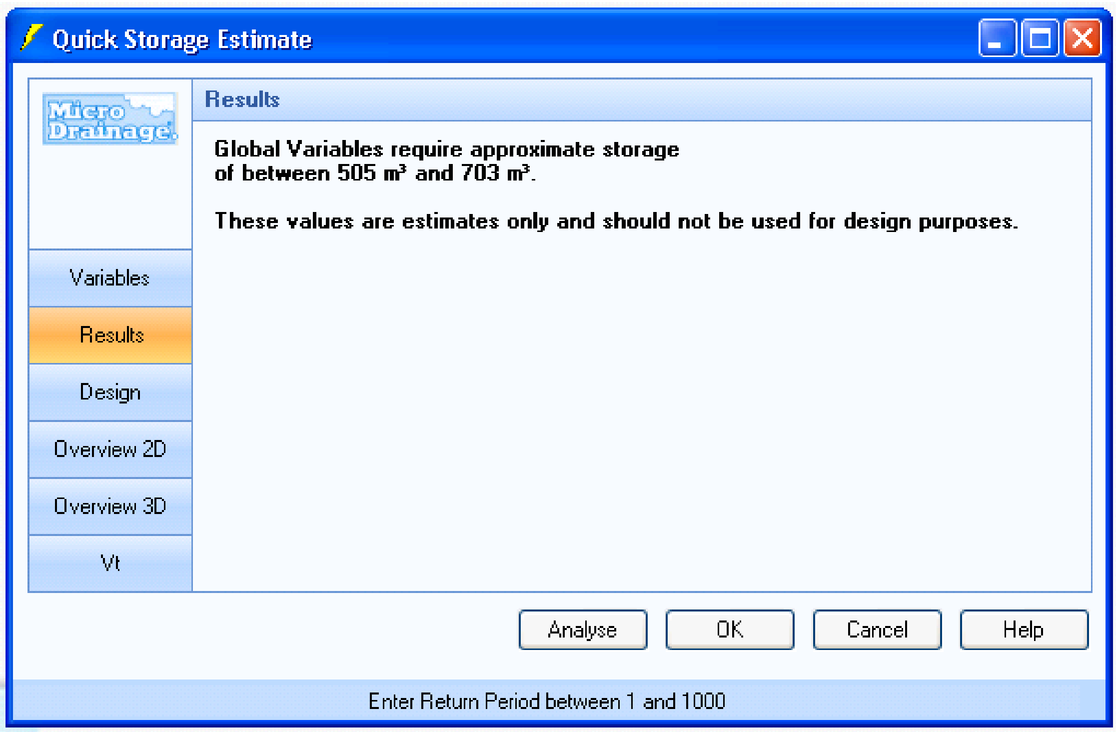
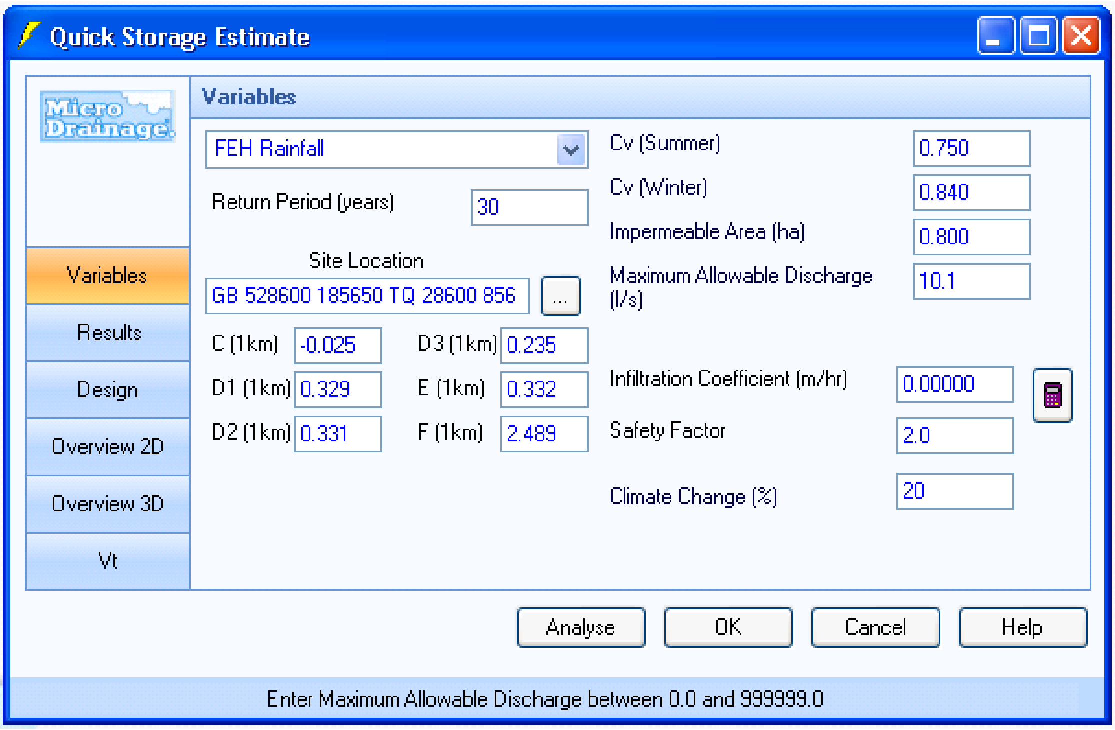
1:100 Year Return Period - Discharge Rate Attenuated to 7.1l/s

