South West London and St George's Mental Health NHS Trust

Barnes Hospital

Flood Risk Assessment

BAH-FRA-2018

3rd Issue | 6 December 2018

Job number 226594

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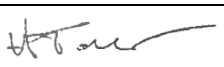
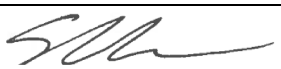
Document Verification

ARUP

Job title		Barnes Hospital			**Job number** 226594
Document title		Flood Risk Assessment			**File reference** 04-05-03
Document ref		BAH-FRA-2018			
Revision	**Date**	**Filename**	Barnes Hospital FRA - Oct 2018.docx		
Draft 1	15 Oct 2018	**Description**	Draft for review		
			Prepared by	Checked by	Approved by
		Name	Richie Turner	Hamish Tozer	Stuart Jordan
		Signature			
Issue	26 Oct 2018	**Filename**	Barnes Hospital FRA - Oct 2018 - Issue.docx		
		Description	Final Issue		
			Prepared by	Checked by	Approved by
		Name	Richie Turner	Hamish Tozer	Stuart Jordan
		Signature			
2nd Issue	2 Nov 2018	**Filename**	Barnes Hospital FRA - Nov 2018 - Issue.docx		
		Description	2nd Issue		
			Prepared by	Checked by	Approved by
		Name	Richie Turner	Hamish Tozer	Stuart Jordan
		Signature			
3rd Issue	6 Dec 2018	**Filename**	Barnes Hospital FRA - Dec 2018 - 3rd Issue.docx		
		Description	3rd Issue		
			Prepared by	Checked by	Approved by
		Name	Richie Turner	Hamish Tozer	Stuart Jordan
		Signature			
				Issue Document Verification with Document	✓

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Executive Summary

Arup has been commissioned by the South West London and St George's Mental Health Trust (SWLStG) to prepare a site-specific Flood Risk Assessment (FRA) to support a full planning application for the proposed Barnes Hospital development.

This FRA has been undertaken in accordance with the National Planning Policy Framework (NPPF) (July 2018), the London Plan (March 2016), the London Borough of Richmond upon Thames (LBRT) Local Plan (adopted July 2018) and the LBRT Strategic Flood Risk Assessment (March 2016). Refer to Appendix A for a summary of relevant legislation and planning policy documents.

The findings of this site-specific Flood Risk Assessment are as follows:

- The site is in Flood Zone 1 and at a low risk of river or sea flooding (<0.1% annual probability);
- Future climate change effects are not expected to significantly increase the risk of flooding from sources except rainfall;
- The site is at a low risk of flooding from other sources such as surface water, sewers, groundwater, and artificial sources;
- The groundwater level is a minimum of 2.7 m below ground level, and previous borehole logs show sandy gravel down to approximately 10 m below ground level. Therefore, infiltration is considered a feasible method of discharge of surface water, however this is subject to further ground investigation;
- Surface water runoff is proposed to be captured primarily by permeable paving, with a geo-cellular sub-base replacement layer providing attenuation. Disposal is intended to be by infiltration and discharge at a restricted rate into existing Thames Water surface water sewers within South Worple Way.

1 Introduction

This FRA assesses the flood risk to the SWLStG Barnes Hospital development site, considering changes to the current flood risk caused by the development and from climate change. It also considers a preliminary drainage strategy for the site, in accordance with Sustainable Drainage Systems (SUDS) objectives to restrict the rate of surface water discharge from the site into the existing drainage network.

2 Existing Site

2.1 Location

The Barnes Hospital site lies on South Worple Way at SW14 8SU in the London Borough of Richmond upon Thames (LBRT). The site is approximately 1.4 hectares and is located to the south of the River Thames, bounded by South Worple Way to the north, Old Mortlake Burial Ground to the west, Grosvenor Avenue residences to the south and South Worple Avenue (public footpath) to the east. National Rail tracks are located along the far side of South Worple Way.

The site is currently occupied by the existing hospital and associated facilities which provide community and in-patient mental health services. It is made up mostly of buildings and hard standing with a small amount of green space.

A topographical survey was undertaken by XYZ Land Chartered Surveyors dated February 2016. It shows that the site levels across the site are generally in the range of +5.8 to +6.5 mAOD.

Figure 1 below illustrates the location of the site.

2.2 Flood Zone

The Environment Agency (EA) produces flood maps for the UK, which show the areas at risk of fluvial and/or tidal flooding. These express the risk of flooding as an annual probability of occurrence.

The EA has provided a Product 1, which is a Flood Map for planning. This shows that the site is located in Flood Zone 1 (i.e. a very low risk of flooding from rivers or sea, with < 0.1 % annual probability). This Flood Map is included in Figure 2 and Appendix C.

Figure 1: Location of Barnes Hospital site

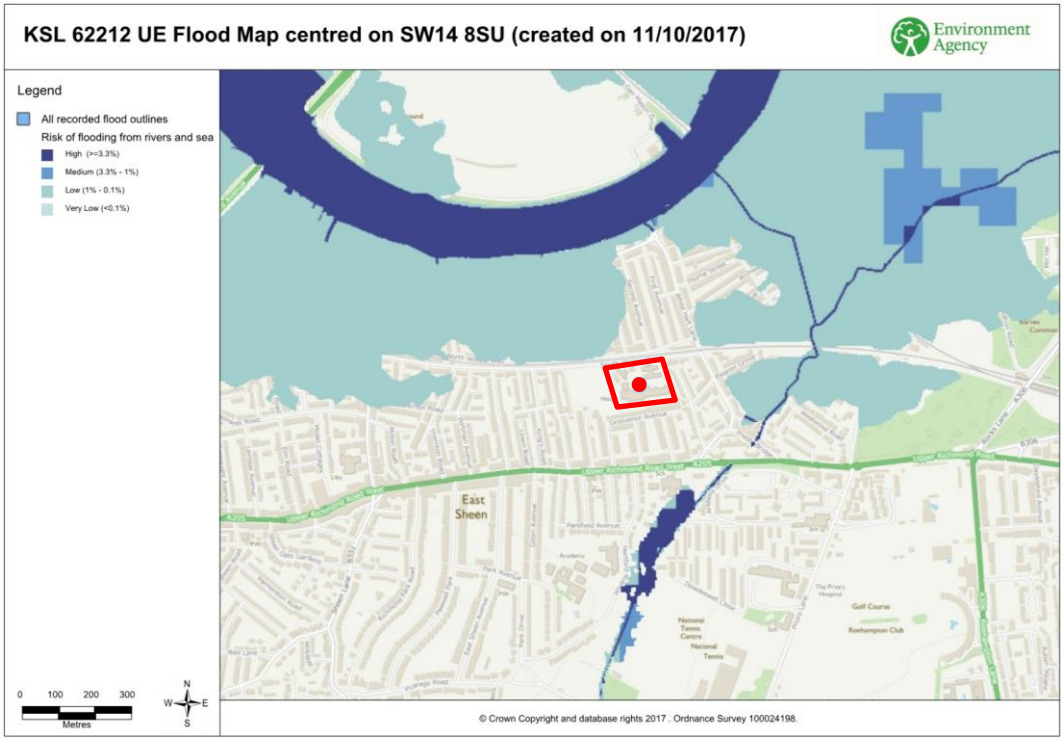


Figure 2: EA Product 1 showing risk of flooding from rivers and sea

3 Proposed Development

Outline planning permission for the demolition and comprehensive redevelopment (phased development) of land at Barnes Hospital to provide a mixed use development comprising a health centre (Use Class D1), a Special Educational Needs (SEN) School (Use Class D1), up to 80 new build residential units (Use class C3), the conversion of two of the retained BTMs for use for up 3no. residential units (Use Class C3), the conversion of one BTM for medical use (Use Class D1), car parking, landscaping and associated works. All matters reserved save for the full details submitted in relation to access points at the site boundaries.

The new buildings and roads will replace the majority of the existing arrangement on site. The extent of site considered by this report is indicated by the black and dashed red boundary in Figure 3, which shows an illustrated masterplan of the site.

Figure 3: Proposed ground floor plan for the development. (Source: Squire & Partners Architects)

4 Climate Change

4.1 Fluvial and Tidal Flooding

Since the proposed site is within Flood Zone 1, climate change is not expected to have a significant impact on the risk of fluvial or tidal flooding.

4.2 Surface Water Flooding

Rainfall intensity is anticipated to increase with climate change. The upper end allowance, as defined by the EA for a design life of 100 years (typical for residential development), is +40%. This has been taken into account when developing the surface water drainage strategy in Section 6.

4.3 Sewer Flooding

Climate change is not expected to have a significant impact on the risk of flooding from foul water drainage through existing foul water sewers, as foul water is primarily from internal sources.

4.4 Groundwater Flooding

Since the measured groundwater level is between 2.7-4.5m below proposed ground level, climate change is not expected to significantly increase the risk of flooding from groundwater.

5 Site Specific Flood Risk

A Level 1 Strategic Flood Risk Assessment (SFRA) has been carried out for the LBRT in June 2008 with updates in August 2010 and March 2016, which is applicable for this site. The SFRA has a strong emphasis on flooding from the river and sea.

Additionally, the LBRT Surface Water Management Plan 2011 (SWMP) assesses the surface water flood risk within the borough, using both historical information and undertaking pluvial modelling to determine the future flood risk for a range of rainfall events. These identify the areas of significant surface water and groundwater flooding risk and options to address this.

The National Planning Policy Framework (NPPF) (published in July 2018) and accompanying Planning Practice Guidance highlight the risk of flooding from the following sources:

- Fluvial (river) and tidal (sea);
- Pluvial (surface water);
- Groundwater;
- Drainage (surface water and foul);
- Reservoirs, canals, and other artificial sources.

