k. SUDS Report by Mint Structures

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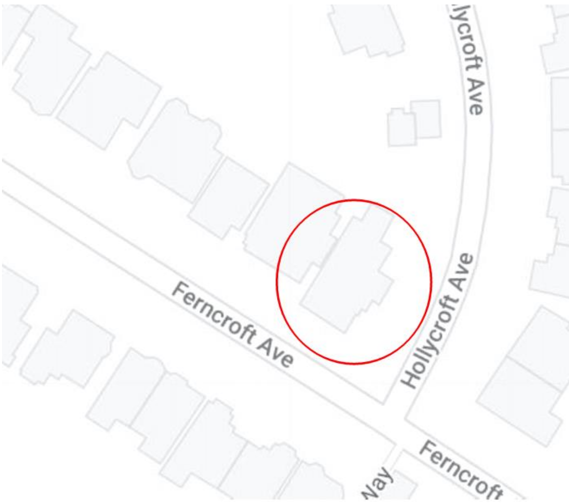
SUSTAINABLE UNDERGROUND DRAINAGE SYSTEMS REPORT

PROJECT REF:	M20202/LS
SUBJECT ADDRESS:	30 Ferncroft Avenue London NW3 7PH
COMMISSIONING CLIENT:	**Mr Duikagjin Lipa**
DATE OF WRITING:	July 2021

This document has been prepared by;	
Luke Smith BSc. MSc. CEng. MICE.	

TABLE OF CONTENTS

OVERVIEW	
1 PRELIMINARIES	The primary details contained within this document are generated from drawings produced by 4M Group. This document is intended for the exclusive usage of the clients listed above; the report remains the property of MiNT Structures and must not be reproduced in full or in part or used by any third party without prior written consent. This SuDS report is intended to be used to support a planning application and requires reviewing and superseding at the detailed design stage.
2 SUMMRY OF PROPOSED WORKS	*EXISTING STRUCTURE:* The subject property is located on a site of approximately 0.089 Hectares, a substantial late 19th/ early 20th century four-storey (including existing lower ground floor) detached house, situated on a corner plot at the junction between Ferncroft Avenue and Hollycroft Avenue, in the London Borough of Camden. The house is of traditional construction, and over its life has undergone alterations to the internal layouts carried out by previous occupants. However the main building envelope remains largely unchanged from that of the originally constructed building. *PROPOSED WORKS:* 1. Lowering of existing lower ground floor level & extension of the lower ground floor into the front and rear of the site. 2. Mass excavation at the rear of the property to form a single storey basement extension, including the installation of a lower ground level swimming pool. 3. Rebuilding of part of the single storey extension to the rear. 4. Support of superstructure over to allow RC basement wall construction and new basement slab installation.
3 SITE LOCATION	 **Fig.1** – Site map (Image from Google Maps, Copyright 2021).

4 SCOPE OF DOCUMENT

MiNT Structures have been appointed by the owners of 30 Ferncroft Avenue to carry out a pre-planning appraisal of the sustainable urban drainage, (SuDS), requirements for the proposed development.

Considering the increasing amount of hard surface water runoff from developments the purpose of this Sustainable Urban Drainage Systems (SuDS) report is to provide recommendations for the mimicking, where possible, of natural water movement from a development with the aim to reduce flood risk and improve water quality.

SUDS fall into three broad groups which aim to:

1. Reduce the quantity of runoff from the site (source control techniques);
2. Slow the velocity of runoff to allow settlement filtering and infiltration (permeable conveyance systems);
3. Provide passive treatment to collected surface water before discharge into groundwater or to a watercourse (end of pipe systems).

These systems may be incorporated into drainage designs to take a portion of the runoff whenever it is not feasible to use SUDS for draining a whole site.

The content of this document should be read in conjunction with the wider planning application documentation. The purpose of this package is to provide suggested SuDS measures to enable the required elements of drainage to comply with environmental and Local Authority requirements.

It should be noted that any SuDS drawings are indicative only and are not intended as detailed construction drawings therefore all specific construction details should be provided at the detailed design stage by other relevant parties.

5 SUDS SPECIFIC INFORMATION

The aim of this report is primarily to identify what SuDS systems are necessary to meet requirements set out in local and national guidance documentation. The plan areas used in the following calculations for the proposed development are taken directly from the Planning drawings produced by 4M Group.

Development classification: Small Scale domestic (less than 1.0ha)

Site situated in a conservation area – *Redington Frognal* Listed Building – NO

Total site area= 0.0891ha (891m2)

The table below is a summary of the proposed planning level construction elements that may affect surface and rain water runoff, including a brief description of the method by which the water is intended to be discharged.

Impermeable Element	Plan area (m^2)	Proposed method of discharge
Roofs/Garage/Terraces	411	Rainwater harvesting system for garden and CBPP attenuation.
Total impermeable	411	

Permeable Element	Plan area (m^2)	Proposed method of discharge
Rear Parking/Gardens	480	Into storage via permeable paving.
Total Permeable	480	

6	SITE TOPOGRAPHY	The site slopes up, Northward from the front to the rear, with the rear garden being 4.0metres above the front of the property. The site is mainly level having been terraced at the front and rear to form a level ground floor/garden area. Also see GEA reports for greater topographical information.
7	SITE GEOLOGY	Following a site investigation the site was confirmed to be underlain by a Claygate member over a deeper London Clay (see Borehole logs within GEA geotechnical report). The site investigation included eight trial pits and three boreholes (location plan appended to this report) with ground water being encountered at two levels across the site. For the purposes of the assessments within this report the Claygate member has been assumed to be an impermeable soil type.
8	HYDROLOGY & EXISTING DRAINAGE	Within this report it is assumed that the existing site is served by separate foul and surface water drainage systems (as part of contact with Thames water to check acceptable flow rates etc. the local sewer layout should also be confirmed at the same time). The current site houses a traditional brick built substantial detached house and a mixture of hard standing and vegetated areas, it is therefore assumed that surface water runoff from roofs and hardstanding areas flow from these areas and is collected in piped systems and discharged without being attenuated into the local Thames Water storm and foul sewerage network located within Ferncroft Avenue beyond the Southern site boundary.
9	PERMEABILITY	As mentioned above borehole investigations showed that the upper geology at the site is shown to be a Claygate member with clay content becoming more clayey with depth until the transition to a deeper London Clay stratum. Claygate members have sand/silt content and may display some permeable characteristics, however the complex cohesive nature of Claygate soils found at the site will likely reduce any exploitable soil permeability. The impact that clay content will have on permeability is assumed to render the site unsuitable for a SuDS solution that depends on infiltration.
10	FLOOD RISK	**Surface Water** The EA's 'uFMfSW' (updated Flood Map for Surface Water) provides a theoretical assessment of likely surface water flows, ground levels and drainage systems from Local Authority information to indicate areas that may be susceptible to surface water flooding. The map indicates the existing site has a 'very low' risk of flooding from surface water runoff (less than a 1:1000 or 0.1%). The proposed surface water drainage system, incorporating a SuDS system to manage rainfall hitting the site, will provide a better drainage solution than that currently serving the existing brownfield conditions. **Fluvial** The EA's 'Flood Zone Map' indicates that the site is positioned within the lowest risk category - Flood Zone 1. 'Flood Zone 1' is land assessed as having a less than 1 in 1000 (<0.1%) annual probability of flooding from a main river in each year and is not within an area of recorded river flooding. The flood zone map provided by the EA does not include allowances increases in peak river flows due to climate change. The National Planning Policy Framework (NPPF) however requires the effects of climate change to be taken into account. **Tidal / Reservoir** Tidal/Reservoir flooding is not an issue for this site.

		Groundwater The site is located over a secondary aquifer (a Claygate member) which is categorised by being able to transport groundwater flows through its granular lenses. The risk from groundwater has been discussed in detail in the BIA document therefore; it is only mentioned within this report with specific regard to the SuDs scheme. The proposed development is unlikely to have an impact on existing groundwater flows to any great degree, due to the modest level of excavation required compared to the existing lower ground floor condition (i.e. damming is not considered an issue). Furthermore the risk of groundwater overtopping risk will likely be reduced proximate to the proposed site due to the implementation attention storage. This is because surface water from current hardstanding surfaces will now be stored and discharged at a controlled rate into the sewerage system rather than charging groundwater flows (as it likely does in the existing condition). Therefore considering the above, Groundwater risk, as is also mentioned in the BIA reports, is considered low. **Existing sewers** It is assumed that the existing site is served by separate or combined foul and surface water drains, that discharge into Thames Water foul and storm sewers within Ferncroft Avenue (with the existing system adequately serving the existing site). The control limits on proposed drainage system are intended to mitigate the risk of overstressing the local sewerage network; and with the limiting of outflow from the proposed attenuation tank, the current sewerage system should gain increased capacity to accept the demands from the proposed development. Where existing drainage becomes redundant as part of the proposed works, all runs will be appropriately abandoned and removed from site (In the event that existing drainage is to be diverted or retained these will be protected during all works). Thames Water must be contacted to ensure that sufficient capacity is available within the existing foul and surface water sewers to accept proposed flows.
11	EXISTING DRAINAGE SYSTEM	Currently, the surface water runoff to the existing site is assumed to be collected into a traditional pipe drainage system.
12	SUDS HIERACHY	The SuDS hierarchy offers techniques to reduce flood risk and reduce pollution. Preference in designing a SuDS scheme is given to techniques located higher up the SuDS management hierarchy. These are systems that attenuate water at/or close to the source, rather than further downstream. This hierarchy below shows the preferred 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

13 RUNOFF RATE AND VOLUME FOLLOWING CONSTRUCTION	Additional volume of runoff generated from the development is to be limited, where possible, to the existing greenfield runoff or allowable flows restricted to avoid system blockages. The 'Non-statutory technical standards for sustainable drainage systems' states; "Where reasonably practicable, for developments which have been previously developed, the runoff volume from the development to any highway drain, sewer or surface water body in the 1 in 100 year, 6 hour rainfall event must be constrained to a value as close as is reasonably practicable to the greenfield runoff volume for the same event, but should never exceed the runoff volume from the development site prior to redevelopment for that event. Where it is not reasonably practicable to constrain the volume of runoff to any drain, sewer or surface water body, the runoff volume must be discharged at a rate that does not adversely affect flood risk". The development will increase the peak flows and volume of water running off of the site over existing values, therefore runoff must be managed to avoid undue risk of overloading the local drainage network. To reduce the impact of the development, the peak surface water runoff for a 100year return rainfall (plus climate change) will be limited as close to the corresponding greenfield runoff rate for the site as practically possible. Over the life time of the development, the proposed management strategy should effectively mitigate the risk of flooding neighbouring properties and of also overburdening the local sewer network.
14 GROUND INFILTRATION	Due to the impermeable nature of the subsoil it will not be possible to use infiltration techniques as methods for discharging excessive collected rainfall. In line with the SuDS manual however, where possible impervious areas should be drained in to the upper, topsoil layer in a manner similar or more effective than is currently the case by the use of permeable paving and new planting.
15 STORAGE	Following the runoff calculations (refer to Appendix B of this report) it was found that SuDS measures were required in the form of attenuation storage. The purpose of the storage facility differs from that of the rainwater harvesting in that it is to store and discharge surface water into the local drainage infrastructure at a controlled rate so as to prevent overburdening the existing system. Surface water discharge will be slowed by a flow control valve when leaving the lined storage crate, or type C tanked permeable paving system, to ensure that the local drainage infrastructure is not overburdened. The CBPP system will be tanked in an impermeable geomembrane, buried below permeable paved or landscaped areas feeding in to drainage channels, and in turn transporting the surface water to the local drain system. The storage system must also be constructed with access chambers to allow periodic inspections and maintenance to be carried out.