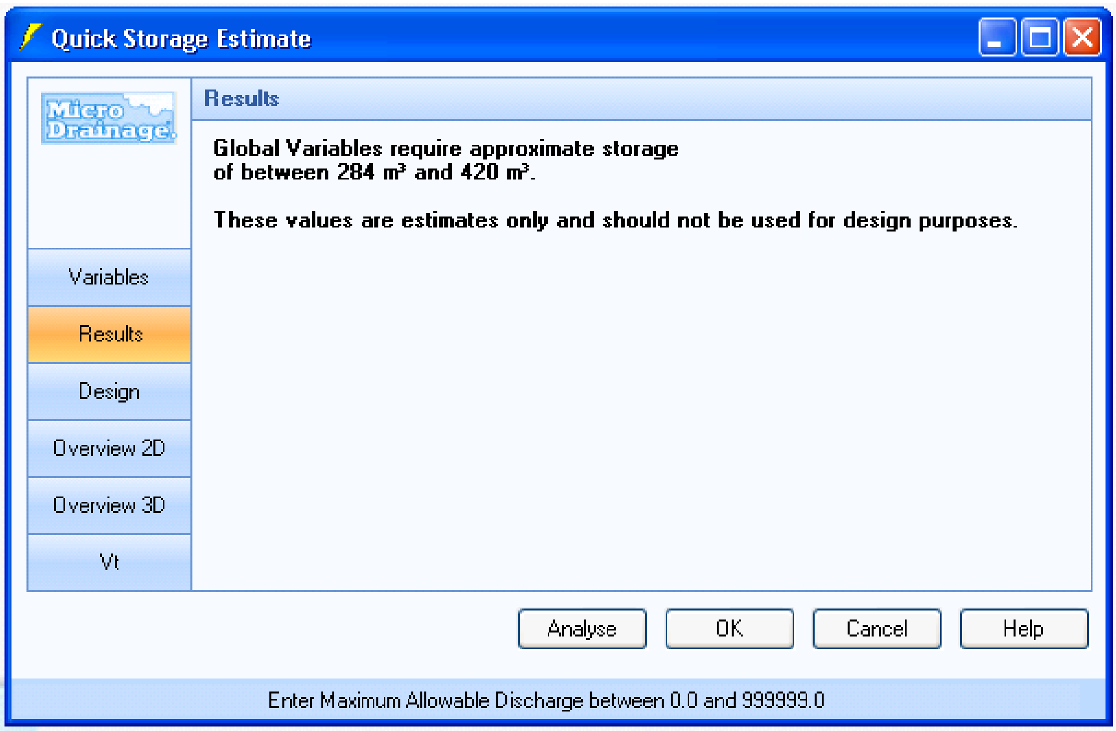




FEH Rainfall Data

1:30 Year Return Period - Discharge Rate Attenuated to 10.1l/s





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