5.1 Fluvial and Tidal Flooding

5.1.1 Environment Agency Fluvial Flood Maps

The Environment Agency (EA) produces flood maps for the UK, which show the areas at risk of fluvial and/or tidal flooding. These express the risk of flooding as an annual probability of occurrence.

The EA has provided a Product 1, which is a Flood Map for planning. This shows that the site is located in Flood Zone 1 (i.e. a very low risk of flooding from rivers or sea, with < 0.1 % annual probability). This Flood Map is included in Figure 4 and Appendix C.

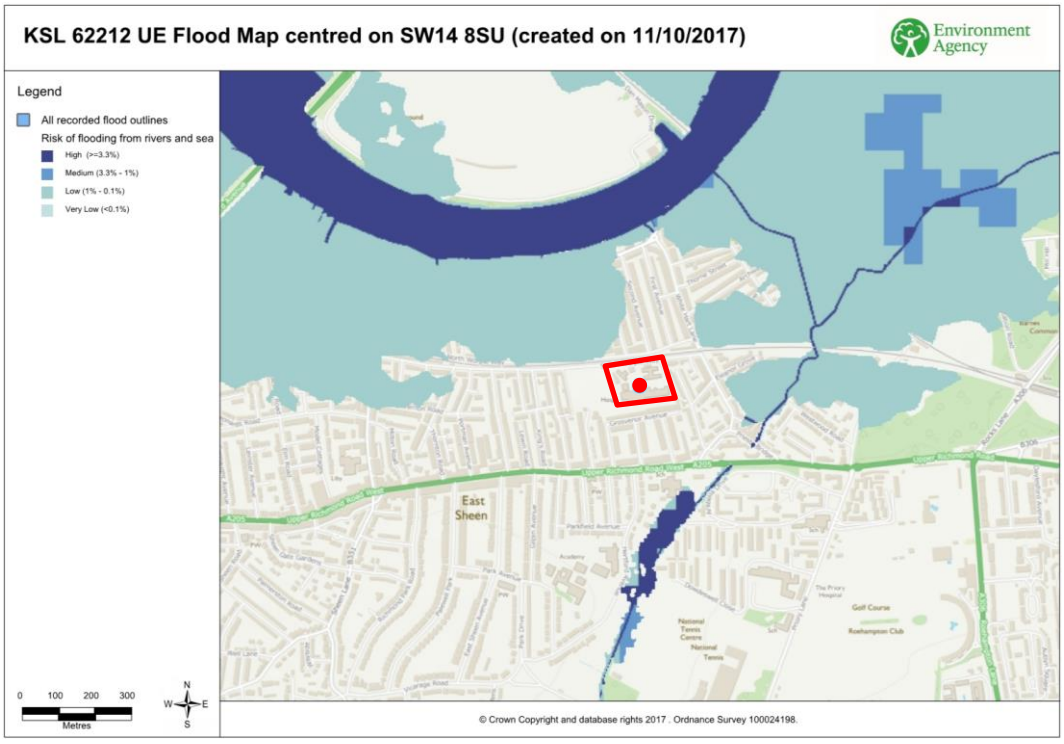


Figure 4: EA Product 1 showing risk of flooding from rivers and sea

5.1.2 Strategic Flood Risk Assessment

A Level 1 Strategic Flood Risk Assessment (SFRA) has been carried out for the LBRT in March 2016 in accordance with Planning Policy Statement 25: Development & Flood Risk. An extract of the SFRA maps show flood zones for planning is shown in Figure 5.

The SFRA shows the site is within Flood Zone 1, which is consistent with the EA flood maps.

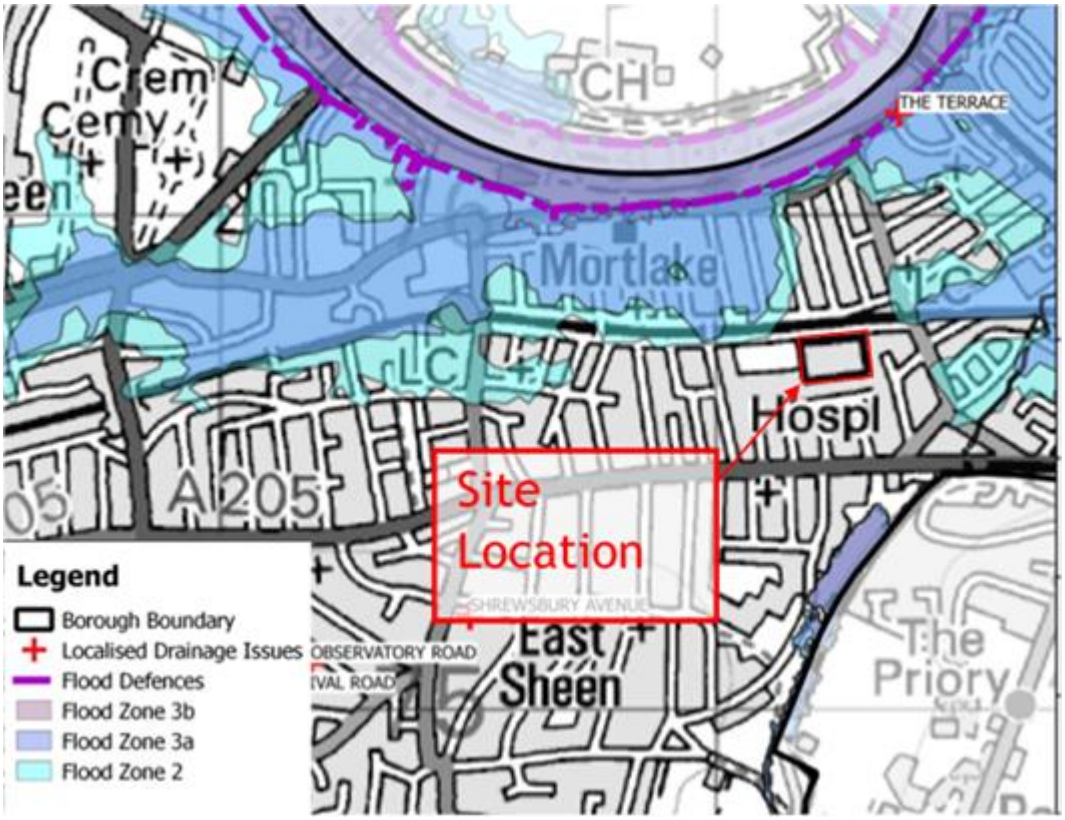


Figure 5: Extract from LBRT SFRA for Barnes

5.2 Pluvial (Surface Water) Flooding

The LBRT SFRA includes an assessment of the risk of flooding from surface water. This is driven by topography rather than existing drainage networks, and therefore is focussed on obstructions to overland flow.

Figure 6 is an extract from the SFRA, which shows that the Barnes Hospital site may have a flooding depth of 0.00 – 0.15 m. This is expected to be primarily due to the very flat topography of the site, rather than flow from off-site, and should be mitigated by a proposed surface water drainage network.

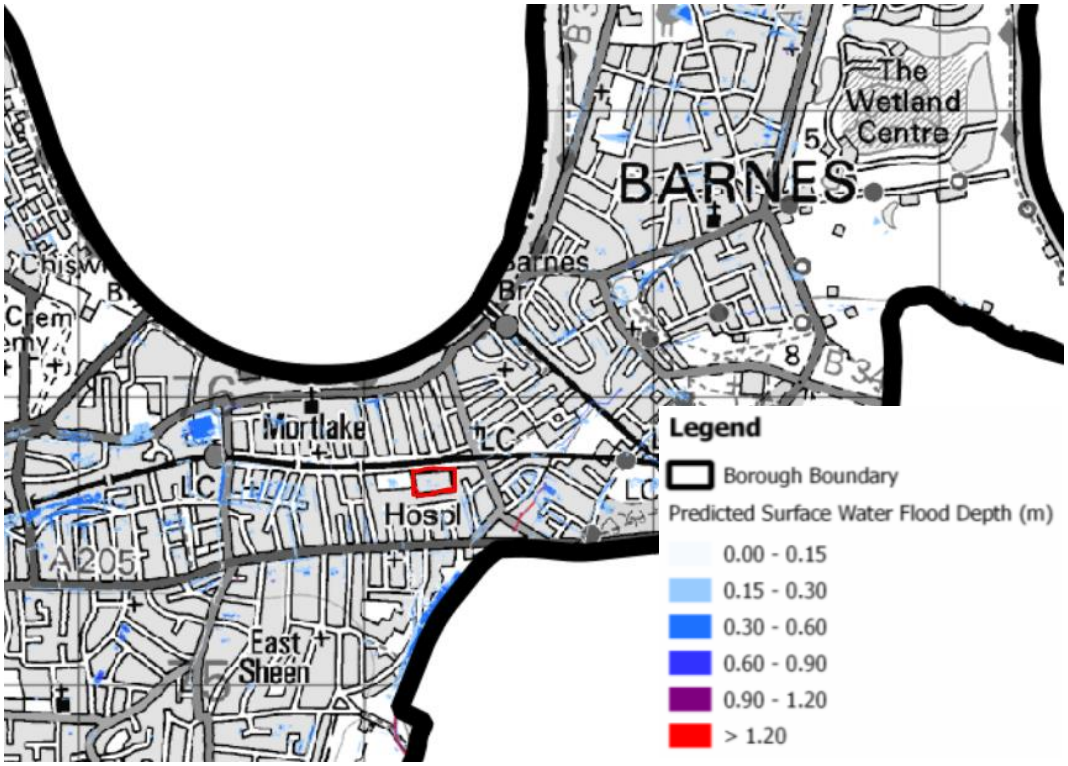


Figure 6: SFRA risk of flooding from surface water (for 1% chance of flooding in any one year) – approximate site boundary in red

5.3 Sewer Flooding

The LBRT SFRA shows that there have been between 1 and 5 reported incidences of sewer flooding within the vicinity of the site, though does not give any further detail on the exact location of these incidents, see Figure 7. This number is relatively low over a large area, hence sewer flood risk is considered to be low.