16 ATTENUATION REQUIREMENTS	The discharge from the system at Greenfield rates would be restricted to a maximum of 0.31l/s (1 year) and to 1.14l/s (100year +cc) via a hydraulic vortex flow control device. These flow rates are less than 2.0l/s discharge and therefore can be set at an outflow of 2.0l/s to maintain a practical outflow for small sites.
17 FLOW CONTROL	A simple SuDS control valve with an aperture sized to limit peak flow rate will be required. An orifice or vortex control is the most appropriate flow control measure as they have no moving parts, can be maintained with ease and also be protected against blockages.
18 PERMEABLE BLOCK PAVING	Permeable block paving over Course Graded Aggregate (CGA) or type 3 sub-Base and filter membrane will allow runoff to drain at source providing attenuation and treatment of runoff prior to discharging into the CBPP system (Alternatively Attenuation crates may also be used to provide adequate storage).
19 RAINWATER HARVESTING	Although the primary SuDS system proposed is for attenuation storage to the site, the proposed gardens give opportunity to use harvested rainwater collected from the impermeable surfaces. It is assumed this will be beneficial to the maintenance of these garden areas whilst also reducing the need to use potable treated water on garden vegetation. An appropriate system for this would be the installation of water butts directly fed from the roofs. The use of butts will require a provision for overflow discharge to allow for instances where the system cannot be used or may fall into disrepair. The system should also allow for the possibility of heavy storm rainfall flowing into water butts to a volume beyond a maximum allowable level meaning discharge via a suitable diameter outflow pipe is required.
20 DISPOSAL METHOD	Due to the presence of the relatively impermeable deep clay layer it has been decided to provide a drainage solution to discharge the majority of runoff into the public sewer system. <u>Discharge to sewer</u> Discharge to sewer is the optimum sustainable drainage option for the development area. Consultation with the local sewer undertaker should be undertaken as it is likely that if SuDS are to be installed on the Site, then discharge to the sewer would be the only reasonably practical option for discharge.
21 PROPOSED SOLUTION	The volume of water that will runoff of the proposed development means that to rely on a storage system for reusing all the water volume later is not feasible. Due to soil having low permeability, the use of infiltration would not be an effective means of disposing of the surface water runoff. There are also no suitable ponds or open water features to discharge into locally. Therefore the surface water runoff is proposed to be discharged into to the Thames Water surface water network. A CBPP attenuation storage system will be required to store surface water runoff up to a 100year return rainfall even (1:100 + 40% c/c). The attenuation system will be fitted with an appropriate restrictor to limit the outflow into the public sewer to the equivalent greenfield runoff rate.

	The proposed SuDS solution is to use a tanked concrete block permeable paving system in permeable areas of the site linked to the sewer. As mentioned already, a control on the rate and volume of runoff to Greenfield would be required for the site, for all storm events up to and including the 1 in 100 year 6 hour storm (including an allowance of 40% for climate change). This report proposes using the rear section of the site for attention storage. Using location of a shallow attenuation system here provides the most practical route to the assumed main sewer. As mentioned flow control systems will be required for the site. Rainwater guttering, downpipes and linear channels from the development roof and hard standing areas should drain directly into the attenuation system. A non-return valve must be fitted to the outflow pipes to reduce the risk of a backflow surge from the sewer during flooding.
22 SYSTEM EXCEEDANCE	In the unlikely event of a rainfall event that exceeds the designed capacity of the system; additional measures should be carried out on site to channel any overland flow towards areas of the site that will create the minimum flood risk and potential for disruption to neighbouring properties and residents of subject property.
23 MAINTAINANCE OF SYSTEM	Responsibility for the maintenance and up keep of the SuDS system remains with the site owner and they must be responsible for implementing the maintenance and management plan and ensuring a competent person is charged with the maintenance of the system. A log detailing periodic condition and maintenance of SuDS systems should be kept, being made available for review if requested by the Council. Maintenance of any tanked permeable paving should be carried out to ensure the infiltration is not compromised. The regime that follows is intended as initial guidance and should be read in conjunction with all relevant manufacturers guidance i.e. Interpave or similar. An inspection of the paving should also be carried out approximately three months after installation. • General inspections of the SuDS system as a whole should be carried out on a monthly basis. • Inspect all gullies, gutters and gratings removing any debris/litter to ensure water can freely enter the system as intended min. every three months. • Attenuation system should be regularly checked to ensure that inlets/outlets are working as designed and allowing water to be transferred as designed. • Gullies should be regularly purged (3-6 month cycle max), filling the system with water to try and release blocked organic matter/sediment that may cause unpleasant smells. • The paving surface should be agitated by brushing or vacuuming at least twice a year to ensure no vegetation of any sort is allowed to grow and develop within joints (Ideally carried out in the spring and autumn seasons.) • Visual inspections of the paving should be carried regularly to confirm the effectiveness of brushing/vacuuming maintenance allow for refinement of the regular cleaning activities if necessary. • Inspections of the paving should be carried out after any heavy precipitation events, to ensure that no displacement of organic matter onto the surface of the pavement occurs. • For winter maintenance, any de-icing carried out should be carried out with in moderation with care but can be done without causing significant detrimental effect on permeable pavement performance. • Where permeable paving is designed as lined (Type C), inspections of the outfalls should be undertaken initially on a biannual basis.

	• Weed growth – if sedimentation is allowed to occur over permeable paving, the potential for weed growth increases; especially in areas with overhanging trees; near soft landscaping slopes; or in areas of infrequent over run from vehicles. All weeds should be removed from the paving surface using appropriate weed removal methods to kill the plant entirely. • Depending the type and frequency of use of the permeable pavement, the laying course material may require either cleaning or replacing after a 25 to 30 year period. Evidence if this would be prolonged paving infiltration rates allowing ponding to develop. Should this occur, uplifting and cleaning of the laying course (or replacing, depending on condition and costings) should be considered. • Cracked or broken blocks must be repaired when identified following routine inspections, as well as any areas which may be hazardous to users or effect the structural performance of the paving. And depressions that form within the paving surface should also be remediated. • Inspection chambers and orifices should be monitored once a year to check for any siltation which should be removed from the sump.

18. REFERENCES

1) Codes / Regulations

1) ENVIRONMENT AGENCY : SUSTAINABLE DRAINAGE SYSTEMS (SUDS): AN INTRODUCTION

2) IoH REPORT 124 (Marshall & Bayliss, 1994)

2) FSSR 16 runoff model

2) THE WALLINGFORD PROCEDURE 1981

3) NATIONAL PLANNING POLICY FRAMEWORK (NPPF)

4) CIRIA C697: THE SUDS MANUAL.

5) UK SUSTAINABLE DRAINAGE (WWW.UKSUDS.COM)

17. APPENDICES

Appendix A – GEA – SI Report

Appendix B – Greenfield runoff estimation / Design rainfall / Attenuation design.

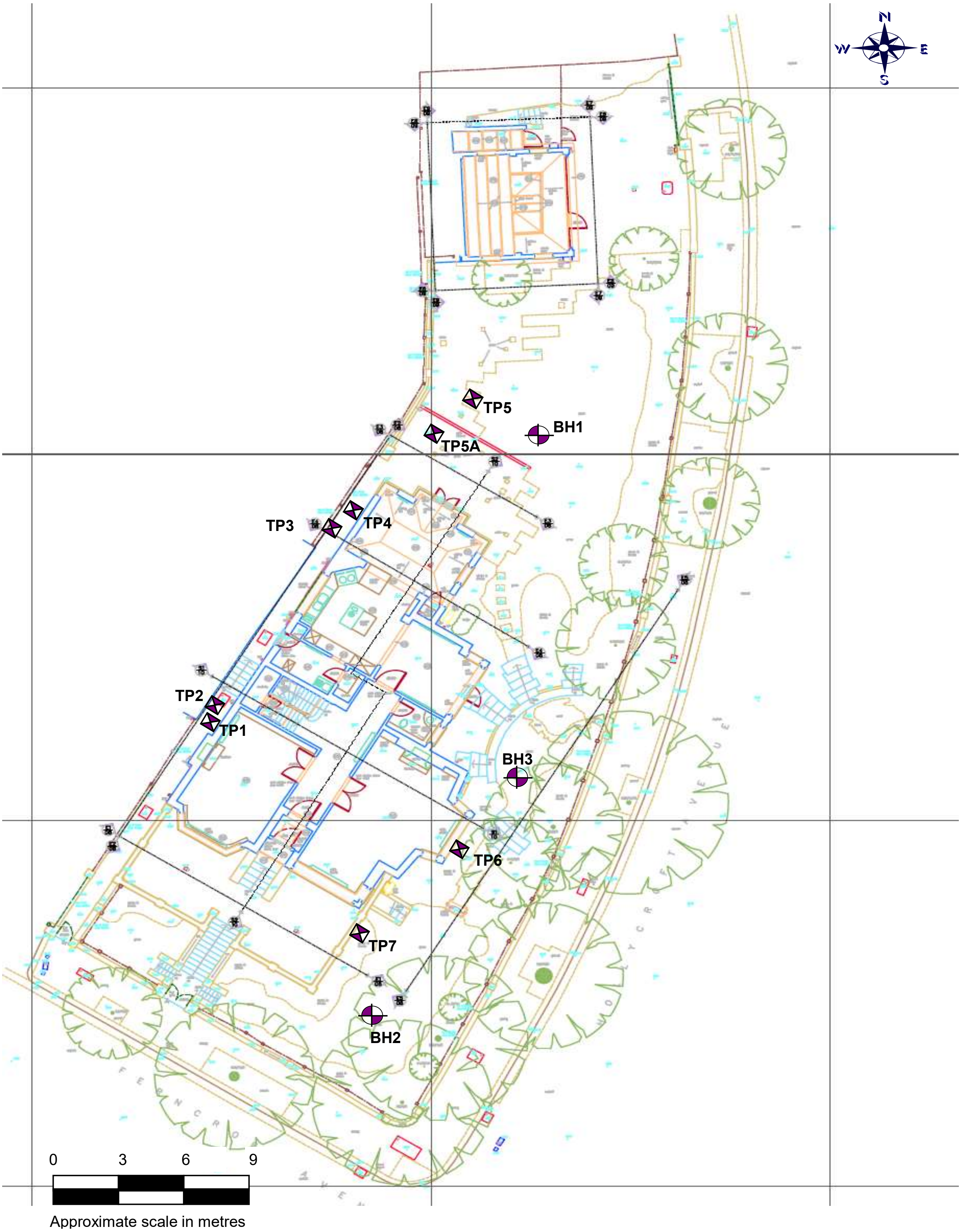
Appendix C – Sample Geo-cellular specification details.

Appendix D – Proposed drawing.