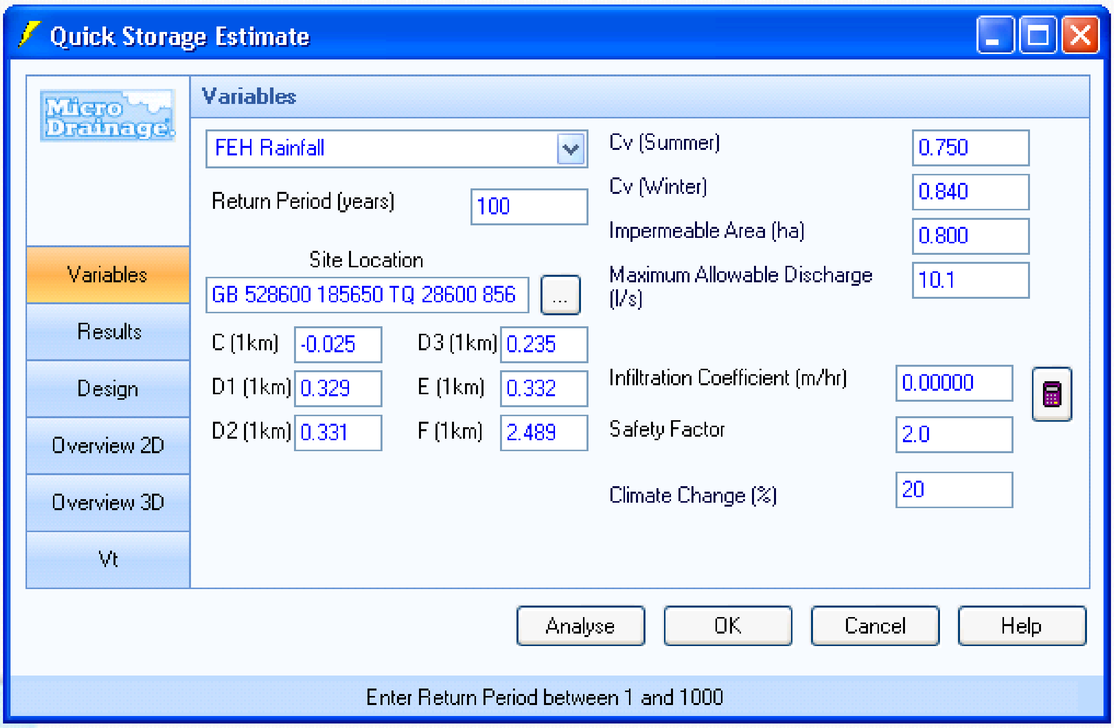
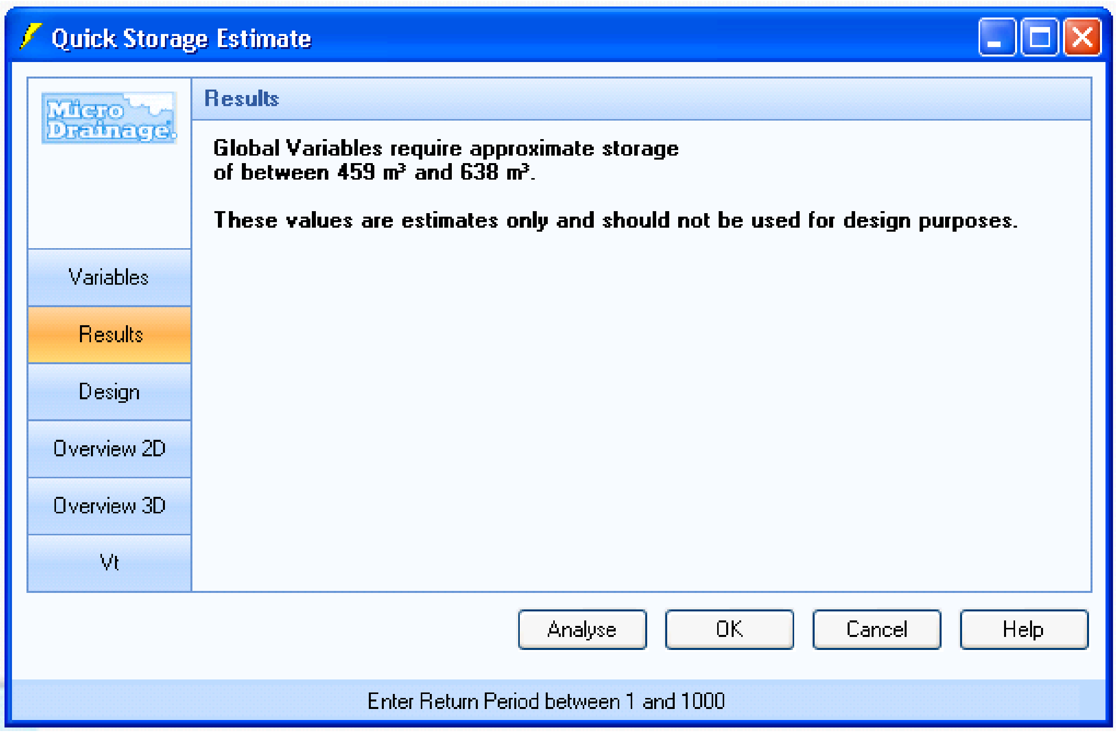
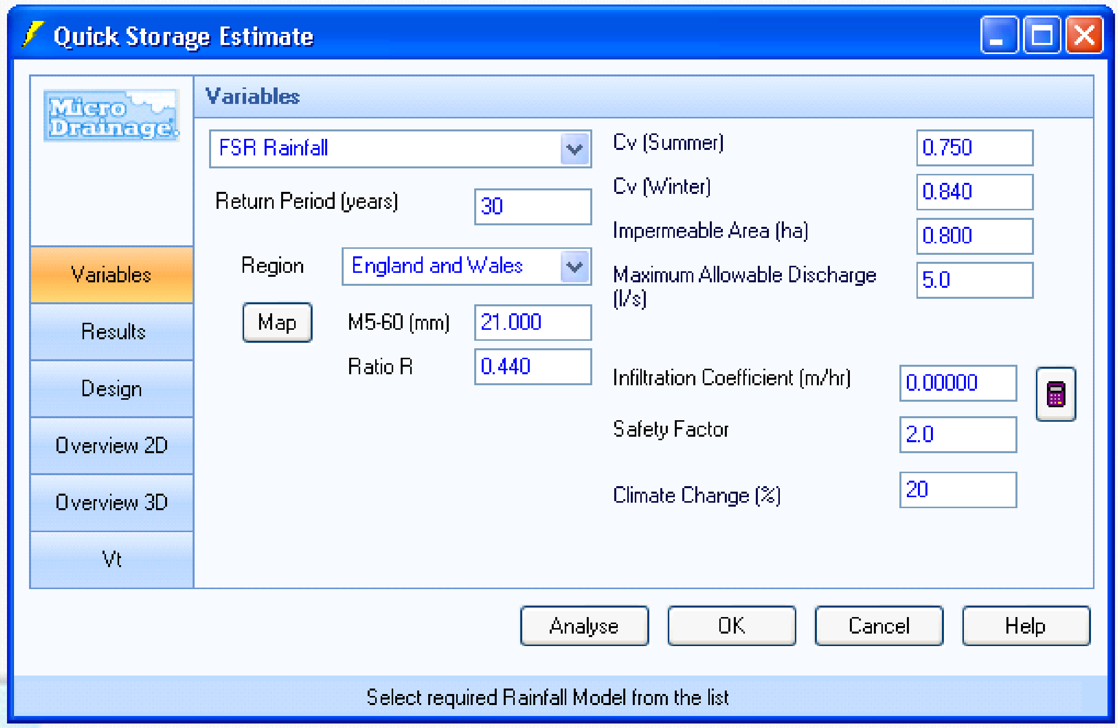
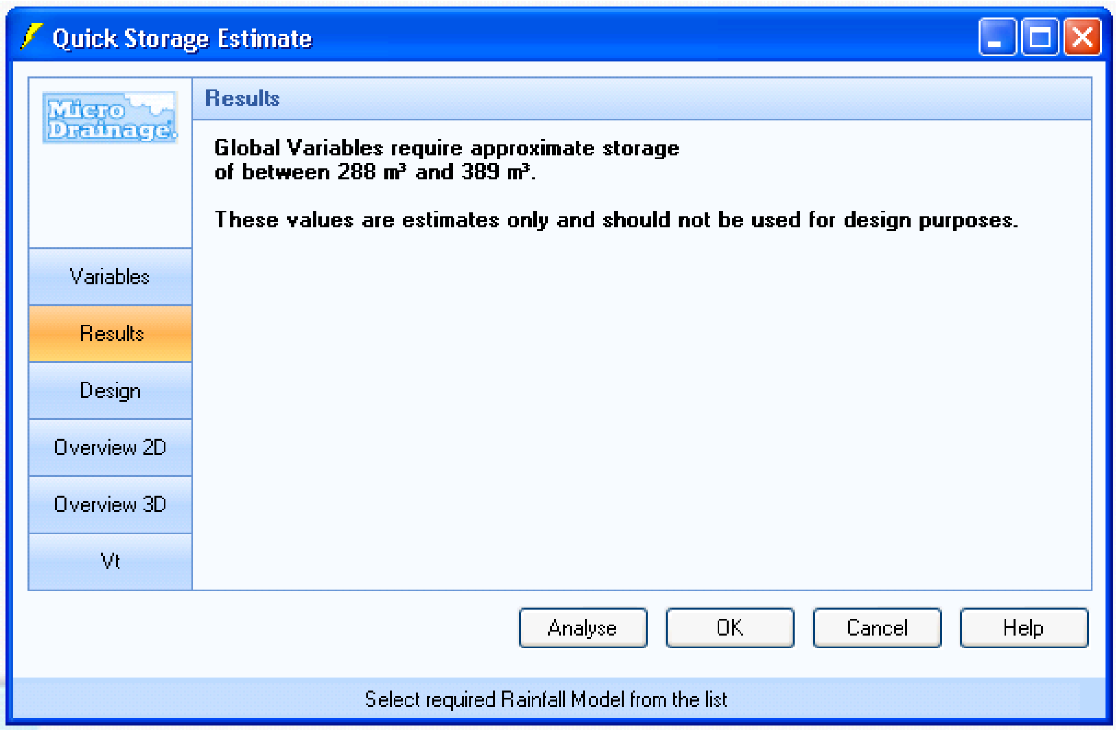