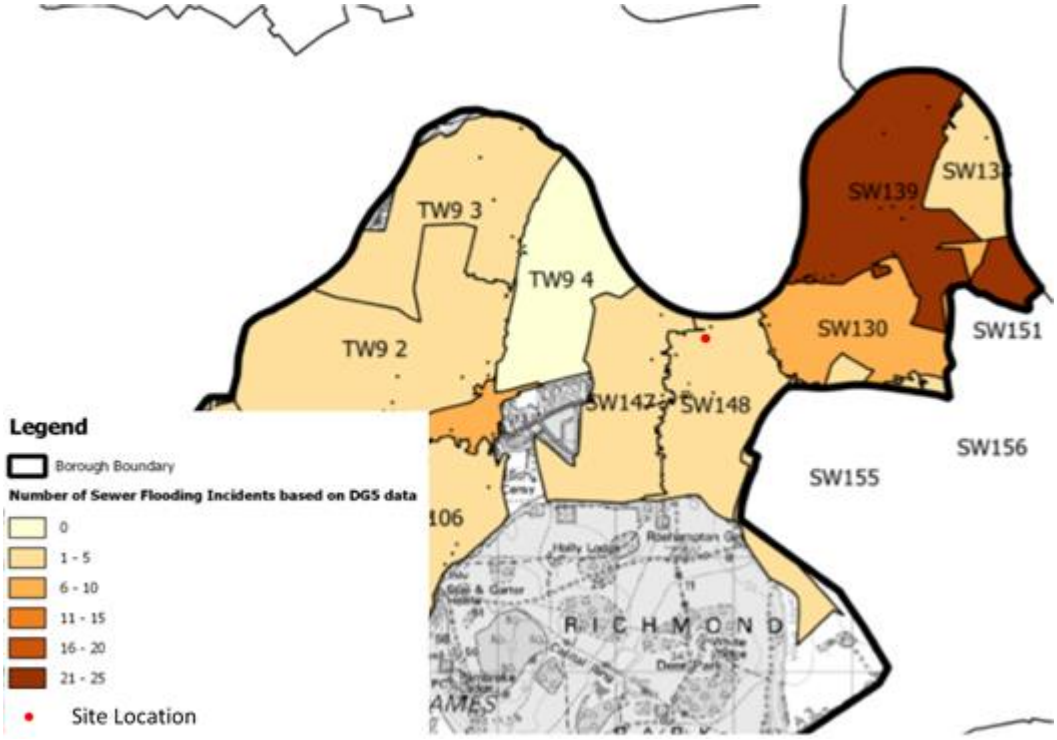


Figure 7: SFRA historic sewer flooding incidents

5.4 Groundwater Flooding

The LBRT SFRA includes the British Geological Survey (BGS) susceptibility to groundwater flooding assessment. An extract is included in Figure 8, which shows that the Barnes Hospital site does have a potential for groundwater flooding of property situated below ground.

Current proposals for the site include some subterranean car parking. It is expected that these elements would include sufficient waterproofing measures.

The risk of flooding from groundwater is considered to be low.

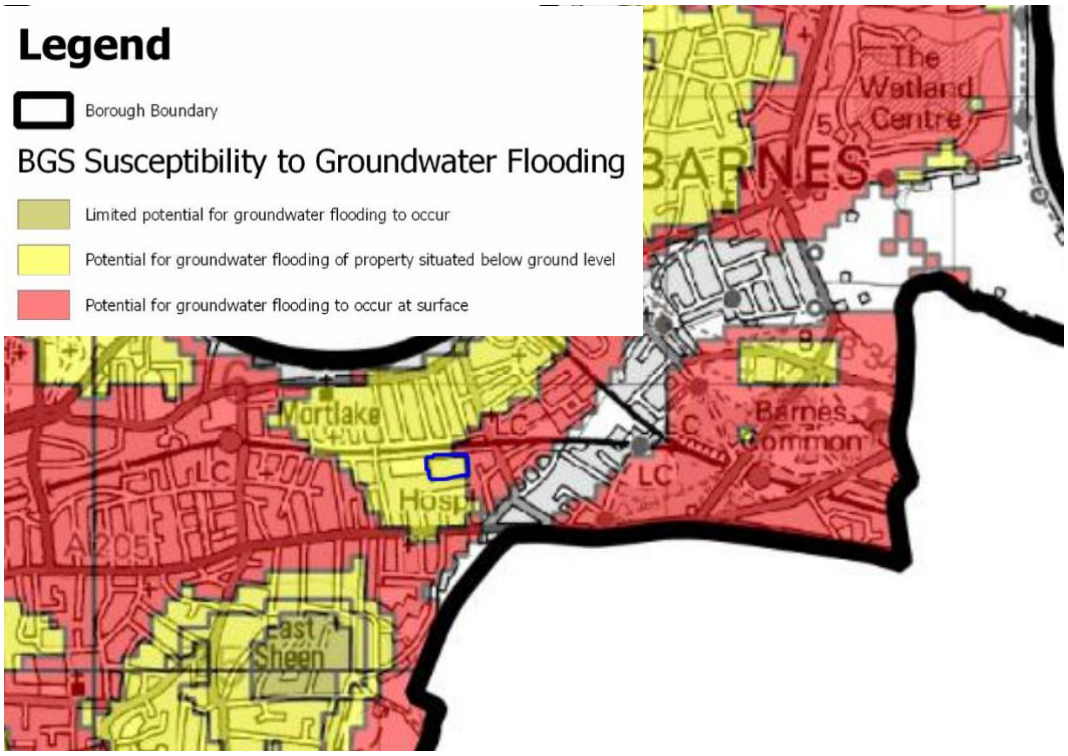


Figure 8: SFRA BGS susceptibility to groundwater flooding – approximate site boundary in blue

5.5 Artificial Sources of Flooding

The EA produce maps showing flood risk to the site due to the breach of a large reservoir. It can be seen in Figure 9, below, that the site has a negligible risk of being exposed to such flooding.

Figure 9: Extract of the EA Map showing risk of flooding from Artificial Water Sources

6 Surface Water Management

6.1 Preliminary Surface Water Drainage Study

Thames Water Utilities Limited (TWUL) have been identified as the local provider for surface water collection and operate services in South Worple Way, Lodge Avenue, Grosvenor Avenue and Buxton Road east of South Worple Avenue.

The Barnes Hospital site generally drains from south to north served by a private on-site network of sumps, downpipes, slot drains, manholes and pipes which discharge to an existing Ø225 mm TWUL sewer located in South Worple Way. The connection is located at the head of the TWUL network at a depth to invert ranging from 0.76-1.83 m, with one length running east before discharging into White Hart Lane, and one length falling to the west before discharging to a culvert beneath South Worple Way. From here, it is likely that this infrastructure feeds into a larger local network, leading to the Thames River, though this was not shown on the extents of the received utility records.

6.1.1 SUDS Assessment

The London Plan 2016 and the relevant Supplementary Planning Guidance (Sustainable Design and Construction 2014) advise developers to aim for 'greenfield' runoff rate from their development. This is defined as the runoff rate from a site in its natural state, prior to any development. For previously developed sites, runoff rates should not be more than three time the calculated greenfield rate.

The Flood and Water Management Act 2010 designate Lead Local Flood Authorities (for this site it is London Borough of Richmond and Thames) to establish requirements for design, building and operating Sustainable Urban Drainage Systems (SuDS) for approval of new developments. Developers will be required to utilise SuDS unless there are practical reasons for not doing so.

SuDS should be fully justified by adopting techniques in a hierarchical manner, maximising the use of those techniques higher up the hierarchy and those that deliver multi-functional benefits before considering others further down the hierarchy:

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

It is anticipated that the new development will require a new on-site surface water network to infiltrate and/or attenuate onsite before release to the TWUL network in South Worple Way at an appropriate rate to be agreed with TWUL.

Appropriate SuDS techniques for this site could include green/blue roofs, rainwater collection for greywater use, permeable pavements, filter drains/strips, swales, underground attenuation tanks and flow control devices. Space for these items should be incorporated into the development masterplan where practicable.

It is proposed that the site will discharge to the existing Ø225 mm TWUL network in South Worple Way. A new connection to the Ø225 mm sewer in Buxton Road may be a viable alternative.

The new network will be designed to adoptable standards and the extent of adoption will need to be discussed and agreed with TWUL.

The following works are recommended to progress the design:

- Further site visits and ground investigations of soil permeability and local hydrogeology to determine the viability of infiltration methods;
- Further site investigations to verify location, level and condition of connection to TWUL sewer;
- A review of a range of SuDS systems to assess the opportunities for inclusion in the development including surface water runoff prevention, runoff rate and volume reduction;
- Development of an integrated surface water drainage strategy for the development's masterplan which incorporates a SuDS management train with consideration for key issues including: construction and utility phasing, adoption strategy, suitability of existing connection points to external networks, details of new connections required to external networks, the extent of off-site reinforcements required and location of proposed utility corridors and building discharge locations;
- Consultation with and payment to TWUL to complete a sewer impact study to assess the impact of the proposed development flows on their existing drainage network.

6.2 Proposed Surface Water Drainage

The proposed strategy for surface water drainage primarily collects run off from roads and buildings within a new surface water network, using a permeable paving strategy to collect run off and transfer it to an on-site attenuation tank for storage and infiltration, before discharging by a restricted outflow to a Thames Water manhole within South Worple Way.