Geotechnical & Environmental Associates
www.gea-ltd.co.uk

Site Plan

Site	30 Ferncroft Avenue, London NW3 7PH	**Job Number** J20268
Client	Mr Dukagjic Lipa	**Sheet** 1 / 1
Engineer	Mint Structures	



GEA Geotechnical & Environmental Associates

Project				BOREHOLE No
30 Ferncroft Avenue, London NW3 7PH				BH1
Job No J20268	Date 03-12-20 04-12-20	Ground Level (m OD) 100.05	Co-Ordinates ()	
Client Mr Dukagjin Lipa		Engineer Mint Structures		Sheet 1 of 2

SAMPLES & TESTS / STRATA

Depth	Type No	Test Result	Water	Reduced Level	Legend	Depth (Thickness)	DESCRIPTION
				99.85		0.20	TOPSOIL (dark brown silty slightly gravelly CLAY)
0.40	D						Firm medium strength to high strength orange-brown mottled brown and grey silty sandy CLAY, locally clayey sandy SILT
1.00	D						
1.20-1.65	U						
1.70	D						
1.90	D						
2.00-2.45	SPT	2,2/3,3,3,4 N60 = 14					
2.80	D						
3.00-3.45	U					(6.30)	
3.50	D						
4.00-4.45	SPT	1,2/3,3,3,4 N60 = 14					
5.00-5.45	U						
5.50	D		1				5.50 ... becoming stiff
6.00-6.45	SPT	3,4/4,5,6,7 N60 = 23					
				93.55		6.50	Stiff high strength dark grey silty CLAY with partings of pale grey fine sand and sandy silt
6.70	D		1				
7.50-7.95	U						
8.00	D						
9.00-9.45	SPT	3,3/4,4,5,5 N60 = 19				(5.50)	

Instrument / Backfill

Boring Progress and Water Observations

Depth	Date	Time	Casing Depth	Casing Dia. mm	Water Depth
6.50	03-12-20	00.00	6.00	150	
6.50	04-12-20	08.30	6.00	150	5.6

GENERAL REMARKS

Excavating services insepction pit from GL to 1.20 m for 1 hr.
Groundwater monitoring standpipe installed to 7.00 m.
Groundwater monitoring on 14/01/21 recorded groundwater at a depth of 3.80 m.
Groundwater monitoring on 29/01/21 recorded groundwater at a depth of 3.71 m.
Groundwater monitoring on 11/02/21 recorded groundwater at a depth of 3.67 m.

All dimensions in metres Scale 1:62.5	Method/ Plant Used Cable percussion rig	Logged By ML

GEA

Geotechnical & Environmental Associates

Project				BOREHOLE No
30 Ferncroft Avenue, London NW3 7PH				**BH1**
Job No: J20268	Date: 03-12-20 04-12-20	Ground Level (m OD): 100.05	Co-Ordinates ()	
Client: Mr Dukagjin Lipa		Engineer: Mint Structures		Sheet: 2 of 2

Depth	Type No	Test Result	Water	Reduced Level	Legend	Depth (Thickness)	DESCRIPTION
							Stiff high strength dark grey silty CLAY with partings of pale grey fine sand and sandy silt(continued)
10.50-10.95	U						
11.00	D		2				
			3	88.05		12.00	
12.00-12.45	SPT	5,5/6,6,7,7 N60 = 28					Stiff becoming very stiff high strength to very high strength fissured dark grey locally greyish brown and brownish grey silty CLAY with mica
13.50-13.95	U						
14.00	D						
15.00-15.45	U						
15.50	D						
						(8.00)	
17.00-17.45	U						
17.50	D						
18.00-18.45	U						18.00 ... occasional shells
18.50	D						
18.60-19.05	SPT	5,6/7,7,9,10 N60 = 35					
				80.05		20.00	

Boring Progress and Water Observations

Depth	Date	Time	Casing Depth	Casing Dia. mm	Water Depth
20.00	04-12-20	16.00	8.00	150	14

GENERAL REMARKS

Excavating services insepction pit from GL to 1.20 m for 1 hr.
Groundwater monitoring standpipe installed to 7.00 m.
Groundwater monitoring on 14/01/21 recorded groundwater at a depth of 3.80 m.
Groundwater monitoring on 29/01/21 recorded groundwater at a depth of 3.71 m.
Groundwater monitoring on 11/02/21 recorded groundwater at a depth of 3.67 m.

All dimensions in metres Scale 1:62.5	Method/Plant Used: Cable percussion rig	Logged By: ML

GEA

Geotechnical & Environmental Associates

Project				BOREHOLE No
30 Ferncroft Avenue, London NW3 7PH				**BH2**
Job No: J20268	Date: 04-12-20 04-12-20	Ground Level (m OD): 97.61	Co-Ordinates ()	
Client: Mr Dukagjin Lipa		Engineer: Mint Structures		Sheet: 1 of 1

SAMPLES & TESTS			Water	STRATA				Instrument / Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thickness)	DESCRIPTION	
0.20	ES			97.31		(0.30) 0.30	TOPSOIL (dark brown silty slightly gravelly CLAY)	
				96.61		(0.70) 1.00	Firm orange-brown silty sandy CLAY	
				94.61		(2.00) 3.00	Orange-brown clayey sandy SILT to sandy silty CLAY	

Boring Progress and Water Observations

Depth	Date	Time	Casing Depth	Casing Dia. mm	Water Depth

GENERAL REMARKS

Groundwater not encountered.
Groundwater monitoring standpipe installed to 3.00 m.
Groundwater monitoring on 14/01/21 recorded the standpipe to be dry.
Groundwater monitoring on 29/01/21 recorded groundwater at a depth of 2.58 m.
Groundwater monitoring on 11/02/21 recorded groundwater at a depth of 2.33 m.

All dimensions in metres Scale 1:31.25	Method/ Plant Used: Window sampler	Logged By: ML

GEA

Geotechnical & Environmental Associates

Project				BOREHOLE No
30 Ferncroft Avenue, London NW3 7PH				**BH3**
Job No: J20268	Date: 04-12-20 04-12-20	Ground Level (m OD): 98.57	Co-Ordinates ()	
Client: Mr Dukagjin Lipa		Engineer: Mint Structures		Sheet: 1 of 1

SAMPLES & TESTS: Depth	Type No	Test Result	Water	STRATA: Reduced Level	Legend	Depth (Thickness)	DESCRIPTION	Instrument / Backfill
0.20	ES			98.27		(0.30) 0.30	MADE GROUND (greyish brown clayey sandy silt with brick and slate fragments)	
				95.57		(2.70) 3.00	Firm brownish grey mottled pale grey and orange-brown laminated silty sandy CLAY	
				94.57		(1.00) 4.00	Orange-brown clayey sandy SILT to sandy silty CLAY	

Boring Progress and Water Observations

Depth	Date	Time	Casing Depth	Casing Dia. mm	Water Depth

GENERAL REMARKS

Groundwater not encountered.
Groundwater monitoring standpipe installed to 4.00 m.
Groundwater monitoring on 14/01/21 recorded groundwater at a depth of 3.20 m.
Groundwater monitoring on 29/01/21 recorded groundwater at a depth of 3.18 m.
Groundwater monitoring on 11/02/21 recorded groundwater at a depth of 3.15 m.

All dimensions in metres Scale 1:31.25	Method/ Plant Used: Window sampler	Logged By: ML

SUMMARY OF GEOTECHNICAL TESTING

Sample details					Classification Tests					Density Tests		Undrained Triaxial Compression				Chemical Tests			Other tests and comments
Location	Depth (m)	Sample Ref	Type	Description	WC %	LL %	PL %	PI %	<425 µm %	Bulk Mg/m³	Dry Mg/m³	Condition	Cell Pressure kPa	Deviator Stress kPa	Shear Stress kPa	pH	2:1 W/S SO4 g/L	W/S Mg mg/L	
BH1	1.00	D2	D	Greyish brown mottled grey CLAY.	27.6	43	22	21	100										
BH1	1.20	U1	U	Firm brown mottled grey silty CLAY.	27.8					1.97	1.54	Undisturbed	20	128	64				
BH1	1.90	D4	D	Yellowish brown mottled greyish brown CLAY.	30.7	69	28	41	100										
BH1	2.80	D5	D													5.2	< 0.010		
BH1	3.00	U2	U	Firm orange brown sandy silty CLAY	27.0					1.98	1.56	Undisturbed	60	115	58				
BH1	3.60	D6	D	Yellowish brown silty CLAY.	26.2	38	19	19	100										
BH1	5.00	U3	U	Firm orange brown sandy silty CLAY.	31.9					1.98	1.50	Undisturbed	100	130	65				
BH1	6.00	S3	D	Yellowish brown silty CLAY.	29.0	39	21	18	100										
BH1	7.50	U4	U	Stiff grey silty CLAY.	25.1					2.02	1.61	Undisturbed	150	233	117				
BH1	8.00	D9	D	Dark grey silty CLAY.	24.9	51	20	31	100										

Sample type: B (Bulk disturb.) BLK (Block) C (Core) D (Disturbed) LB (Large Bulk dist.) U (Undisturbed)

Checked and Approved by

S Burke

S Burke - Senior Technician
15/01/2021

Project Number: **GEO / 32330**

Project Name: **30 FERNCROFT AVENUE, NW3**
J20268

GEOLABS®

SUMMARY OF GEOTECHNICAL TESTING

Sample details					Classification Tests					Density Tests		Undrained Triaxial Compression				Chemical Tests			Other tests and comments
Location	Depth (m)	Sample Ref	Type	Description	WC %	LL %	PL %	PI %	<425 µm %	Bulk Mg/m³	Dry Mg/m³	Condition	Cell Pressure kPa	Deviator Stress kPa	Shear Stress kPa	pH	2:1 W/S SO4 g/L	W/S Mg mg/L	
BH1	10.50	U5	U	Stiff dark grey silty CLAY.	24.9					2.01	1.61	Undisturbed	210	297	148				
BH1	11.00	D10	D													8.1	0.22		
BH1	12.00	S5	D	Dark grey CLAY.	22.6	52	21	31	100										
BH1	13.50	U6	U	Very stiff greyish brown silty CLAY.	22.7					2.08	1.70	Undisturbed	270	295	148				
BH1	15.00	U7	U	Stiff grey silty CLAY.	26.4					2.04	1.61	Undisturbed	300	215	108				
BH1	17.00	U8	U	Very stiff grey silty CLAY.	24.6					2.10	1.69	Undisturbed	340	463	231				
BH1	17.50	D12	D													8.6	0.33		
BH1	18.00	U9	U	Very stiff dark grey silty CLAY.	22.9					2.11	1.72	Undisturbed	360	444	222				

Sample type: B (Bulk disturb.) BLK (Block) C (Core) D (Disturbed) LB (Large Bulk dist.) U (Undisturbed)

Checked and Approved by

S Burke

S Burke - Senior Technician
15/01/2021

Project Number: **GEO / 32330**

Project Name: **30 FERNCROFT AVENUE, NW3**
J20268

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1731 - UUTXL BH1 01.20 U1 U Test 01 - 32330-385801.XLSM

BS EN ISO 17892-8 : 2018

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION

Location	BH1
Sample Ref	U1
Depth (m)	1.20
Sample Type	U

Description:

Firm brown mottled grey silty CLAY.