FSR Rainfall Data

1:30 Year Return Period - Discharge Rate Attenuated to 5l/s





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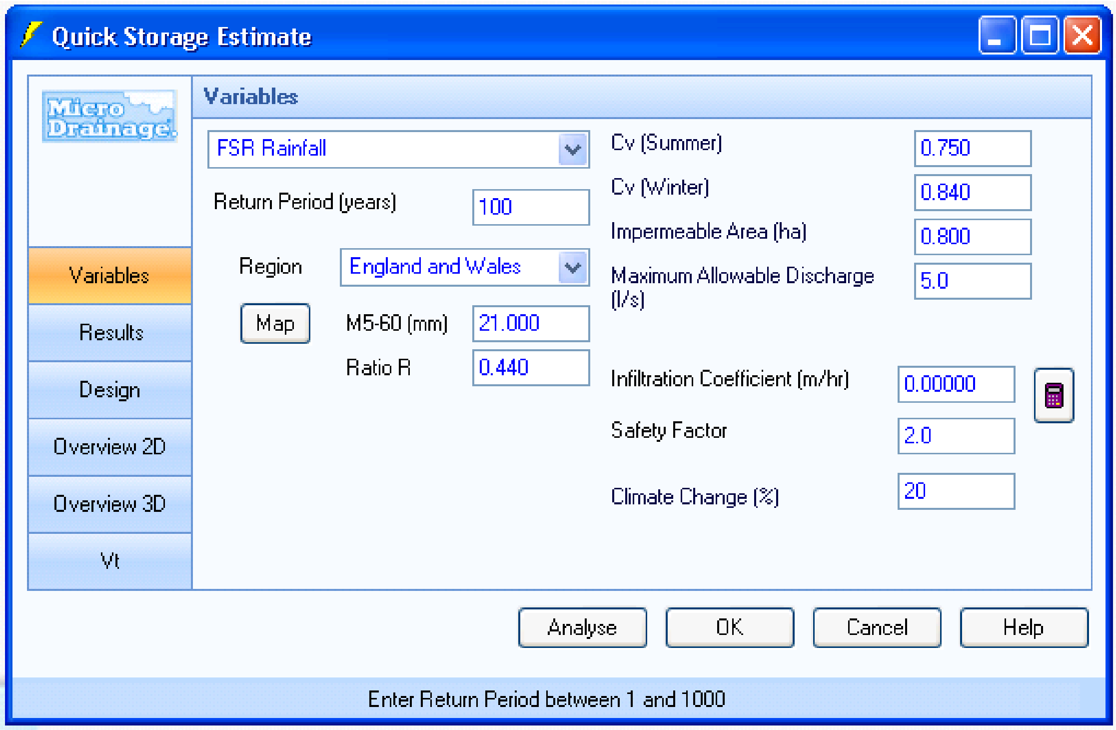