6.2.1 Feasibility of Infiltration

Geology

Available published map data from the British Geological Survey, see Figure 10 below, indicates the following strata will be encountered at or near surface within the site boundary:

- Kempton Park Gravel Formation (comprising sand and gravel, locally with lenses of silt, clay or peat);
- London Clay Formation (comprising clay, silt and sand).

It is anticipated that artificial deposits (made ground and re-worked deposits) will be encountered as a result of historical developments.

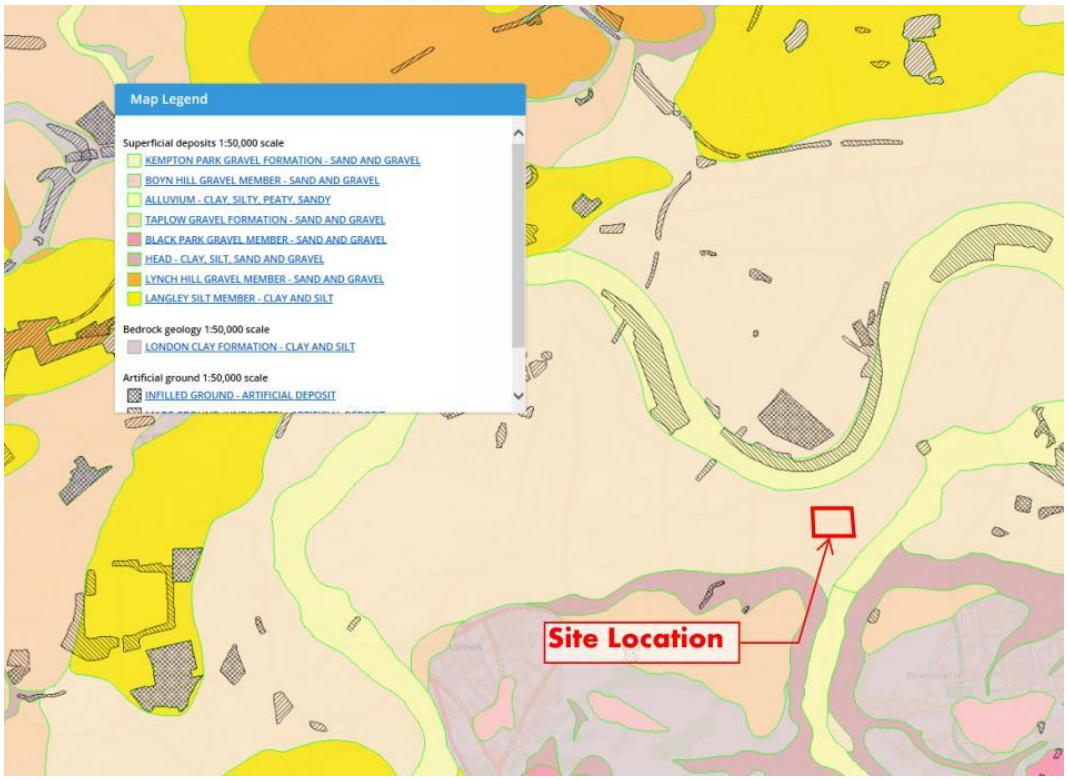


Figure 10: Superficial deposits and bedrock geology.

Borehole Records

A selection of historical borehole records, obtained from the BGS, were reviewed to confirm shallow ground conditions. Borehole record locations are shown on Figure 11 below and included the following:

- TQ27NW12
- TQ27NW11
- TQ27NW423

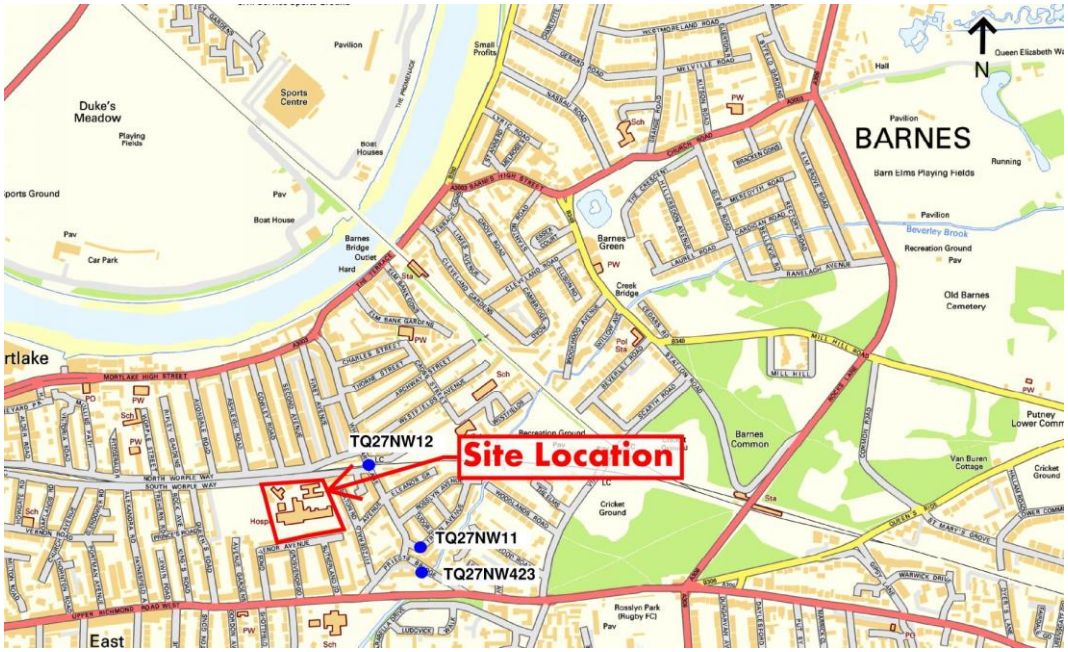


Figure 11: Borehole record locations

Borehole records generally confirm that there is a presence of sandy gravel to approximately 10 m below ground level followed by a clay formation to a depth of 45 m. This would indicate that infiltration methods could be viable for this site.

Records also indicated a groundwater level between 2.7 to 4.5 m below ground level. Ground water levels on site should be confirmed. There is a negligible risk of the site being exposed to groundwater flooding.

Allowing infiltration of surface water reduces the amount of water going into the existing network and also allows for the construction of a smaller attenuation tank on site. For the purposes of this FRA, two designs for the attenuation tank (one with and one without use of infiltration), have been made.

6.2.2 Greenfield Runoff Estimation

The greenfield runoff from the site was estimated using the online tool at uksuds.com; the results are included in Table 1 and Appendix D.

Table 1: Greenfield Runoff Rates

Design Storm	Greenfield Runoff Rate (l/s)
Qbar	2.19
1 in 1 year	1.86
1 in 30 years	5.04
1 in 100 years	6.98

6.2.3 Drainage Strategy

The site has a very flat topography, with a range of ground levels between 6.5 mAOD in the south-west corner of site and 6.0 mAOD just north of the centre of the site. The existing surface water drainage pipe in South Worple Way (north of site) is very shallow, at a depth of 0.76 m to invert (invert level (IL) of 5.28 mAOD) at its highest point, a manhole immediately adjacent to the proposed site egress.

The surface water drainage strategy is to store the runoff from a 1 in 30 year design storm (+40% allowance for climate change) below ground, and restrict the discharge into the existing TWUL network in South Worple Way to the estimated greenfield runoff rate for a 1 in 30 year design storm of approximately 5.0 l/s.

For the design of the surface water drainage, the buildings, healthcare / school car parking and access road to the residential underground car park are assumed to be 100% impermeable. These areas can be seen in the site plan (Appendix E). The strip of soft landscaping, approximately 8.0 m wide, along the west and south-western edges of the site is assumed to have no positive drainage (i.e. infiltrates naturally). The remainder of the site area is assumed 50% impermeable; a conservative estimate considering the site is predominantly soft landscaping intersected by footpaths. The total impermeable area is therefore approximately 0.95 ha.

A MicroDrainage Quick Storage Estimate was used to obtain an approximate volume of attenuation storage required for a 1 in 30 year rainfall event. Without infiltration this volume is 667 m^3, and with infiltration this is 601 m^3 (refer to Appendix B).

6.2.4 Proposed Solution

The proposed surface water drainage solution divides the attenuation and discharge into two separate areas: The healthcare / school area on the eastern side of the site and the residential area on the western side.

Eastern area

The volume of water to be attenuated in the eastern area of the site is 338 m^3 (refer Appendix B). The solution in the eastern area is to use permeable paving with geocellular sub-base replacement within the healthcare centre car park. The geocellular elements could be 600 mm deep and therefore would require a total surface area of approx. 560 m^2 to attenuate the area, with no infiltration. A potential layout for the geocellular area is in Figure 12. The remainder of the eastern area would be drained via channel drains and shallow pipes to discharge into the geocellular units.

Utilities required to/from the healthcare / school buildings could be routed around areas with geocellular storage, or utility corridors could be created through the geocellular system if necessary.

Western Area

To attenuate storm water on the western (residential) area of the site, geocellular blocks with a total depth of 900 mm could be installed under the soft landscaping between the residential blocks. These will have a cover of 150mm to allow for grass growth on the land above. The volume of water to be attenuated is approx. 330 m^3 without infiltration, therefore a total surface area of 366 m^2 would be required. A potential layout for the geocellular area is also shown in Figure 12. The remainder of the western area in hard landscaping could be drained via channel drains and shallow pipes to discharge into the geocellular units.

Utilities required to/from the residential blocks could be routed around areas with geocellular storage, or utility corridors could will be created through the geocellular system if necessary.