Specimen Details

Specimen conditions		Undisturbed
Length	(mm)	201.9
Diameter	(mm)	102.5
Moisture content	(%)	27.8
Bulk density	(Mg/m³)	1.97
Dry density	(Mg/m³)	1.54
Test Details		
Latex membrane thickness	(mm)	0.3
Specimen height prior to shearing	(mm)	201.9
Membrane correction	(kPa)	1.1
Mean rate of shear	(%/min)	2.0
Cell pressure	(kPa)	20
Strain at failure	(%)	19.8
Maximum deviator stress	(kPa)	128
Shear Stress Cu	(kPa)	64

Mode of failure

Orientation of the sample	Vertical
Distance from top of tube mm	40

Processed by SB
Checked and Approved by

S Burke

S Burke - Senior Technician
15/01/2021

Project Number: **GEO / 32330**

Project Name: **30 FERNCROFT AVENUE, NW3**
J20268

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Version 82.200602

BS EN ISO 17892-8 : 2018

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION

Location	BH1
Sample Ref	U2
Depth (m)	3.00
Sample Type	U

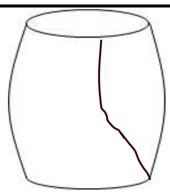
Description:

Firm orange brown sandy silty CLAY

Specimen Details

Specimen conditions		Undisturbed
Length	(mm)	200.3
Diameter	(mm)	102.1
Moisture content	(%)	27.0
Bulk density	(Mg/m³)	1.98
Dry density	(Mg/m³)	1.56
Test Details		
Latex membrane thickness	(mm)	0.3
Specimen height prior to shearing	(mm)	200.3
Membrane correction	(kPa)	1.1
Mean rate of shear	(%/min)	2.0
Cell pressure	(kPa)	60
Strain at failure	(%)	19.5
Maximum deviator stress	(kPa)	115
Shear Stress Cu	(kPa)	58

Mode of failure



Orientation of the sample	Vertical
Distance from top of tube mm	20

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Checked and Approved by

S Burke - Senior Technician
15/01/2021

Project Number:

GEO / 32330

Project Name:

30 FERNCROFT AVENUE, NW3
J20268

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BS EN ISO 17892-8 : 2018

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION

Location	BH1
Sample Ref	U3
Depth (m)	5.00
Sample Type	U

Description:

Firm orange brown sandy silty CLAY.

Specimen Details

Specimen conditions		Undisturbed
Length	(mm)	187.9
Diameter	(mm)	101.9
Moisture content	(%)	31.9
Bulk density	(Mg/m³)	1.98
Dry density	(Mg/m³)	1.50
Test Details		
Latex membrane thickness	(mm)	0.3
Specimen height prior to shearing	(mm)	187.9
Membrane correction	(kPa)	1.2
Mean rate of shear	(%/min)	2.1
Cell pressure	(kPa)	100
Strain at failure	(%)	21.3
Maximum deviator stress	(kPa)	130
Shear Stress Cu	(kPa)	65

Mode of failure

Orientation of the sample	Vertical
Distance from top of tube mm	20

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15/01/2021

Project Number:

GEO / 32330

Project Name:

30 FERNCROFT AVENUE, NW3
J20268

GEOLABS

1731 - UUTXL BH1 07.50 U4 U Test 01 - 32330-385808.XLSM

BS EN ISO 17892-8 : 2018

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION

Location	BH1
Sample Ref	U4
Depth (m)	7.50
Sample Type	U

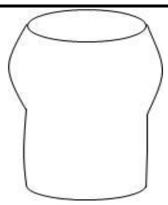
Description:

Stiff grey silty CLAY.

Specimen Details

Specimen conditions		Undisturbed
Length	(mm)	200.7
Diameter	(mm)	103.1
Moisture content	(%)	25.1
Bulk density	(Mg/m³)	2.02
Dry density	(Mg/m³)	1.61
Test Details		
Latex membrane thickness	(mm)	0.3
Specimen height prior to shearing	(mm)	200.6
Membrane correction	(kPa)	0.9
Mean rate of shear	(%/min)	2.0
Cell pressure	(kPa)	150
Strain at failure	(%)	15.9
Maximum deviator stress	(kPa)	233
Shear Stress Cu	(kPa)	117

Mode of failure



Orientation of the sample	Vertical
Distance from top of tube mm	50

Version 82.200602

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S Burke

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15/01/2021

Project Number:

GEO / 32330

Project Name:

30 FERNCROFT AVENUE, NW3
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BS EN ISO 17892-8 : 2018

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION

Location	BH1
Sample Ref	U5
Depth (m)	10.50
Sample Type	U

Description:

Stiff dark grey silty CLAY.

Specimen Details

Specimen conditions		Undisturbed
Length	(mm)	201.7
Diameter	(mm)	102.9
Moisture content	(%)	24.9
Bulk density	(Mg/m³)	2.01
Dry density	(Mg/m³)	1.61
Test Details		
Latex membrane thickness	(mm)	0.3
Specimen height prior to shearing	(mm)	201.6
Membrane correction	(kPa)	1.0
Mean rate of shear	(%/min)	2.0
Cell pressure	(kPa)	210
Strain at failure	(%)	18.3
Maximum deviator stress	(kPa)	297
Shear Stress Cu	(kPa)	148

Mode of failure

Orientation of the sample	Vertical
Distance from top of tube mm	50

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Checked and Approved by

S Burke - Senior Technician
15/01/2021

Project Number: **GEO / 32330**

Project Name: **30 FERNCROFT AVENUE, NW3**
J20268

Test Report By GEOLABS Limited Bucknalls Lane, Garston, Watford, Hertfordshire, WD25 9XX

Client : Geotechnical & Environmental Associates Limited, Widbury Barn, Widbury Hill, Ware, Hertfordshire, SG12 7QE

1731 - UUTXL BH1 13.50 U6 U Test 01 - 32330-385807.XLSM

BS EN ISO 17892-8 : 2018

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION

Location	BH1
Sample Ref	U6
Depth (m)	13.50
Sample Type	U

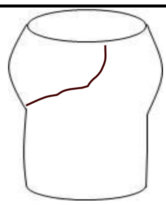
Description:

Very stiff greyish brown silty CLAY.

Specimen Details

Specimen conditions		Undisturbed
Length	(mm)	201.3
Diameter	(mm)	102.6
Moisture content	(%)	22.7
Bulk density	(Mg/m³)	2.08
Dry density	(Mg/m³)	1.70
Test Details		
Latex membrane thickness	(mm)	0.3
Specimen height prior to shearing	(mm)	200.8
Membrane correction	(kPa)	1.0
Mean rate of shear	(%/min)	2.0
Cell pressure	(kPa)	270
Strain at failure	(%)	17.4
Maximum deviator stress	(kPa)	295
Shear Stress Cu	(kPa)	148

Mode of failure



Orientation of the sample	Vertical
Distance from top of tube mm	130

Processed by SB
Checked and Approved by

S Burke - Senior Technician
15/01/2021

Project Number:

GEO / 32330

Project Name:

30 FERNCROFT AVENUE, NW3
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BS EN ISO 17892-8 : 2018

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION

Location	BH1
Sample Ref	U7
Depth (m)	15.00
Sample Type	U

Description:

Stiff grey silty CLAY.

Specimen Details

Specimen conditions		Undisturbed
Length	(mm)	201.9
Diameter	(mm)	102.3
Moisture content	(%)	26.4
Bulk density	(Mg/m³)	2.04
Dry density	(Mg/m³)	1.61
Test Details		
Latex membrane thickness	(mm)	0.3
Specimen height prior to shearing	(mm)	201.4
Membrane correction	(kPa)	1.0
Mean rate of shear	(%/min)	2.0
Cell pressure	(kPa)	300
Strain at failure	(%)	17.8
Maximum deviator stress	(kPa)	215
Shear Stress Cu	(kPa)	108

Mode of failure

Orientation of the sample	Vertical
Distance from top of tube mm	240

Processed by SB
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S Burke - Senior Technician
15/01/2021

Project Number: **GEO / 32330**

Project Name: **30 FERNCROFT AVENUE, NW3**
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BS EN ISO 17892-8 : 2018

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION

Location	BH1
Sample Ref	U8
Depth (m)	17.00
Sample Type	U

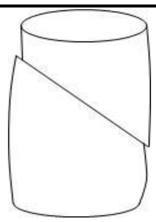
Description:

Very stiff grey silty CLAY.

Specimen Details

Specimen conditions		Undisturbed
Length	(mm)	201.6
Diameter	(mm)	102.0
Moisture content	(%)	24.6
Bulk density	(Mg/m³)	2.10
Dry density	(Mg/m³)	1.69
Test Details		
Latex membrane thickness	(mm)	0.3
Specimen height prior to shearing	(mm)	201.3
Membrane correction	(kPa)	0.8
Mean rate of shear	(%/min)	2.0
Cell pressure	(kPa)	340
Strain at failure	(%)	12.9
Maximum deviator stress	(kPa)	463
Shear Stress Cu	(kPa)	231

Mode of failure



Orientation of the sample	Vertical
Distance from top of tube mm	30

Processed by SB
Checked and Approved by

S Burke - Senior Technician
15/01/2021

Project Number:

GEO / 32330

Project Name:

30 FERNCROFT AVENUE, NW3
J20268

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1731 - UUTXL BH1 18.00 U9 U Test 01 - 32330-385802.XLSM

BS EN ISO 17892-8 : 2018

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION

Location	BH1
Sample Ref	U9
Depth (m)	18.00
Sample Type	U

Description:

Very stiff dark grey silty CLAY.