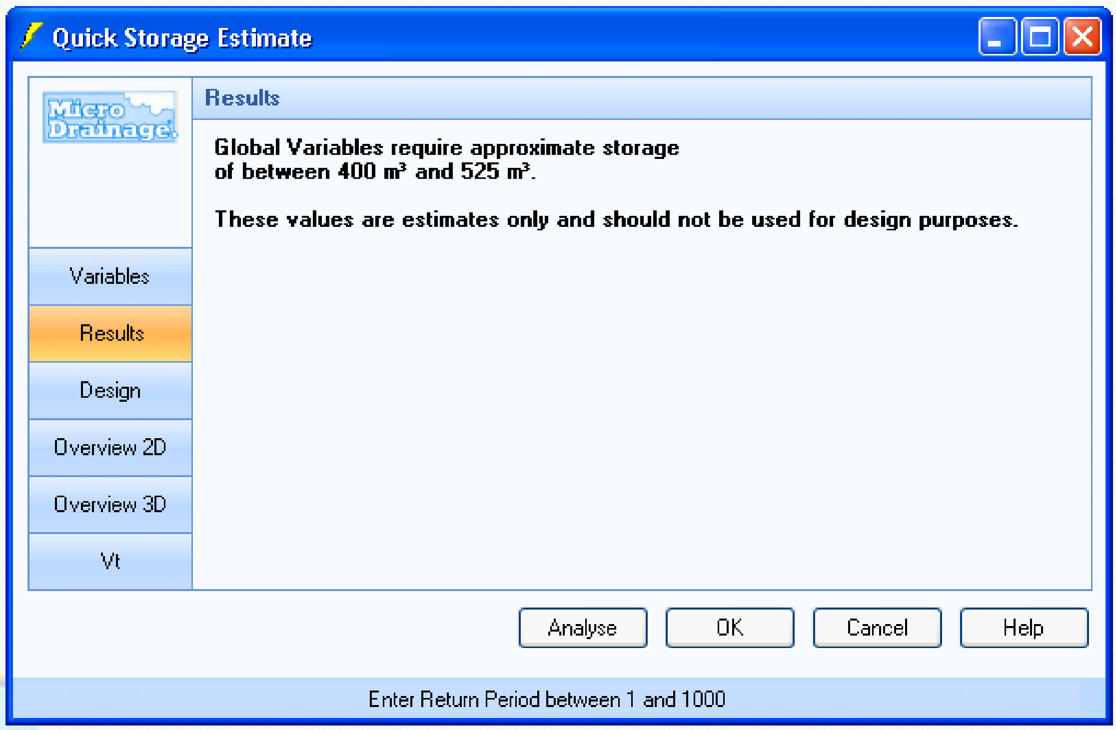
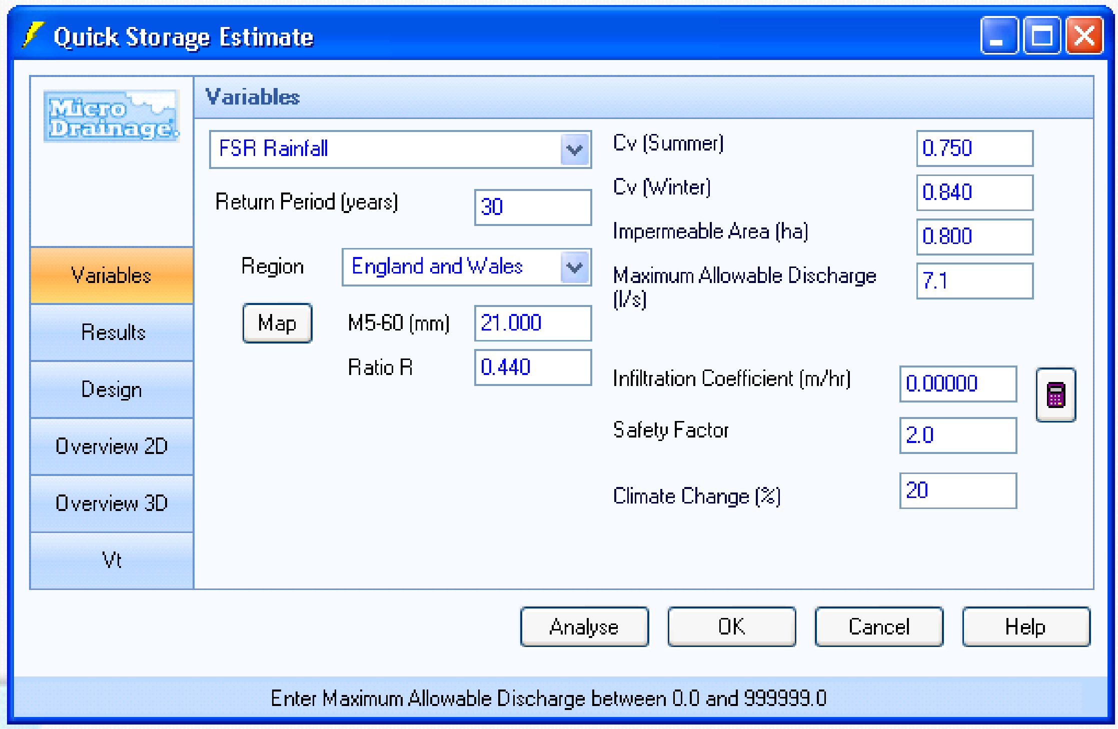
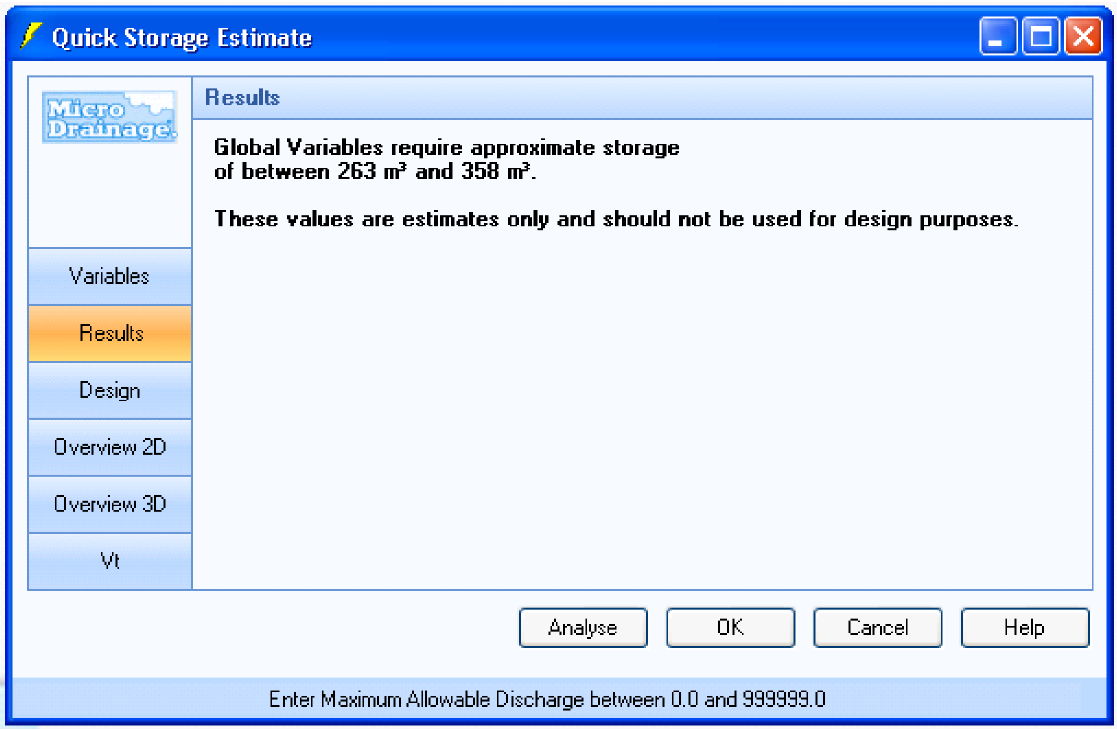




FSR Rainfall Data