Figure 12: Proposed locations of geocellular surface water attenuation.

6.2.5 Proposed Connections

Two connections are proposed from the site, and shown in Figure 12 above. The eastern attenuation will connect to a new manhole on the existing drainage pipe in South Worple Way to the north-east of site, which would have an estimated IL of 5.20 mAOD. The permeable paving/geocell in the eastern area would have an IL of approximately 5.34 mAOD and so a 1% pipe grade for the short (approx. 12 m) distance between the attenuation tank and existing pipe is feasible for this connection.

The western area is to connect into the existing manhole TW1705 on South Worple Way. The pipe at this manhole is Ø225 mm with an IL of 4.60 mAOD. The base of the western geocellular tanks will be at approximately 5.10 mAOD, hence a 1% pipe grade over the approximately 66 m length would allow this connection.

6.3 Proposed Foul Water Drainage

6.3.1 Existing Network

The existing foul network around the Barnes Hospital site shows an existing foul water drainage pipe in South Worple Way to the north of the site. It is assumed that the site currently drains to manhole TQ2175NW1702 at the start of this run. The manhole in South Worple Way is 3.80m deep (CL: 6.43m, IL: 2.63m.) There is another drainage route on South Worple Avenue to the south east of the site, with an unknown depth. See Figure 13 below.

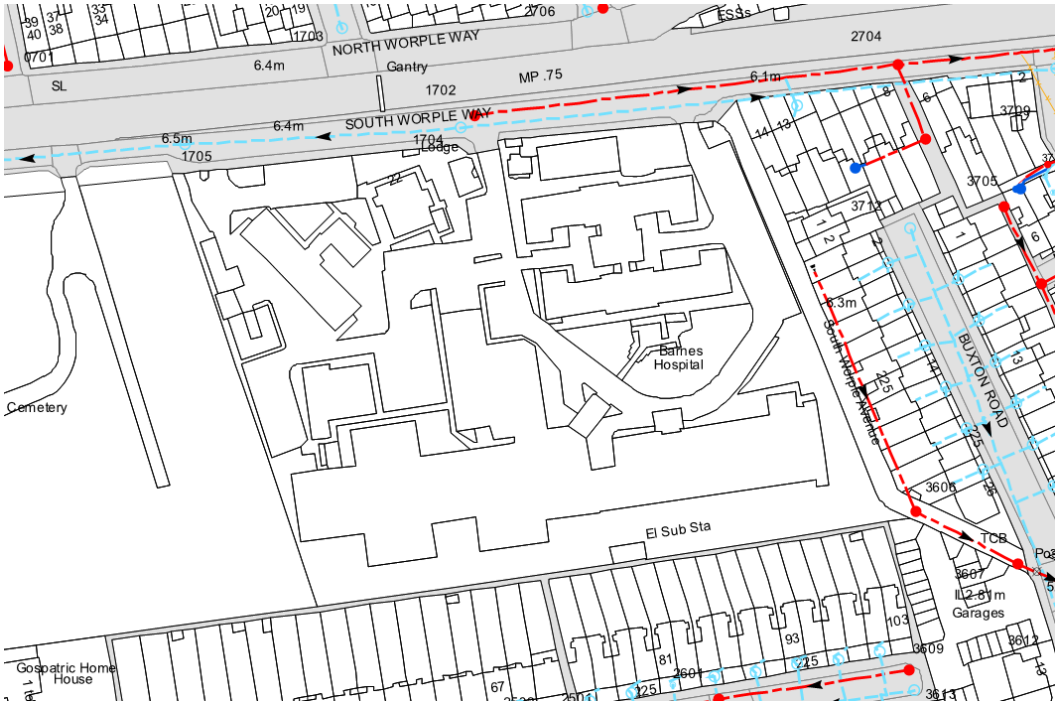


Figure 13: Existing drainage around Barnes hospital site (from Thames Water (TWUL) Asset Location Search (ALS))

6.3.2 Proposed Network

The proposed foul water drainage solution for the site is to gather the foul water from all buildings on site in manholes and pipes, and direct the flow north to the existing manhole TQ2175 NW1702 on South Worple Way. An indicative pipe network is shown in Figure 14. The pipe network will be designed to the standards set out in SfA 7th Edition.

6.3.3 Proposed Connections

One foul water connection is proposed from each building on the site. Foul water from the buildings will flow by gravity to these points and any foul water from the basements will be pumped up to these points. An indicative location for these can be seen on Figure 14.

There is one proposed connection to the existing manhole in South Worple Way. This will be routed into the existing connection in the manhole if possible, or this manhole could be rebuilt if required.

A survey of the existing network in this area should be carried out before finalising the design to establish the depth of the existing incoming pipe to manhole TQ2175 NW1702. A maximum allowable outflow to the existing network is to be agreed with TWUL before design completion.

Figure 14: Indicative FW network design

7 Conclusion

The findings of this site-specific Flood Risk Assessment are as follows:

- The site is in Flood Zone 1 and at a low risk of river or sea flooding (<0.1% annual probability);
- Future climate change effects are not expected to significantly increase the risk of flooding from sources except rainfall;
- The site is at a low risk of flooding from other sources such as surface water, sewers, groundwater, and artificial sources;
- The groundwater level is a minimum of 2.7 m below ground level, and previous borehole logs show sandy gravel down to approximately 10 m below ground level. Therefore, infiltration is considered a feasible method of discharge of surface water, however this is subject to further ground investigation;
- Surface water runoff is proposed to be captured by permeable paving and shallow drainage, directed to geo-cellular tanks under the sub-base; providing attenuation. Disposal is intended to be by infiltration and at a restricted rate of 5.0 l/s into existing Thames Water surface water sewers within South Worple Way;
- Foul water drainage from buildings will be collected in a series of new manholes and pipes and discharged to the existing manhole TQ2175NW1702 in South Worple Way.

Appendix A

Background Legislation and Guidance

A1 Legislation

A1.1 Floods Directive (2007/60/EC)

The aim of the Directive[1] is to provide a consistent approach across the European Union to reducing and managing the risks posed by flooding to human health, the environment, cultural heritage and economic activity. The Floods Directive is to be delivered in conjunction with the objectives of the Water Framework Directive (2000/60/EC) to deliver a better water environment through river basin management.

In the UK the Floods Directive is transposed into law via the Flood Risk Regulations (2009) by setting out the duties of local government in assessing flood risk to their area.

A1.2 Flood Risk Regulations (2009)

The Flood Risk Regulations[2] transpose the Floods Directive (2007/60/EC) into law in England and Wales.

The Regulations required the Lead Local Flood Authority (LLFA), in this case LBRT, to produce:

- a Preliminary Flood Risk Assessment (PFRA) by December 2011;
- flood hazard and flood risk maps by December 2013; and
- a Local Flood Risk Management Strategy by December 2015.

A1.3 The Flood and Water Management Act (2010)

The Flood and Water Management Act 2010 (FWMA)[3], which received Royal Assent on 8th April 2010, takes forward some of the proposals in three previous documents published by the UK Government:

- Future Water;
- Making Space for Water; and
- The Government's Response to the Sir Michael Pitt's Review of the summer 2007 Floods.

The Act gives the EA a strategic overview of the management of flood and coastal erosion risk in England. In accordance with the Government's Response to the Pitt Review, it also gives upper tier local authorities in England responsibility for

[1] European Parliament and Council, October 2007. Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks.
[2] UK Parliament, November 2009. The Flood Risk Regulations 2009, 2009 No. 3042.
[3] UK Parliament, April 2010. The Flood and Water Management Act 2010, 2010 c. 29.

preparing and putting in place strategies for managing flood risk from groundwater, surface water and ordinary watercourses in their areas.

A1.4 The Water Resources Act (1991) and Water Act (2003, 2014)

The Water Resources Act 1991[4] provides legislation for the control of the pollution of water resources. Under this Act, offences of polluting controlled waters occur if a person knowingly permits any poisonous, noxious or polluting matter or any solid waste matter to enter any controlled waters. The Water Resources Act also provides an all-embracing system for the licensing of the abstraction of water for use, which is administered by the EA. The Water Acts (2003[5], 2014[6]) modernise water legislation and amend the Water Resources Act 1991 to improve long-term water resource management.

A1.5 Land Drainage Acts (1991, 1994)

The water quality and flood risk management of controlled waters including rivers and aquifers is protected by legislation under the Land Drainage Acts (1991[7], 1994[8]).

A1.6 Land Drainage Byelaws (1981)

This law was made by the Thames Water Authority under Section 34 of Land Drainage Act 1976. The Thames Water Authority Land Drainage Byelaws 1981[9] are in force in the Thames Region of the EA. They are now enforced by the EA by virtue of the Water Resources Act and the Environment Act. These Byelaws have effect within the area of the Thames Regional Flood Defence Committee of the National Rivers Authority for the purposes of their functions relating to land drainage and flood risk management.

[4] UK Parliament, November 2009. Water Resources Act 1991, 1991 c. 57.
[5] UK Parliament, November 2003. Water Act 2003, 2014 c. 37.
[6] UK Parliament, May 2014. Water Act 2014, 2014 c. 21.
[7] UK Parliament, July 1991. Land Drainage Act 1991, 1991 c. 59.
[8] UK Parliament, July 1994. Land Drainage Act 1994, 1994 c. 25.
[9] Environment Agency, April 2014. Thames water authority: land drainage byelaws, Thames Region: Land Drainage Byelaws.

A2 National Policy and Guidance

A2.1 National Planning Policy Framework (July 2018)

The NPPF[10] includes policies on flood risk and minimising the impact of flooding under '14. Meeting the challenge of climate change, flooding and coastal management' (Paragraphs 155-165).