Specimen Details

Specimen conditions		Undisturbed
Length	(mm)	202.0
Diameter	(mm)	102.1
Moisture content	(%)	22.9
Bulk density	(Mg/m³)	2.11
Dry density	(Mg/m³)	1.72
Test Details		
Latex membrane thickness	(mm)	0.3
Specimen height prior to shearing	(mm)	201.8
Membrane correction	(kPa)	0.9
Mean rate of shear	(%/min)	2.0
Cell pressure	(kPa)	360
Strain at failure	(%)	15.8
Maximum deviator stress	(kPa)	444
Shear Stress Cu	(kPa)	222

Mode of failure

Orientation of the sample	Vertical
Distance from top of tube mm	20

Processed by SB
Checked and Approved by

S Burke

S Burke - Senior Technician
15/01/2021

Version 82.200602

Project Number:

GEO / 32330

Project Name:

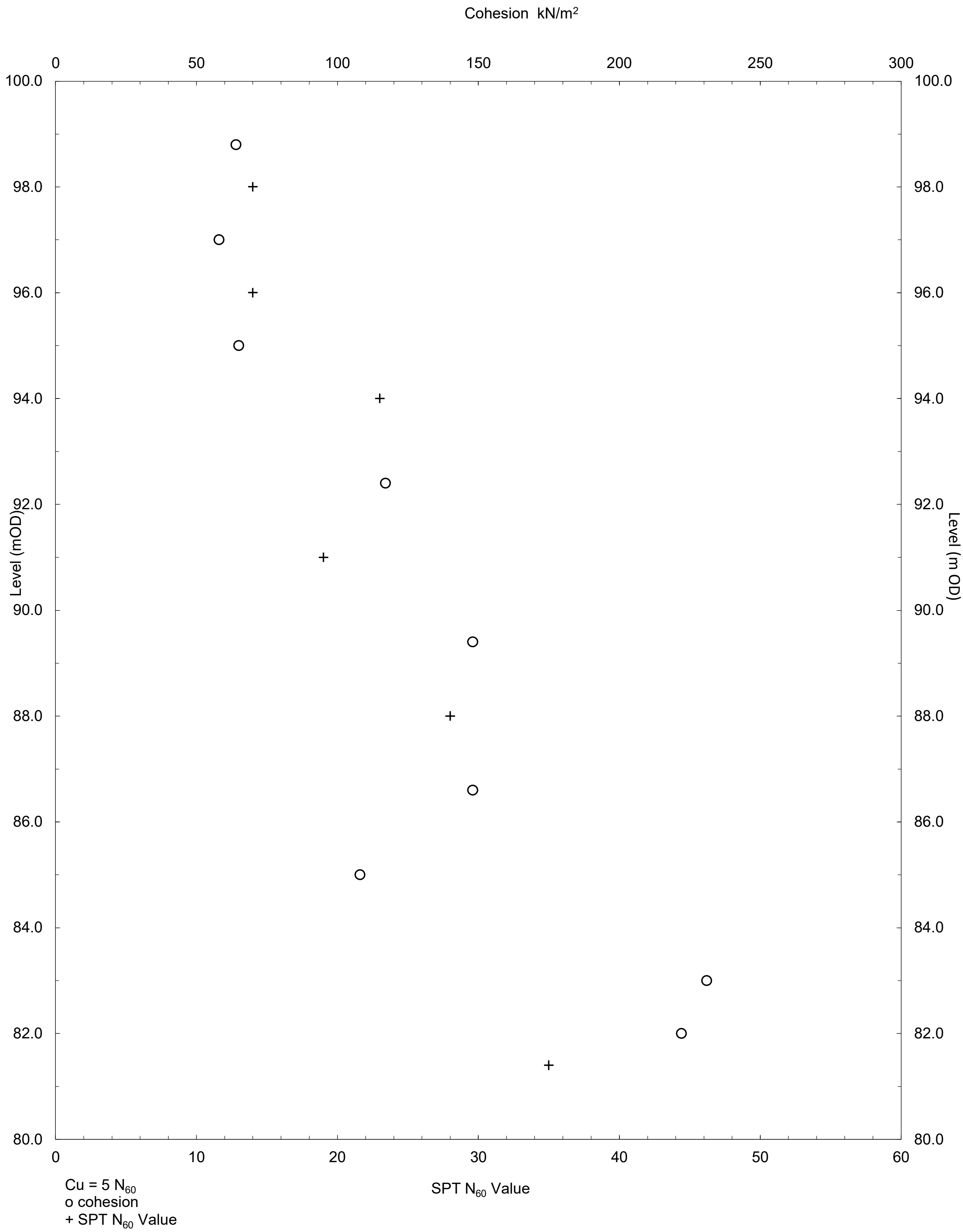
30 FERNCROFT AVENUE, NW3
J20268

GEOLABS

UKAS TESTING 1982

GEA	www.gea-ltd.co.uk Herts | 01727 824666 Notts | 01509 674888	**SPT & Cohesion / Level Graph**

Site	30 Ferncroft Avenue, London NW3 7PH	**Job Number** J20268
Client	Mr Dujagjic Lipa	**Sheet** 1 / 1
Engineer	Mint Structures	



SURFACE WATER RUN OFF CALCULATIONS & ATTENUATION ESTIMATION

DESIGN BRIEF

To calculate pre and post development rainfall runoff in accordance with the requirements of the local authority and national framework for Sustainable Drainage Systems. Peak runoff rates and volumes are estimated for return periods of up to 100 years. An allowance for climate change is also included within post-development runoff calculations.

DATA REFERENCES

1. IoH Report 124 (Marshall & Bayliss)
2. FSSR 16 runoff model - Fixed Percentage Runoff Method
3. Wallingford Procedure 1981
4. CIRIA C697 - The SUDS Manual

BASIS OF CALCULATIONS

IoH 124 has been used to calculate the peak greenfield runoff rates - the site is less than 50Ha, therefore the calculations are based on a 50 Ha site and adjusted for the subject site.
CIRIA C697 recommends the use of the FSSR 16 runoff method for calculating the runoff volume for greenfield sites.
Brownfield sites existing drainage systems are analysied using the Rational Method to calculate the runoff for the impermeable sections of the site (pre- & post development).
Any sites that have no existing drainage are analysed for pre-development runoff using greenfield values, assuming soil type 5.
In accordance with National Planning Policy Framework (NPPF) and assuming a 100yr projection, a 30% on peak rainfall intensity increase in rainfall / runoff has been included to allow for the climate change and additnal 10% has been added to this for contributiond from pervious areas i.e. 40% increase overall.
Rainfall data is taken from maps in Defra / EA Tech Report W5-074/A Rev D.
Site discharge should be as close to 50% of greenfiled values, however, as the actual rates are often low for small sites, in accordance with best practice, outflow controls will be set to discharge at a rate of 2 litres/second for all storm events.
The impervious area within the following calculations is limited to a minimum of 50% of the full site area to give exceedance capacity and ensure undersizing of small catchments is avoided.

This SuDS report is intended to be used to support a planning application and requires reviewing and superseding at the detailed design stage.

SEE FOLLOWING PAGES FOR SUDS CALCULATIONS.

GREENFIELD RUNOFF ESTIMATION

DESIGN DATA

Site area (ha): $A := 0.0891\ hectare$ Note: Site less than 50ha therefore IS124 method used

Hydrological area: $A_{hyd} := 6$ CIRIA C967 SuDS manual Fig. 4.2 [11 = Ireland for calculation]

Catchment area: $AREA := 0.5\ km^2$ CIRIA C967 SuDS manual Tab. 4.2

Standard ave. rainfall: $SAAR := 650\ mm$ From SAAR 41-71 map contours

SOIL type: $S := 4$ From Vol. 3 WRAP map (1975)

WRAP SOIL index: $SPR = 0.45$ From Flood Studies Report (1975)

Mean annual peak flow (for 50ha):

$$Q_{bar50} := 0.00108\ \frac{m^3}{s} \cdot \left(\frac{AREA}{km^2}\right)^{0.89} \cdot \left(\frac{SAAR}{mm}\right)^{1.17} \cdot SPR^{2.17}$$

$Q_{bar50} = 0.2\ m^3 \cdot s^{-1}$ CIRIA C967 SuDS manual Box. 4.2

Qbar for 50ha (l/s): $Q_{bar50} = 201.41\ l \cdot s^{-1}$

Qbar for site area (l/s): $Q_{bar} := Q_{bar50} \cdot \left(\frac{A}{hectare} \cdot 50^{-1}\right) = 0.36\ l \cdot s^{-1}$

Mean annual peak flow per unit area (l/s/ha): $Q_{barha} := \frac{Q_{bar}}{A \cdot hectare^{-1}} = 4.03\ l \cdot s^{-1}$ *(allowable Greenfield discharge from site)*

Allowable limit of discharge : $Q_{throttle} := 2.0\ l \cdot s^{-1}$

1:100yr flow for site area : $Q_{throttle100} := \frac{Q_{throttle}}{A \cdot hectare^{-1}} = 22.45\ l \cdot s^{-1}$

Eqiv. mean ann. site peak flow: $Q_{throttlemean} := \frac{Q_{throttle}}{3.5 \cdot A \cdot hectare^{-1}} = 6.41\ l \cdot s^{-1}$

Growth curve factors: *(CIRIA C753 SuDS manual 2015 Tab. 24.2)*

<u>1 year return period</u> $yr_1 = 0.85$

<u>30 year return period</u> $yr_{30} = 2.4$

<u>100 year return period</u> $yr_{100} = 3.19$

GREENFIELD RUNOFF ESTIMATION (cont'd)

Greenfield runoff rates (l/s):	1 year return period	$Q_{1G} := Q_{bar} \cdot yr_1 = 0.31\ l \cdot s^{-1}$
	30 year return period	$Q_{30G} := Q_{bar} \cdot yr_{30} = 0.86\ l \cdot s^{-1}$
	100 year return period	$Q_{100G} := Q_{bar} \cdot yr_{100} = 1.14\ l \cdot s^{-1}$
Greenfield discharge rates per unit area (l/s/ha):	1 year return period	$Q_{1G} \cdot \left(\frac{A}{hectare}\right)^{-1} = 3.42\ l \cdot s^{-1}$
	30 year return period	$Q_{30G} \cdot \left(\frac{A}{hectare}\right)^{-1} = 9.67\ l \cdot s^{-1}$
	100 year return period	$Q_{100G} \cdot \left(\frac{A}{hectare}\right)^{-1} = 12.85\ l \cdot s^{-1}$
Greenfield runoff volume (100yr 6hr event):	100 year return period	$V_{100G} := Q_{100G} \cdot 6\ hr = 24.73\ m^3$
Allowable flow rate :		$Q_{throttle} = 2\ l \cdot s^{-1}$

Design greenfield runoff rates (l/s):	1 year return period	$Q_{A1} = 2\ l \cdot s^{-1}$
	30 year return period	$Q_{A30} = 2\ l \cdot s^{-1}$
	100 year return period	$Q_{A100} = 2\ l \cdot s^{-1}$
Design greenfield discharge rates per unit area (l/s/ha):	1 year return period	$Q_1 := Q_{A1} \cdot \left(\frac{A}{hectare}\right)^{-1} = 22.45\ l \cdot s^{-1}$
	30 year return period	$Q_{30} := Q_{A30} \cdot \left(\frac{A}{hectare}\right)^{-1} = 22.45\ l \cdot s^{-1}$
	100 year return period	$Q_{100} := Q_{A100} \cdot \left(\frac{A}{hectare}\right)^{-1} = 22.45\ l \cdot s^{-1}$
Design greenfield runoff volume (100yr 6hr event):	100 year return period	$V_{100g} := Q_{100} \cdot 6\ hr = 484.85\ m^3$

ASSESSMENT OF ATTENUATION STORAGE VOLUME

Hydrological area:	$A_{hyd} = 6$	CIRIA C967 SuDS manual Fig. 4.2 [11 = Ireland for calculation]
Hrdrological rainfall zone M560 , r:	$M_5 60 := 20\ mm$ $r := 0.4$	Wallingford 5yr return 60 min / ratio maps
Development area:	$A = 0.089\ hectare$	
Development impervious area:	$A_i := 0.0411\ hectare$	
Proportion of impervious area:	$\alpha := A_i \cdot A^{-1} = 0.461$	*(Proportion of site for attenuation min 50%)*
Percentage of site impermeable area:	$PIMP := \alpha = 50\%$	
Greenfield flow per unit area (l/s/ha):	$Q_{barha1} := \max\left(Q_{barha}, Q_{throttlemean}\right) = 6.41\ l \cdot s^{-1}$	
Climate change factor:	$CC := 1.4$	*(40% increase for climate change)*