1:30 Year Return Period - Discharge Rate Attenuated to 7.1l/s





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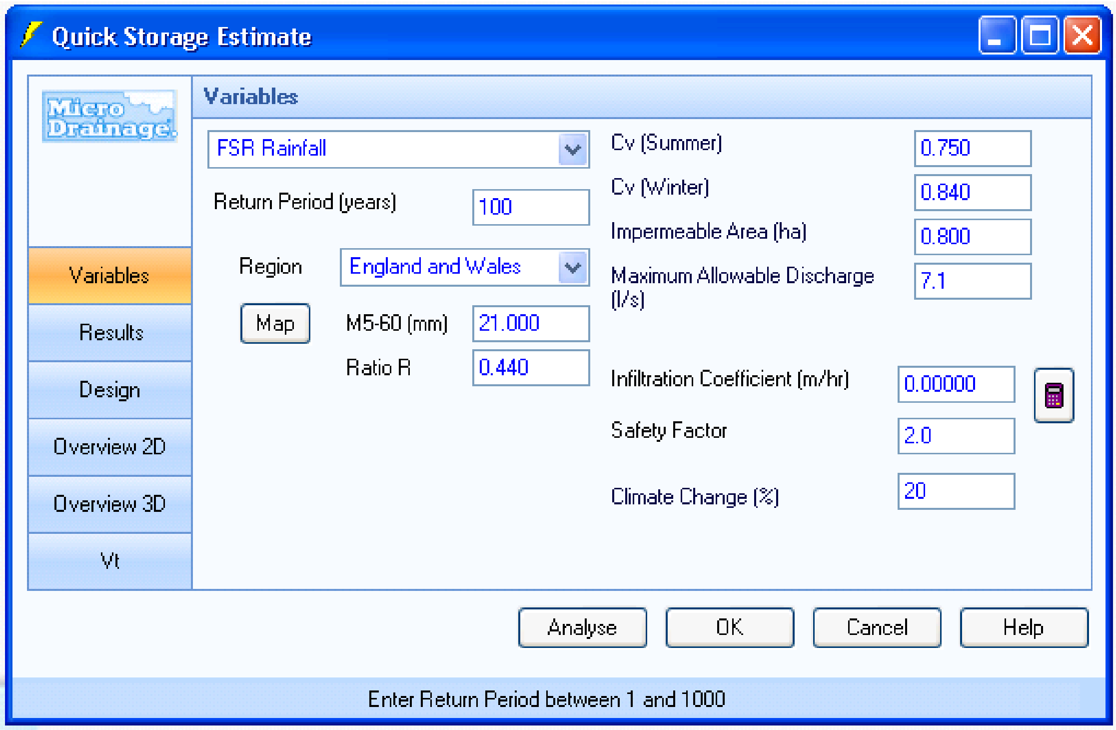