The NPPF states that:

- Inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk (whether existing or future). Where development is necessary in such areas, the development should be made safe for its lifetime without increasing flood risk elsewhere.
- Strategic policies should be informed by a Strategic Flood Risk Assessment (SFRA), and should manage flood risk from all sources. They should consider cumulative impacts in, or affecting, local areas susceptible to flooding, and take account of advice from the Environment Agency and other relevant flood risk management authorities, such as Lead Local Flood Authorities (LLFA) and internal drainage boards.
- All plans should apply a sequential, risk-based approach to the location of development – taking into account the current and future impacts of climate change – so as to avoid, where possible, flood risk to people and property. They should do this, and manage any residual risk
- When determining any planning applications, Local Planning Authorities (LPAs) should ensure that flood risk is not increased elsewhere. Where appropriate, applications should be supported by a site-specific flood-risk assessment. Development should only be allowed in areas at risk of flooding where, in the light of this assessment (and the sequential and exception tests, as applicable) it can be demonstrated that:

  a) within the site, the most vulnerable development is located in areas of lowest flood risk, unless there are overriding reasons to prefer a different location;

  b) the development is appropriately flood resistant and resilient;

  c) it incorporates sustainable drainage systems, unless there is clear evidence that this would be inappropriate;

  d) any residual risk can be safely managed; and

  e) safe access and escape routes are included where appropriate, as part of an agreed emergency plan.
- Major developments should incorporate sustainable drainage systems unless there is clear evidence that this would be inappropriate. The systems used should:

[10] Ministry of Housing, Communities and Local Government, July 2018. National Planning Policy Framework.

a) take account of advice from the LLFA;

b) have appropriate proposed minimum operational standards;

c) have maintenance arrangements in place to ensure an acceptable standard of operation for the lifetime of the development; and

d) where possible, provide multifunctional benefits.

A2.2 National Planning Practice Guidance (November 2016)

The NPPG[11], comprising a web-based resource, has been issued to ensure the effective implementation of the NPPF and contains a section covering Flood Risk and Coastal Change. With regard to planning for flood risk, the Guidance assesses the suitability of the development type with respect to the flood risk zone in which it lies.

The NPPG also provides an overview of the expected effect of climate change and recommends contingency allowances for sensitivity ranges for peak rainfall intensities. Advice regarding allowance for climate change was updated in February 2016.

A2.3 Sewers for Adoption (2012)

An adopted drainage network needs to meet the criteria outlined in Sewers for Adoption[12]. A piped drainage system is required to not flood the ground in a 1 in 30 year flood, or surcharge for a 1 in 2 year event, using a design storm with the critical duration relevant to the site (i.e. the worst-case for a given return period). Private drainage systems also tend to use these criteria as a basis for design. Adoption of new sewers or abandonment of old sewers should take place in accordance with the Water Industry Act 1991, Sections 104 and 116 respectively.

A2.4 National Encroachment Policy for Tidal Rivers and Estuaries (2005)

The EA's National Encroachment Policy for Tidal Rivers and Estuaries has been approved by the Regional Flood Defence Committees of England and Wales. The EA is generally opposed to works on tidal rivers and estuaries that cause encroachment, but treat developments on a case by case basis.

[11] Department for Communities and Local Government, November 2016. Planning practice guidance.
[12] Water UK/WRc plc, August 2012. Sewers for Adoption (7th Edition): A design and construction guide for developers.

A3 Regional Policy and Guidance

A3.1 The London Plan: The Spatial Development Strategy for London Consolidated with Alterations Since 2011 (March 2016)

The document in its current state is The London Plan (2011) consolidated with Revised Early Minor Alteration to The London Plan (2013), Further Alterations to The London Plan (2015), Housing Standards Minor Alterations to The London Plan (March 2016) and Parking Standards Minor Alterations to The London Plan (March 2016)[13].

The London Plan is the overall strategic plan for London setting out an integrated economic, environmental, transport and social framework for the development of London; it recognises the need to address the increasing effects of climate change as predictions show there are more people likely to be living and working on the floodplain.

Relevant policies from the Plan are outlined below:

Policy 5.12: Flood risk management

The policy states:

- Development proposals must comply with the flood risk assessment and management requirements set out in the NPPF on flood risk over the lifetime of the development and have regard to measures proposed in Thames Estuary 2100 and Catchment Flood Management Plans.
- Developments which are required to pass the Exceptions Test set out in the NPPF will need to address flood resilient design and emergency planning by demonstrating that:
    1. The development will remain safe and operational under flood conditions;
    2. A strategy of either safe evacuation and/or safely remaining in the building is followed under flood conditions;
    3. Key services including electricity, water etc. will continue to be provided under flood conditions; and
    4. Buildings are designed for quick recovery following a flood.
- Development adjacent to flood defences will be required to protect the integrity of existing flood defences and wherever possible should aim to be set back from the banks of watercourses and those defences to allow their management, maintenance and upgrading to be undertaken in a sustainable and cost effective way.

[13] Greater London Authority, March 2016. The London Plan: The Spatial Development Strategy for London consolidated with alterations since 2011.

Policy 5.13: Sustainable drainage

The policy states:

- Development should utilise Sustainable Urban Drainage Systems (SuDS) unless there are practical reasons for not doing so, and should aim to achieve Greenfield runoff rates and ensure that surface water runoff is managed as close to its source as possible in line with the following drainage hierarchy:
    1. Store rainwater for later use;
    2. Use infiltration techniques, such as porous surfaces in non-clay areas;
    3. Attenuate rainwater in ponds or open water features for gradual release;
    4. Attenuate rainwater by storing in tanks or sealed water features for gradual release;
    5. Discharge rainwater direct to a watercourse;
    6. Discharge rainwater to a surface water sewer/drain;
    7. Discharge rainwater to the combined sewer.
- Drainage should be designed and implemented in ways that deliver other policy objectives of this plan, including water use efficiency and quality, biodiversity, amenity and recreation.

Policy 7.13: Safety, security and resilience to emergency

The policy states that developments should maintain a safe, secure environment and minimise potential physical risks, including those arising from flooding and related hazards.

A3.2 The London Plan: Supplementary Planning Guidance - Sustainable Design and Construction (April 2014)

The Supplementary Planning Guidance (SPG)[14] sets out the Mayor's priorities with regard to flooding as follows:

- Through their Local Flood Risk Management Strategies boroughs should identify areas where there are particular surface water management issues and develop policies and actions to address these risks.
- Developers should maximise all opportunities to achieve greenfield runoff rates in their developments.
- When designing their schemes developers should follow the drainage hierarchy set out in London Plan policy 5.13.

[14] Greater London Authority, April 2016. Sustainable Design and Construction Supplementary Planning Guidance.

- Developers should design Sustainable Drainage Systems (SuDS) into their schemes that incorporate attenuation for surface water runoff as well as habitat, water quality and amenity benefits.
- Development in areas at risk from any form of flooding should include flood resistance and resilience measures in line with industry best practice.
- Developments are designed to be flexible and capable of being adapted to and mitigating the potential increase in flood risk as a result of climate change.
- Developments incorporate the recommendation of the TE2100 plan for the future tidal flood risk management in the Thames Estuary.
- Where development is permitted in a flood risk zone, appropriate residual risk management measures are to be incorporated into the design to ensure resilience and the safety of occupiers.

A3.3 Thames Estuary 2100 Plan (2012)

The Thames Estuary 2100 (TE2100) Strategy[15] has been prepared by the EA to consider flood risk management for the next 100 years. The plan that has been prepared looks at the work that is needed to maintain and improve the flood defences protecting London and the Thames Estuary, including the Thames Barrier.

A3.4 Thames Region Catchment Flood Management Plan (2008)

A Catchment Flood Management Plan (CFMP) is a high-level strategic plan prepared by the EA, which identifies long-term (50 to 100 year) policies for sustainable flood risk within a catchment.

The relevant key messages contained within the Thames Region CFMP[16] are that:

- Climate change will be the major cause of increased flood risk in the future. In urban areas and areas of narrow floodplain, flooding from heavy rainfall will be more regular and more severe. Surface water, sewer and fluvial flooding can occur within minutes of a severe rainfall event. Flooding can therefore occur at any time of the year, and there is very little time to provide flood warnings.
- It is increasingly necessary to recognise the value of flood plain in reducing the effects of flooding. Technical, environmental and economic constraints mean there are likely to be very few flood defence schemes in areas of narrow floodplain in the foreseeable future.
- Development and urban regeneration provide a crucial opportunity to manage flood risk. The location, layout and design of development can all reduce

[15] Environment Agency, November 2012. TE2100 Plan: Managing flood risk through London and the Thames estuary.
[16] Environment Agency, December 2009. Thames Catchment Flood Management Plan: Summary Report December 2009.

flood risk. For example, the use of SuDS can help to control surface water (design).

A3.5 River Basin Management Plan, Thames River Basin District (2015)

River Basin Management Plans[17] are plans for protecting and improving the water environment and have been developed in consultation with organisations and individuals. They contain the main issues for the water environment and actions required. The River Basin Management Plans have been approved by the Secretary of State (SoS) for the Department of the Environment, Food and Rural Affairs (Defra) and the Welsh Minister.

[17] Department for Environment Food & Rural Affairs/Environment Agency, February 2016. River basin management plans: 2015, Thames river basin district RBMP: 2015.

A4 Local Guidance

A4.1 London Borough of Richmond upon Thames Strategic Flood Risk Assessment (SFRA)

The SFRA document was prepared in consultation with the Environment Agency and determines the level of flood risk across the borough. The SFRA is used to inform and support the Borough's flooding policies in its emerging Local Development Framework, (LDF) in accordance with the NPPF.