Rainfall intensity values

Rainfall 100yrs 6hrs (mm):	$i_{360} := 63\ mm$
Rainfall per hour (mm/h):	$i_{360h} := i_{360} \cdot 6^{-1} = 10.5\ mm$
Rainfall 100yrs 12hrs (mm):	$i_{720} := 99\ mm$
Rainfall per hour (mm/h):	$i_{720h} := i_{720} \cdot 12^{-1} = 8.25\ mm$
Greenfield runoff volume estimate (100yrs 6hrs):	$V_g := \left(SPR \cdot A \cdot i_{360}\right) = 25.26\ m^3$

Vol. runoff coefficient:	$C_v := 0.84$	Typical winter value
routing coefficient:	$C_R := 1.3$	CIRIA C753 24.6.2 recommended value
Runoff coefficient:	$C := C_v \cdot C_R = 1.1$	CIRIA C753 24.6.2 recommended value
Peak flow (100yr 6hr event):	$Q_d := \dfrac{i_{360h}}{1\ hr} \cdot C \cdot A_i = 0.0013\ m^3 \cdot s^{-1}$	
Runoff volume estimate (100yr 6hr event):	$V_d := Q_d \cdot C^{-1} \cdot 6\ hr = 25.893\ m^3$	

ATTENUATION STORAGE CALCULATIONS

Rainfall intensity data from Wallingford Vol. 4 (5yr, 1yr, 30yr, 100yr) & BRE 365 table A1
[Calculated on appended Excel sheet]:

Ratio: $r := 0.4$

D (min)	$Z1$
5	0.373
10	0.523
15	0.633
30	0.803
60	1.00
120	1.207
240	1.447
360	1.603
600	1.793
1440	2.240

Actual rainfall depths for 5yr return period (M5-D):

$$M_{5D} = \begin{bmatrix} 7.46 \\ 10.46 \\ 12.66 \\ 16.06 \\ 20 \\ 24.14 \\ 28.94 \\ 32.06 \\ 35.86 \\ 44.8 \end{bmatrix} mm$$

Z2 values based on actual rainfall depths (calculted on appended Excel sheet):

D (min)	$Z2_1$	$Z2_{30}$	$Z2_{100}$
5	0.615	1.484	1.849
10	0.611	1.523	1.917
15	0.615	1.536	1.953
30	0.625	1.556	1.998
60	0.64	1.580	2.030
120	0.657	1.572	2.013
240	0.676	1.554	1.978
360	0.684	1.540	1.954
600	0.692	1.521	1.923
1440	0.710	1.476	1.852

Actual rainfall depths for 1yr, 30yr, 100yr return period (MT-D):

$$M_{1TD}=\begin{bmatrix}4.59\\6.39\\7.79\\10.04\\12.8\\15.86\\19.56\\21.93\\24.82\\31.81\end{bmatrix}mm \qquad M_{30TD}=\begin{bmatrix}11.07\\15.93\\19.45\\24.99\\31.6\\37.95\\44.97\\49.37\\54.54\\66.12\end{bmatrix}mm \qquad M_{100TD}=\begin{bmatrix}13.79\\20.05\\24.72\\32.09\\40.6\\48.59\\57.24\\62.65\\68.96\\82.97\end{bmatrix}mm$$

Rainfall intensity for 1yr, 30yr, 100yr return period (i):

$$i_1 = \begin{bmatrix} 55.055 \\ 38.346 \\ 31.144 \\ 20.075 \\ 12.8 \\ 7.93 \\ 4.891 \\ 3.655 \\ 2.482 \\ 1.325 \end{bmatrix} \frac{mm}{hr} \quad i_{30} = \begin{bmatrix} 132.848 \\ 95.583 \\ 77.783 \\ 49.979 \\ 31.6 \\ 18.974 \\ 11.243 \\ 8.229 \\ 5.454 \\ 2.755 \end{bmatrix} \frac{mm}{hr} \quad i_{100} = \begin{bmatrix} 165.522 \\ 120.311 \\ 98.9 \\ 64.176 \\ 40.6 \\ 24.297 \\ 14.311 \\ 10.441 \\ 6.896 \\ 3.457 \end{bmatrix} \frac{mm}{hr}$$

Wallingford surface water run off including climate increase (1yr, 30yr, 100yr) Qr = 2.78 C i Ai * CC:

$$Q_{r1} = \begin{bmatrix} 26.71 \\ 18.61 \\ 15.11 \\ 9.74 \\ 6.21 \\ 3.85 \\ 2.37 \\ 1.77 \\ 1.2 \\ 0.64 \end{bmatrix} \frac{l}{s} \quad Q_{r30} = \begin{bmatrix} 64.46 \\ 46.38 \\ 37.74 \\ 24.25 \\ 15.33 \\ 9.21 \\ 5.46 \\ 3.99 \\ 2.65 \\ 1.34 \end{bmatrix} \frac{l}{s} \quad Q_{r100} = \begin{bmatrix} 80.31 \\ 58.38 \\ 47.99 \\ 31.14 \\ 19.7 \\ 11.79 \\ 6.94 \\ 5.07 \\ 3.35 \\ 1.68 \end{bmatrix} \frac{l}{s}$$

Actual discharge volumes (1yr, 30yr, 100yr):

$$V_{sw1} = \begin{bmatrix} 8.014 \\ 11.164 \\ 13.6 \\ 17.533 \\ 22.359 \\ 27.704 \\ 34.173 \\ 38.305 \\ 43.346 \\ 55.561 \end{bmatrix} m^3 \quad V_{sw30} = \begin{bmatrix} 19.338 \\ 27.827 \\ 33.967 \\ 43.651 \\ 55.198 \\ 66.287 \\ 78.557 \\ 86.243 \\ 95.275 \\ 115.505 \end{bmatrix} m^3 \quad V_{sw100} = \begin{bmatrix} 24.094 \\ 35.026 \\ 43.189 \\ 56.05 \\ 70.919 \\ 84.883 \\ 99.991 \\ 109.427 \\ 120.456 \\ 144.929 \end{bmatrix} m^3$$

ATTENUATION STORAGE CALCULATIONS (cont'd

Actual greenfield discharge volumes (1yr, 30yr, 100yr):

$$V_{gact1} = \begin{bmatrix} 0.092 \\ 0.183 \\ 0.275 \\ 0.549 \\ 1.098 \\ 2.197 \\ 4.393 \\ 6.59 \\ 10.983 \\ 26.359 \end{bmatrix} m^3 \qquad V_{gact30} = \begin{bmatrix} 0.258 \\ 0.517 \\ 0.775 \\ 1.551 \\ 3.101 \\ 6.202 \\ 12.404 \\ 18.606 \\ 31.01 \\ 74.425 \end{bmatrix} m^3 \qquad V_{gact100} = \begin{bmatrix} 0.343 \\ 0.687 \\ 1.03 \\ 2.061 \\ 4.122 \\ 8.244 \\ 16.487 \\ 24.731 \\ 41.218 \\ 98.923 \end{bmatrix} m^3$$

Permitted greenfield discharge volumes (1yr, 30yr, 100yr):

$$V_{g1} = \begin{bmatrix} 6.734 \\ 13.468 \\ 20.202 \\ 40.404 \\ 80.808 \\ 161.616 \\ 323.232 \\ 484.848 \\ 808.081 \\ 1.939 \cdot 10^3 \end{bmatrix} m^3 \qquad V_{g30} = \begin{bmatrix} 6.734 \\ 13.468 \\ 20.202 \\ 40.404 \\ 80.808 \\ 161.616 \\ 323.232 \\ 484.848 \\ 808.081 \\ 1.939 \cdot 10^3 \end{bmatrix} m^3 \qquad V_{g100} = \begin{bmatrix} 6.734 \\ 13.468 \\ 20.202 \\ 40.404 \\ 80.808 \\ 161.616 \\ 323.232 \\ 484.848 \\ 808.081 \\ 1.939 \cdot 10^3 \end{bmatrix} m^3$$

Required attenuation storage (1yr, 30yr, 100yr) - *Actual minus permitted discharge volumes* :

$$V_{req1} = \begin{bmatrix} 1.28 \\ -2.304 \\ -6.602 \\ -22.871 \\ -58.449 \\ -133.912 \\ -289.059 \\ -446.543 \\ -764.734 \\ -1.884 \cdot 10^3 \end{bmatrix} m^3 \qquad V_{req30} = \begin{bmatrix} 12.604 \\ 14.359 \\ 13.765 \\ 3.247 \\ -25.61 \\ -95.329 \\ -244.675 \\ -398.606 \\ -712.806 \\ -1.824 \cdot 10^3 \end{bmatrix} m^3 \qquad V_{req100} = \begin{bmatrix} 17.36 \\ 21.558 \\ 22.987 \\ 15.646 \\ -9.889 \\ -76.734 \\ -223.241 \\ -375.421 \\ -687.625 \\ -1.794 \cdot 10^3 \end{bmatrix} m^3$$

Note : Minus values within the above matrices indicate no need for storage.

Maximum attenuation storage required: $V_{req} = 22.99\ m^3$ (100 year return ; 15min duration)

Factored attenuation storage required: $V_{fac} := 1.25 \cdot V_{req} = 28.73\ m^3$

(25% extra allowance as recommended in CIRIA C753 24.9.4)

SUMMARY OF CALCULATIONS

SITE DISCHARGES:

Qbar for site area (l/s):		$Q_{bar} = 0.36\ l \cdot s^{-1}$
IH124 Greenfield runoff rates (l/s):	1 year return period	$Q_{1G} = 0.31\ l \cdot s^{-1}$
	30 year return period	$Q_{30G} = 0.86\ l \cdot s^{-1}$
	100 year return period	$Q_{100G} = 1.14\ l \cdot s^{-1}$
Design 2.0l/s Greenfield discharge (l/s):	1 year return period	$Q_1 = 22.45\ l \cdot s^{-1}$
	30 year return period	$Q_{30} = 22.45\ l \cdot s^{-1}$
	100 year return period	$Q_{100} = 22.45\ l \cdot s^{-1}$

SITE VOLUMES:

Estimated Greenfield discharge volume 100yr, 6hr (l/s): $V_g = 25.26\ m^3$

Allowable Greenfield discharge volume 100yr, 6hr (l/s): $V_{100g} = 484.85\ m^3$

Estimated Brownfield discharge volume 100yr, 6hr (l/s): $V_d = 25.89\ m^3$

STORAGE VOLUMES:

Attenuation storage required : $V_{fac} = 28.73\ m^3$

CONCLUSION:

system outflow limited to 2l/s above calculated greenfield runoff rates due to magnitute of runoff values being impractically small. The value of 2l/s is widely accepted as a minumum value to prevent blockages within SuDS systems.

Attentation is also specified, to provide 29 cubic meters in storage volume (either geocellular or lined permeable paving) to discharge to the local sewer network.