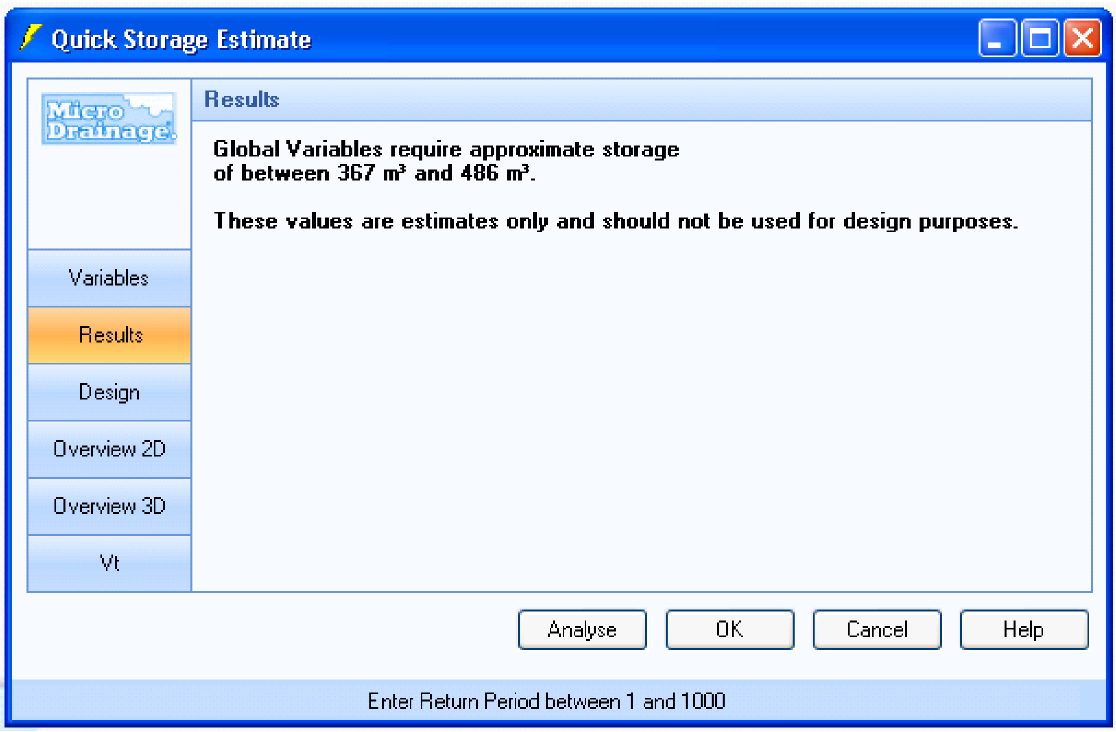

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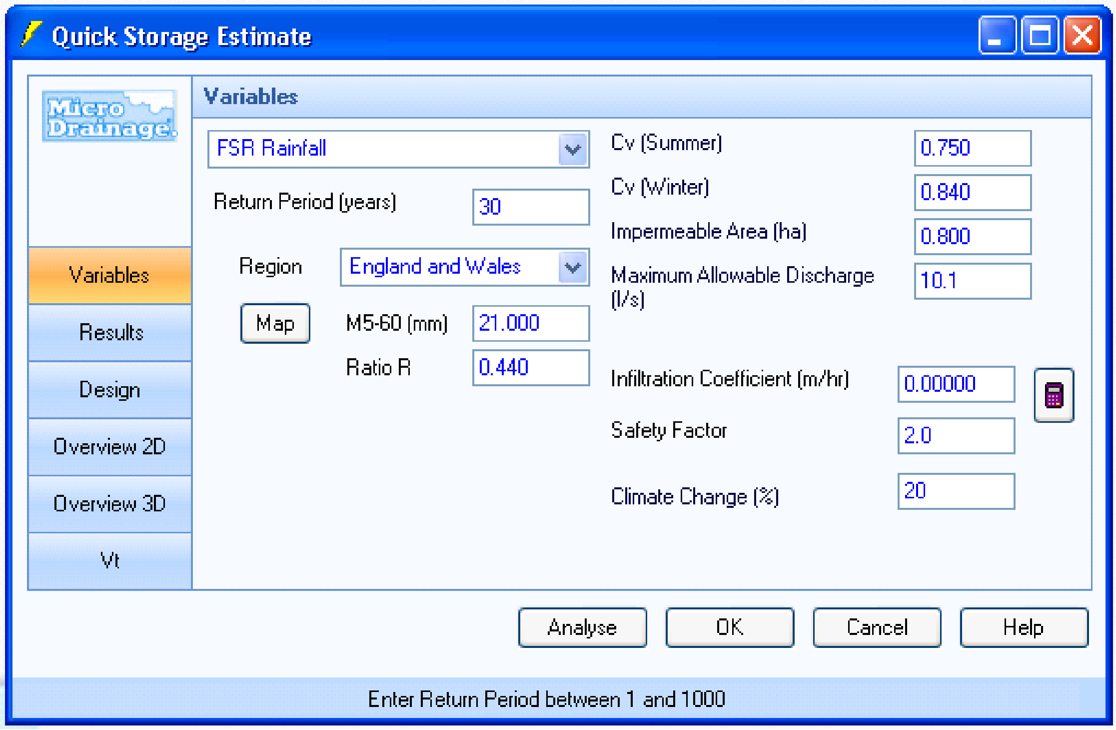
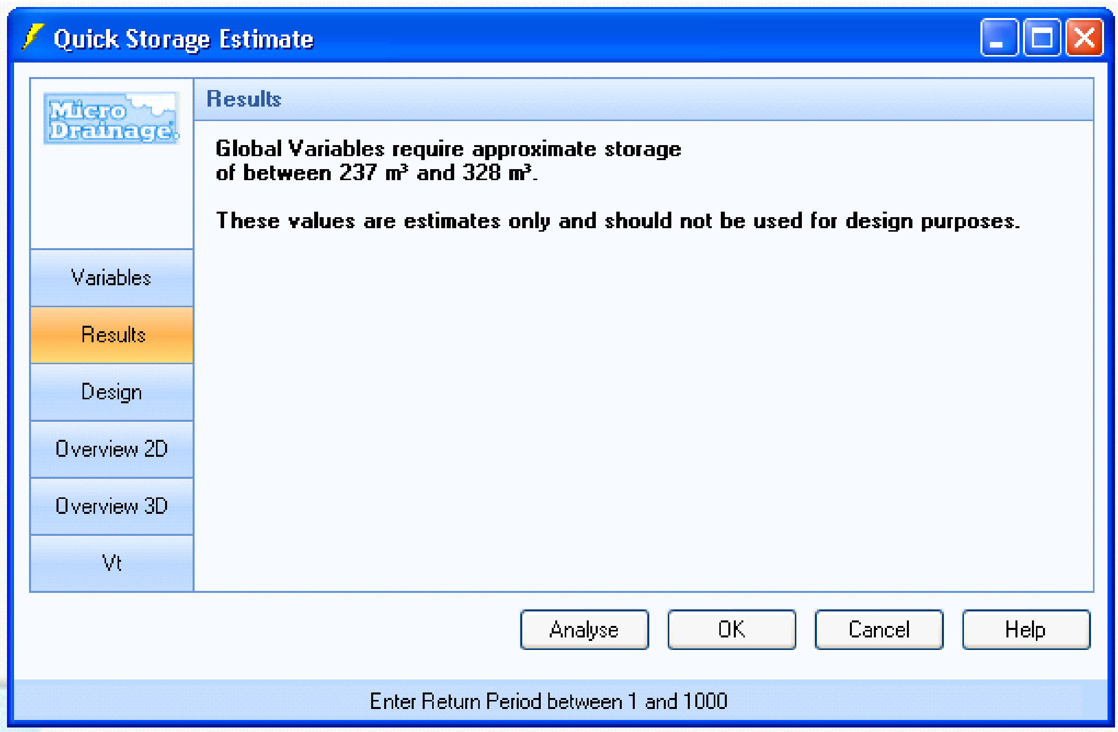
1:30 Year Return Period - Discharge Rate Attenuated to 10.1l/s





FSR Rainfall Data

1:100 Year Return Period - Discharge Rate Attenuated to 10.1l/s