The SFRA states:

- *This residual risk (of flooding) is associated with a number of potential risk factors including (but not limited to):*
    - *a flooding event that exceeds that for which the local drainage system has been designed*
    - *the residual danger posed to property and life as a result of flood defence failure or exceedance*
    - *general uncertainties inherent in the prediction of flooding*
    - *reservoir failure*
- *For all sites greater than 1ha in area, a Flood Risk Assessment / Sustainable Drainage Strategy must be prepared. The potential impacts of the development to increase flood risk elsewhere through the addition of hard surfaces and the effect of the new development on surface water runoff must be considered.*
- *Details of proposed sustainable drainage systems (SuDS) that will be implemented to ensure that runoff from the site (post redevelopment) does not exceed greenfield runoff rates. Any SuDS design must take due account of groundwater and geological conditions.*
- *The risk of other sources of flooding (e.g. urban drainage and/or groundwater) must be considered.*
- *There are four main approaches to designing for flood risk:*
    - *Flood Avoidance: Constructing a building and its surroundings (at site level) in such a way to avoid being flooded.*
    - *Flood Resistance: Constructing a building in such a way to prevent flood water entering the building and damaging its fabric.*
    - *Flood Resilience: Constructing a building in such a way that although flood water may enter the building its impact is reduced.*
    - *Flood Repairable: Constructing a building in such a way that although flood water enters a building, elements that are damaged by flood water can be easily repaired or replaced. This is also a form of flood resilience.*
- *A planning solution to flood risk management should be sought wherever possible, steering vulnerable development away from areas affected by flooding in accordance with the Sequential Test.*

- *Where other planning considerations must guide the allocation of sites following the application of the Sequential Test, specific recommendations have been provided to assist the Borough and the developer to meet the Exception Test. These should be applied as development control recommendations for all future development (refer Section 7.4).*
- *Flood Warning and Evacuation Plans should be in place for those areas at an identified risk of flooding. Developers should ensure that appropriate evacuation and flood response procedures are in place to manage the residual risk associated with an extreme flood event, and include how such plans will be implemented.*
- *When constructing new properties, permanent flood resistance measures are always preferable to temporary measures as they do not require intervention by the property occupants.*

A4.2 London Borough of Richmond upon Thames Local Plan (adopted July 2018)

Policy LP 21

Flood Risk and Sustainable Drainage

A. All developments should avoid, or minimise, contributing to all sources of flooding, including fluvial, tidal, surface water, groundwater and flooding from sewers, taking account of climate change and without increasing flood risk elsewhere. Development will be guided to areas of lower risk by applying the 'Sequential Test' as set out in national policy guidance, and where necessary, the 'Exception Test' will be applied. Unacceptable developments and land uses will be refused in line with national policy and guidance, the Council's Strategic Flood Risk Assessment (SFRA) and as outlined in the table below.

In Flood Zones 2 and 3, all proposals on sites of 10 dwellings or more or 1000sqm of non-residential development or more, or on any other proposal where safe access/egress cannot be achieved, a Flood Emergency Plan must be submitted.

Where a Flood Risk Assessment is required, on-site attenuation to alleviate fluvial and/or surface water flooding over and above the Environment Agency's floodplain compensation is required where feasible.

Basements and subterranean developments

B. Basements within flood affected areas of the borough represent a particularly high risk to life, as they may be subject to very rapid inundation.

Sustainable drainage

C. The Council will require the use of Sustainable Drainage Systems (SuDS) in all development proposals. Applicants will have to demonstrate that their proposal complies with the following:

> *1. A reduction in surface water discharge to greenfield run-off rates wherever feasible.*

2. Where greenfield run-off rates are not feasible, this will need to be demonstrated by the applicant, and in such instances, the minimum requirement is to achieve at least a 50% attenuation of the site's surface water runoff at peak times based on the levels existing prior to the development.

Flood defences

D. Applicants will have to demonstrate that their proposal complies with the following:

1. Retain the effectiveness, stability and integrity of flood defences, river banks and other formal and informal flood defence infrastructure.

2. Ensure the proposal does not prevent essential maintenance and upgrading to be carried out in the future.

3. Set back developments from river banks and existing flood defence infrastructure where possible (16 metres for the tidal Thames and 8 metres for other rivers).

4. Take into account the requirements of the Thames Estuary 2100 Plan and the River Thames Scheme, and demonstrate how the current and future requirements for flood defences have been incorporated into the development.

Policy LP 23

Water Resources and Infrastructure

A. The borough's water resources and supplies will be protected by resisting development proposals that would pose an unacceptable threat to the borough's rivers, surface water and groundwater quantity and quality. This includes pollution caused by water run-off from developments into nearby waterways.

Water Quality

B. The Council encourages proposals that seek to increase water availability or protect and improve the quality of rivers or groundwater.

The development or expansion of water supply or waste water facilities will normally be permitted, either where needed to serve existing or proposed new development, or in the interests of long term water supply and waste water management, provided that the need for such facilities outweighs any adverse land use or environmental impact.

Where rivers have been classified by the Environment Agency as having 'poor' status, any development affecting such rivers is encouraged to improve the water quality in these areas

Water and sewerage provision

C. New major residential or major non-residential development will need to ensure that there is adequate water supply, surface water, foul drainage and sewerage treatment capacity to serve the development. Planning permission will

only be granted for developments which increase the demand for off-site service infrastructure where:

1. sufficient capacity already exists, or

2. extra capacity can be provided in time to serve the development, which will ensure that the environment and the amenities of local residents are not adversely affected.

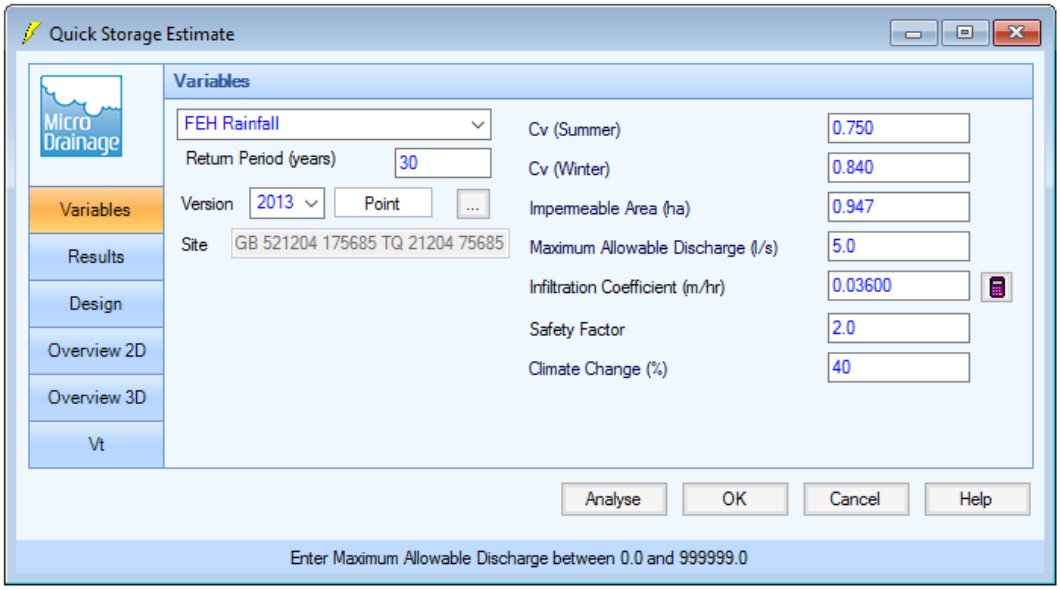
Applicants for major developments will be required to provide evidence in the form of written confirmation as part of the planning application that capacity exists in the public sewerage and water supply network to serve their development.

Any new water supply, sewerage or waste water treatment infrastructure must be in place prior to occupation of the development. Financial contributions may be required for new developments towards the provision of, or improvements to, such infrastructure.