Z1 factor Eng & Wales (BRE 365 - Table 1) - r = 0.2, 0.25, 0.35, 0.4 interpolated

Ratio	Rainfall duration (D)									
r	5	10	15	30	60	120	240	360	600	1440
0.12	0.22	0.34	0.45	0.67	1.00	1.48	2.17	2.75	3.70	6.00
0.15	0.25	0.38	0.48	0.69	1.00	1.42	2.02	2.46	3.23	4.90
0.18	0.27	0.41	0.51	0.71	1.00	1.36	1.86	2.25	2.86	4.30
0.2	0.283	0.423	0.530	0.723	1.000	1.340	1.800	2.163	2.700	3.833
0.21	0.29	0.43	0.54	0.73	1.00	1.33	1.77	2.12	2.62	3.60
0.24	0.31	0.46	0.56	0.75	1.00	1.30	1.71	2.00	2.40	3.35
0.25	0.317	0.467	0.567	0.753	1.000	1.290	1.687	1.960	2.347	3.267
0.27	0.33	0.48	0.58	0.76	1.00	1.27	1.64	1.88	2.24	3.10
0.3	0.34	0.49	0.59	0.77	1.00	1.25	1.57	1.78	2.12	2.84
0.33	0.35	0.50	0.61	0.78	1.00	1.23	1.53	1.73	2.04	2.60
0.35	0.357	0.507	0.617	0.787	1.000	1.223	1.497	1.690	1.947	2.480
0.36	0.36	0.51	0.62	0.79	1.00	1.22	1.48	1.67	1.90	2.42
0.39	0.37	0.52	0.63	0.80	1.00	1.21	1.46	1.62	1.82	2.28
0.400	0.373	0.523	0.633	0.803	1.000	1.207	1.447	1.603	1.793	2.240
0.42	0.38	0.53	0.64	0.81	1.00	1.20	1.42	1.57	1.74	2.16
0.45	0.39	0.54	0.65	0.82	1.00	1.19	1.38	1.51	1.68	2.03

Z2 factor Eng & Wales (Wallingford Table 6.2 - Table 1) - return period = 30 years interpolated

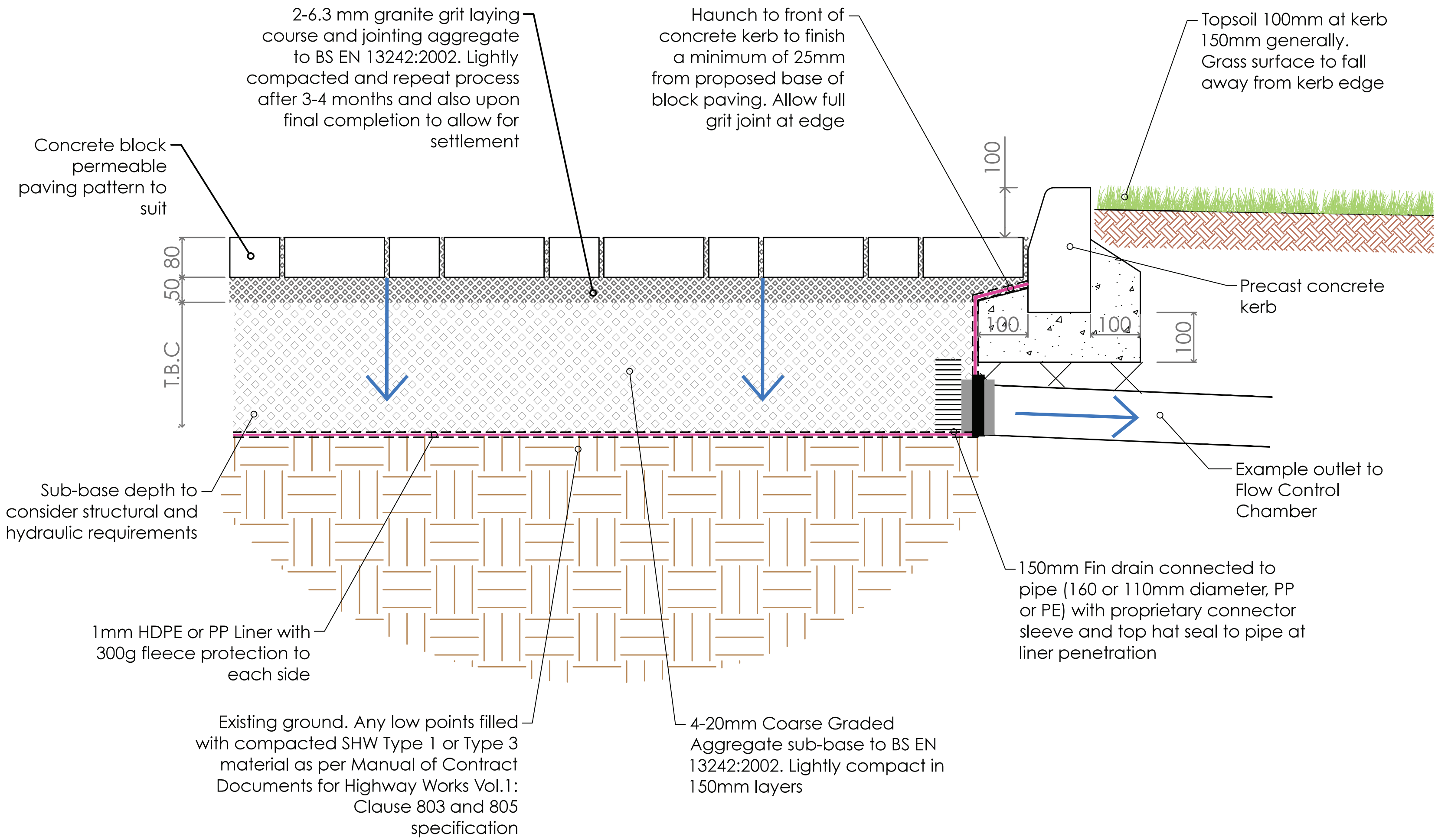
	M5 rainfall	Return period		
	mm	1	30	100
1	5	0.62	1.45	1.79
2	10	0.61	1.52	1.91
3	15	0.62	1.55	1.99
4	20	0.64	1.58	2.03
5	25	0.66	1.57	2.01
6	30	0.68	1.55	1.97
7	40	0.7	1.5	1.89
8	50	0.72	1.45	1.81
9	75	0.76	1.36	1.64
10	100	0.78	1.32	1.54
11	150	0.78	1.26	1.45
12	200	0.78	1.24	1.4

Z2 Values for actual Rainfall depths

Duration	Act. Depth	Z2 (1)	Z2 (30)	Z2 (100)
min	*mm*			
5	7.450	0.615	1.484	1.849
10	10.460	0.611	1.523	1.917
15	12.660	0.615	1.536	1.953
30	16.060	0.624	1.556	1.998
60	20.000	0.640	1.580	2.030
120	24.140	0.657	1.572	2.013
240	28.940	0.676	1.554	1.978
360	32.060	0.684	1.540	1.954
600	35.860	0.692	1.521	1.923
1440	44.800	0.710	1.476	1.852

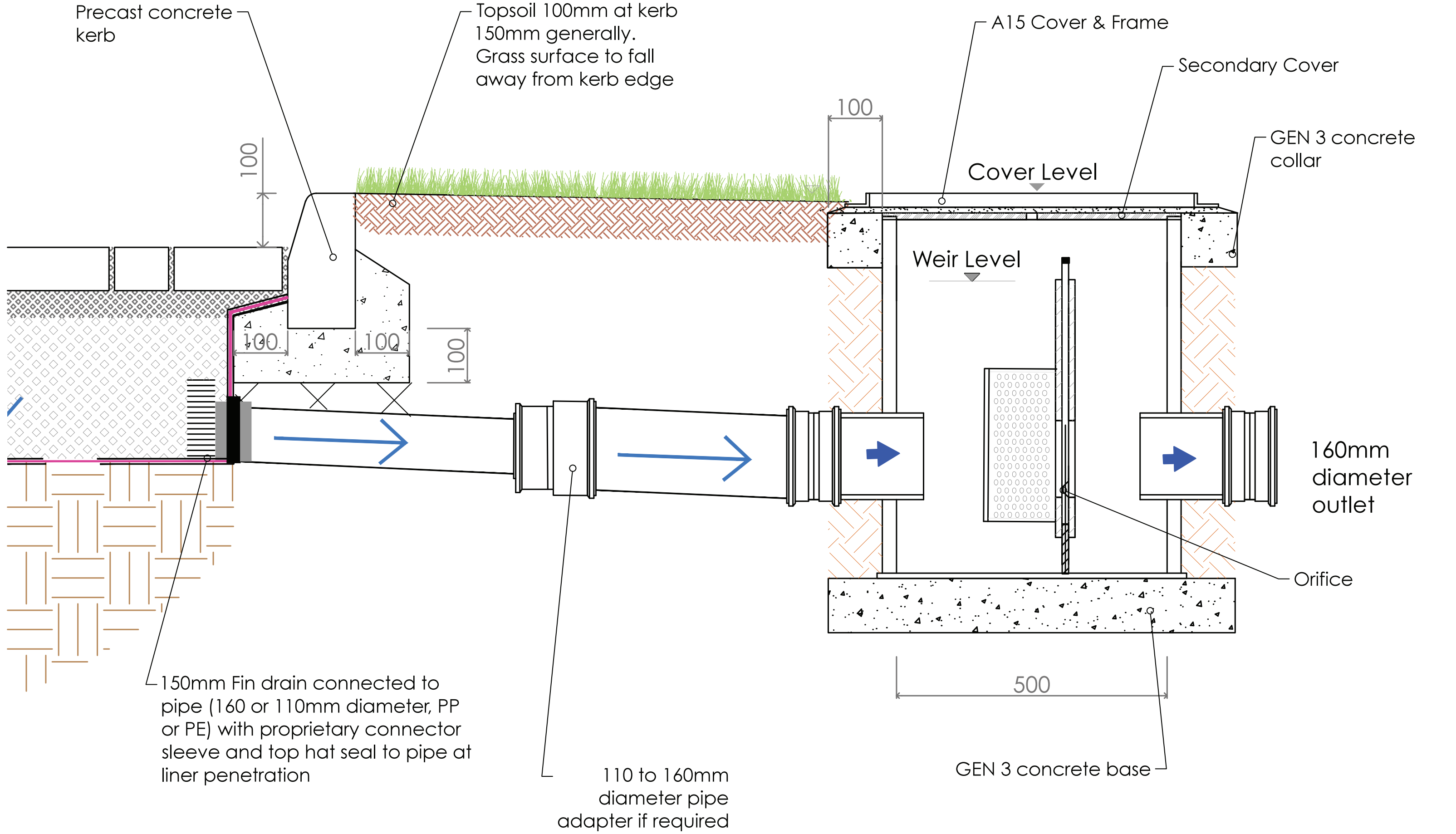
CBPP Details

Detail 3 - Lined Permeable Paving (System C) No Infiltration - with Sealed Outlet to Flow Control



Features for CBPP or SuDS

Detail 15 - Flow control chamber with a protected orifice within a removable plate, suitable for any SuDS technique outlet. For CBPP, flow controls do not need protection from blockages, as the water passing from the CBPP will be free of debris.



Permavoid system - components

Permavoid - Medium Duty with Biomat

Product code: PSM1BM

Permavoid Medium Duty with Biomat is designed for use with Polystorm attenuation and infiltration systems and comprises of a tri-laminate of low density plastic composite (biomat). The biomat floats on water and is designed to intercept and treat any potential residual emulsified oils that may be present within the surface water. The use of Permavoid Medium Duty with Biomat provides additional oil retention and water treatment capability to an underground water storage system.