Appendix B

Micro Drainage Calculations

Whole Site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Micro Drainage
Variables
Results
Design
Overview 2D
Overview 3D
Vt
FEH Rainfall
Return Period (years)
30
Version
2013
Point
Site
GB 521204 175685 TQ 21204 75685
Cv (Summer)
0.750
Cv (Winter)
0.840
Impermeable Area (ha)
0.947
Maximum Allowable Discharge (l/s)
5.0
Infiltration Coefficient (m/hr)
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Safety Factor
2.0
Climate Change (%)
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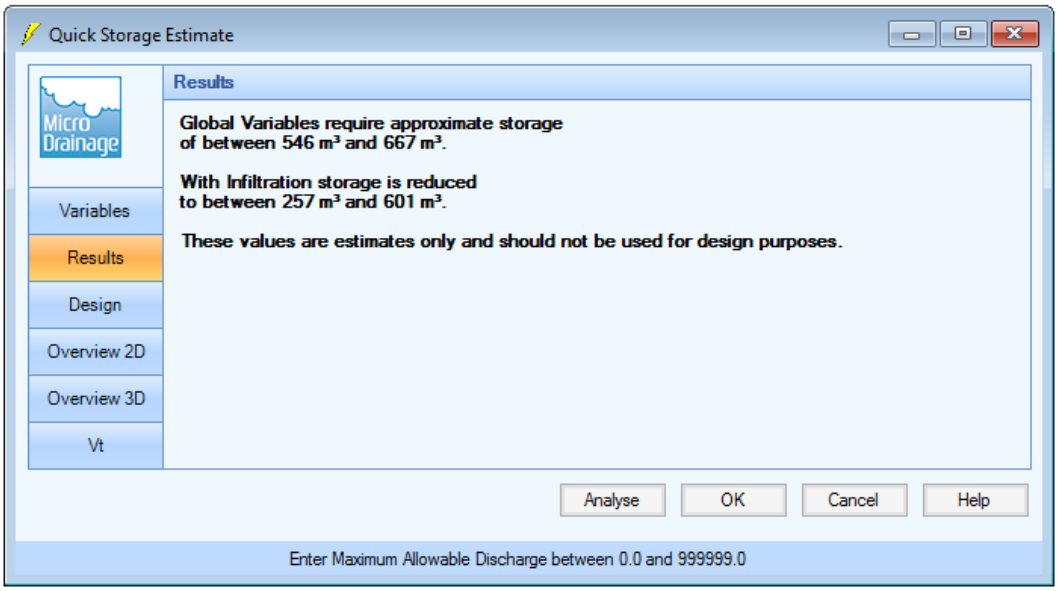
OK
Cancel
Help
Enter Maximum Allowable Discharge between 0.0 and 999999.0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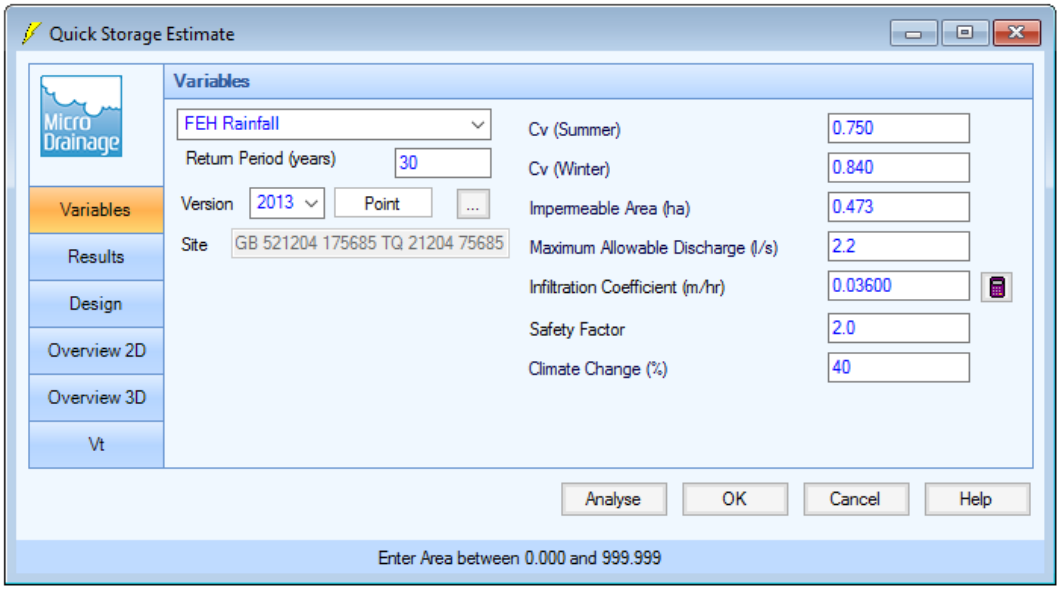
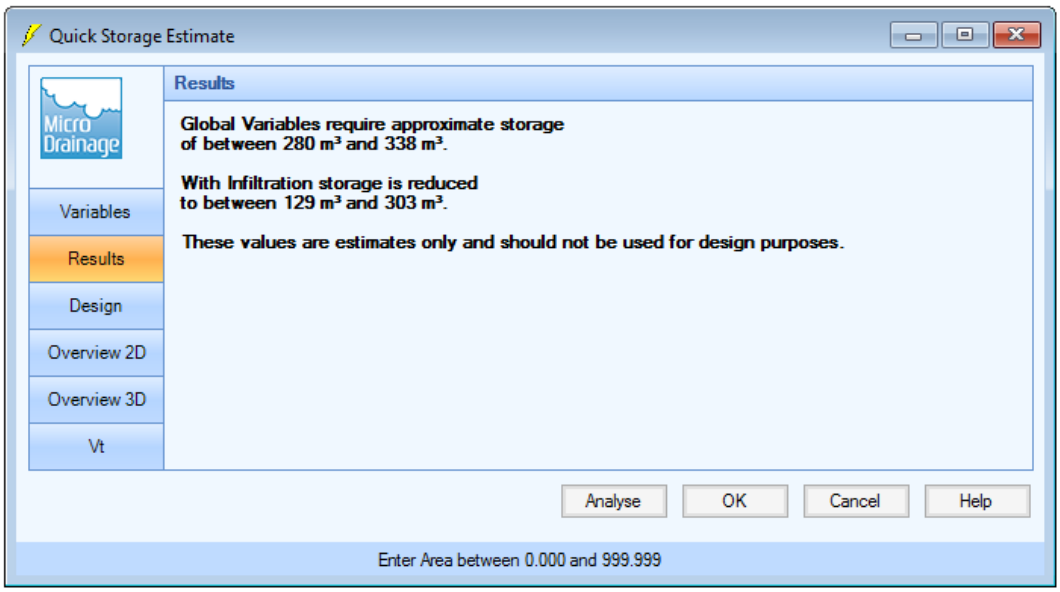
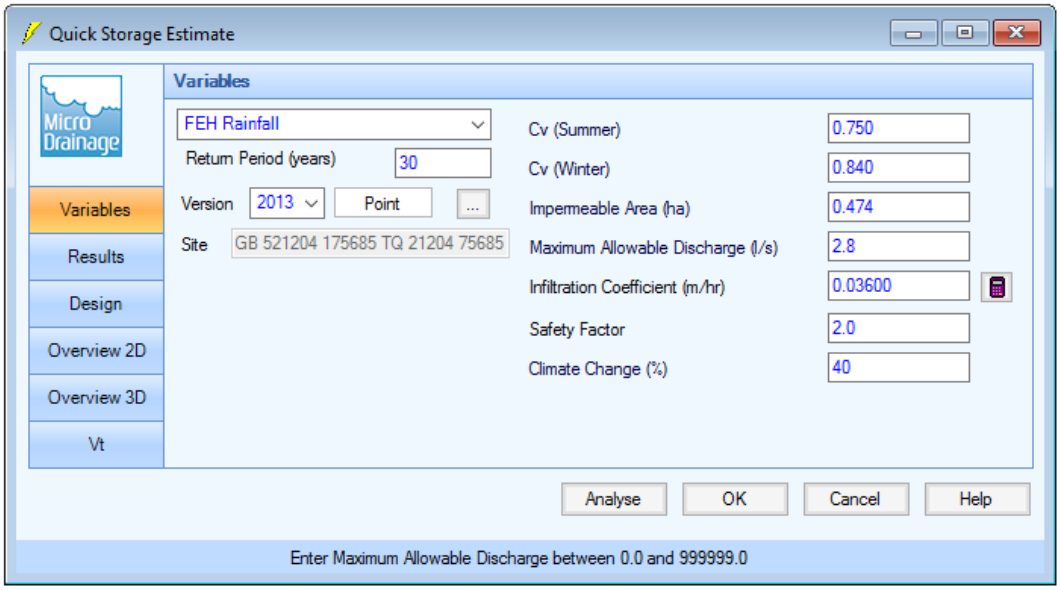
Micro Drainage
Results
Variables
Results
Design
Overview 2D
Overview 3D
Vt
Global Variables require approximate storage
of between 546 m³ and 667 m³.
With Infiltration storage is reduced
to between 257 m³ and 601 m³.
These values are estimates only and should not be used for design purposes.
Analyse
OK
Cancel
Help
Enter Maximum Allowable Discharge between 0.0 and 999999.0

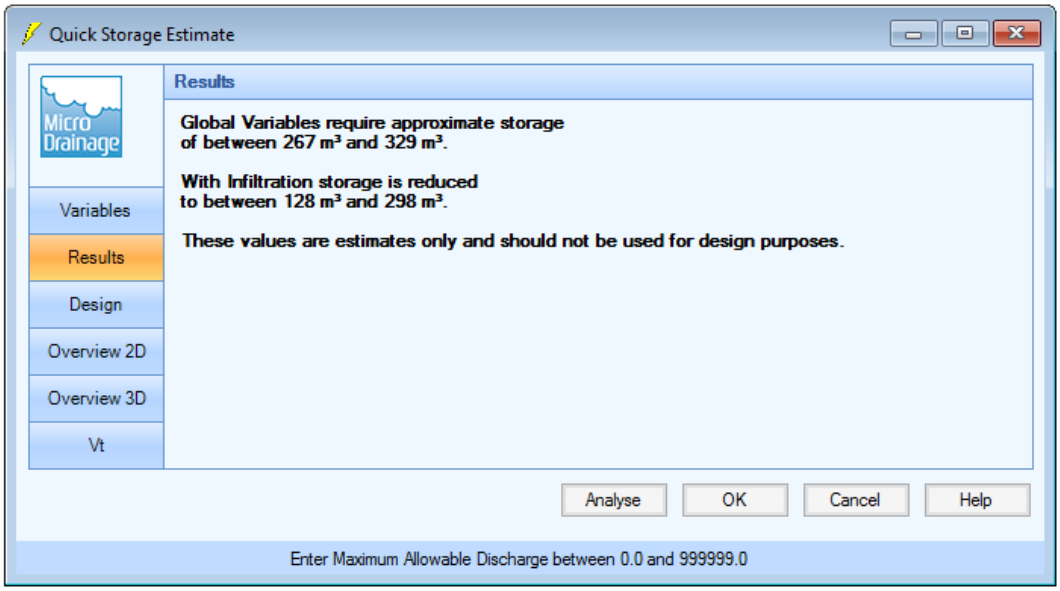
Eastern Site (Healthcare Centre and School)





Western Site (Residential)





Appendix C

Environment Agency Product 1

Appendix D

Greenfield Runoff Estimation

Appendix E

Proposed Drainage Plan