Technical Specification Overview	
Length	1m
Width	0.5m
Depth	0.4m
Total volume	0.2m³
Unit weight	9kg (approx)
Unit storage volume	0.19m³ (190 litres)
Void ratio	95%
Vertical compressive strength	Maximum 610 kN/m² **
Lateral compressive strength	Maximum 63 kN/m² **
Short-term vertical deflection	70.1 kN/m² per mm
Short-term lateral deflection	4.4 kN/m² per mm
Estimated long term vertical deflection (creep)	0.2798 Ln (design life in hrs) [Based on an applied test load = 162 kN/m²] Creep data limit 60 years
Estimated long term lateral deflection (creep)	1.0192 Ln (design life in hrs) [Based on an applied test load = 30.8 kN/m²] Creep data limit 60 years
Other Properties	
Intrinsic permeability (k)	Minimum 1.0 x 10^{-5}
Oil retention	56g/m²
Effluent discharge at max. oil loading	10ppm

Note: Permavoid Medium Duty With Biomat is ideal for use in trafficked and pedestrian applications subject to a structural design check and suitable installation conditions.

* Each unit includes 4 clips and 2 shear connectors.

** Compressive strength at yield, maximum recommended value for design purposes.

Exact colour may vary due to recycled materials.

Applications

The Permavoid Medium Duty with Biomat units are suitable for use as a stormwater retention, attenuation or infiltration system. Used to provide hydrocarbon treatment, they are suitable for a range of applications including, retail, residential, commercial and off-road car parking.

Performance

The structural load bearing capacity of the Permavoid units have been tested in accordance with CIRIA C680. The structural design life is a minimum 60 years.

The units provide 3D flow and have a void ratio of 95%.

Key benefits

- Pollutant-intercepting floating mat degrades residual oils by absorption and aerobic digestion
- Can be incorporated into Polystorm retention, attenuation and infiltration systems
- 95% void ratio
- Light weight yet robust – excellent health and safety and installation benefits
- 60 years creep limited life expectancy
- 100% recyclable
- Units are manufactured from recycled materials

Permaceptor

Product code: PV04002

The Permaceptor functions as a combined run-off collection, silt/oil interceptor and treatment system. The system is designed to be used with conventional road/yard gullies and ideally laid with zero gradient to prevent the development of lateral velocities. Thus, its initial function is to 'still' sheet run-off from each sub-catchment and to encourage silt deposition. The outlet discharges via a weir and baffle component that separates oils and prevents the effluent and silt from progressing into the rest of the drainage system.

Element	Value
Physical Properties	
Weight per unit	29kg
Length	1062mm
Width	708mm
Height	300mm
Short Term Compressive Strength	
Vertical	715kN/m²
Lateral	156kN/m²
Short Term Deflection	
Vertical	1mm per 126kN/m²
Lateral	1mm per 15kN/m²
Tensile Strength	
Of a single joint	42.4kN/m²
Of a single joint at (1% secant modulus)	18.8kN/m²
Bending resistance of unit	0.71kN/m
Bending resistance of single joint	0.16kN/m
Volumetric void ratio	92%
Average effective perforated surface area	52%
Other Properties	
Intrinsic permeability (k)	Minimum 1.0 x 10^{-5}
Oil retention	56g/m²
Effluent discharge at max. oil loading	10ppm
Ancillary	Permavoid Permatie
Material	Polymer concrete

Applications

Permaceptor is used for stormwater collection, interception and the treatment of associated pollutants. The system comprises of Permavoid and Permavoid Biomat units located to collect surface water run-off from sub-catchments of predominantly impervious or pervious pavements via Polypipe Ridgigully and Midigully. Permaceptor is suitable for use in a range of applications including residential, industrial estates, car parks and basements.

Performance

The structural load bearing capacity of the Permavoid units have been tested in accordance with the following European Standard: BS 7533-13:2009. The system's structural design life expectancy, based upon creep test data (tested in accordance with CIRIA guidelines) is as follows; for lightly loaded areas such as car parks a design life of 50 years is achievable. For areas with prolonged HGV loading a typical design life may only be 25 years, depending on the design of the pavement surfacing and structural layers over the tank.

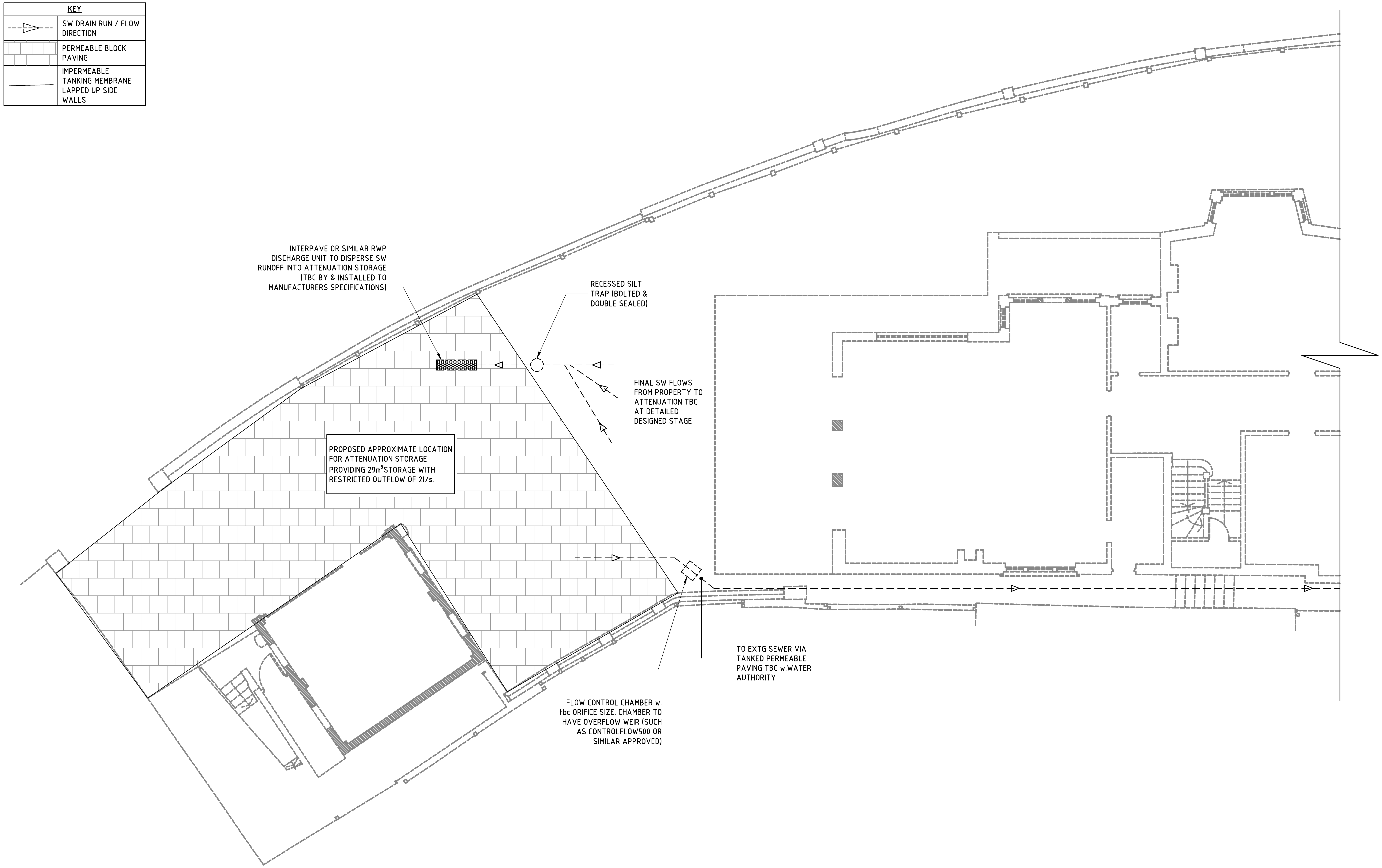
Installation standard

All calculations for Permaceptor units are based upon site-specific load cases, construction types and thickness, soil cover and ground conditions and the suitability must therefore be approved for each project.

Key benefits

- Gravity separation of oils and silts at source
- Accidental/catastrophic spills recoverable at source
- Trapped effluent naturally treated by aerobic digestion
- Can enhance the water quality and eliminate the need for end of line petrol/oil interceptors
- The system complies with the regulations of the treatment train criteria in a SuDS scheme as defined in the PPG3
- 100% recyclable
- Units are manufactured from 90% recycled polypropylene (PP)

KEY	
(dashed line with arrow)	SW DRAIN RUN / FLOW DIRECTION
(hatched block)	PERMEABLE BLOCK PAVING
(solid line)	IMPERMEABLE TANKING MEMBRANE LAPPED UP SIDE WALLS



SURFACE WATER STRATEGY:
RUN OFF TO BE DISCHARGED VIA CBPP INTO ATTENUATION STORAGE. SYSTEM TO BE TANKED AND DISCHARGED TO SEWER. PAVING SIZED TO ACCOMMODATE 1:100 STORM EVENT +40% C.C.

NOTE:
SURFACE WATER FROM PAVING, NEW ROOFS AND DOWNPIPES ASSUMED TO BE DRAINED TO NEW GULLIES TO BE POSITIONED AND CONNECTED TO DRAINAGE RUNS. POSITION OF ALL GULLIES TO BE CONFIRMED BY THE ARCHITECT PRIOR TO CONFIRMATION OF DRAINAGE SCHEME – GULLIES SHOWN ARE INDICATIVE ONLY.

DRAWING NOTES
1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL RELEVANT THIRD PARTY ARCHITECTS & OTHER SPECIALISTS' DRAWINGS AND SPECIFICATIONS.
2. THIS DRAWING SHOULD NOT BE SCALED IN EITHER PAPER OR DIGITAL FORMAT.
3. ALL DIMENSIONS AND LEVELS TO BE CONFIRMED BY THE ARCHITECT.
4. ANY DISCREPANCIES IN DRAWINGS OR DETAILS TO BE IMMEDIATELY REPORTED TO MINT STRUCTURES.
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6. ALL DETAILS ARE SUBJECT TO BUILDING REGULATIONS APPROVAL.
7. TO ENSURE THIS DRAWING HAS BEEN PRINTED CORRECTLY THE BAR BELOW SHOULD MEASURE 50mm:

0mm 25mm 50mm

8. ALL WORK CARRIED OUT SHOULD ADHERE TO SPECIFIC DRAWING NOTES & GUIDANCE AND COMPLY WITH CURRENT RELEVANT HSE & CDM REGULATIONS TO ENSURE SAFE SITE PRACTICE IS MAINTAINED IN ACCORDANCE WITH DETAILS PRODUCED BY OTHERS.
9. FOR GENERAL NOTES SEE DRAWING: M20202/GN01.
10. ALL DIMENSIONS SHOWN ARE IN mm U.N.O.

DRAFT ISSUE

DATE	REV	DETAIL	DRAWN
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LONDON
NW3 7PH

DRAWING TITLE
PLANNING SUDS PLAN

SCALE	DRAWN
1:100 @ A2	LS
	ENGINEER LS
DATE	CHECKED
JUL 21	--
DRAWING No.	REVISION
M20202/SUDS1	-

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