



**PROPOSED RESIDENTIAL DEVELOPMENT
LAND NORTH OF SEFTER ROAD. BOGNOR REGIS**

**DRAINAGE STRATEGY
& SUDS STATEMENT**

AUGUST 2021

Document Control Sheet

Project name: Land north of Sefter Road, Bognor Regis

Project ref: WSC/E4775

Report Title Drainage Strategy &
SuDS Statement

Doc. ref: TRS/E4775/17909

Date: 18th August 2021

	Name	Position	Signature	Date
Prepared by:	Terry Seymour	Director		August 2021
Reviewed by:	Anthony Cooper	Principal Engineer		August 2021
Approved by:	Terry Seymour	Director		August 2021

Revision	Date	Description	Prepared	Approved

Contents

1.0	Introduction.....	2
2.0	Existing Site	4
2.1	<i>Geotechnical.....</i>	5
2.2	<i>Ground Conditions.....</i>	6
2.3	<i>Hydrology.....</i>	6
2.4	<i>Hydrogeology.....</i>	7
3.0	Flood Risk and Existing Surface Water Drainage.....	7
3.1	<i>Existing Site Drainage.....</i>	8
4.0	Surface Water Management	8
4.1	<i>Design Principles</i>	8
4.2	<i>Sustainable Drainage Systems</i>	8
4.3	<i>Surface Water Drainage Strategy.....</i>	9
4.4	<i>Flow Control.....</i>	9
4.5	<i>Water Quality.....</i>	10
4.6	<i>Long Term Maintenance.....</i>	13
4.7	<i>Exceedance</i>	13
5.0	Foul Drainage	13
6.0	Conclusion.....	14

Figures

Figure 1: Site Location.....	4
Figure 2: Site Topography.....	5
Figure 3: Extract of Flood Map from the EA's website.....	6

Appendices

Appendix A	Topographic Survey
Appendix B	Geotechnical Information (Extract)
Appendix C	Proposed Site Layout
Appendix D	Existing Drainage Regime
Appendix E	Proposed Surface Water Strategy
Appendix F	Micro Drainage Calculations
Appendix G	SuDS Maintenance Strategy

1.0 Introduction

Rogers Cory Partnership Limited have been instructed on behalf of Taylor Wimpey to prepare a Surface Water Drainage Strategy and SuDS Statement to support the Reserved Matters submission associated with the proposed development of the site referred to as the Land north of Sefter Road, Bognor Regis, West Sussex per the current Outline Planning Application (P/134/16/OUT) for the approval of Reserved Matters pursuant to condition 1 (Reserved Matters details), condition 6 (Design Code Masterplan) and condition 7 (landscaping and layout details) of Outline planning permission P/134/16/OUT for the erection of 250 dwellings, (including affordable homes), replacement scout hut, and Ambulance Community Response Post Facility. Demolition of No. 80 Rose Green Road and provision of Public Open Spaces including associated children's play areas, landscaping, drainage and earthworks.

Whilst the Reserved Matters application excludes the land identified within the Outline Planning Permission for 'school/care home/residential use' within the north-west corner of the site, this Drainage Strategy has considered a robust worst case scenario in drainage terms which is that a 1 FE Primary School could be located here to demonstrate that the drainage proposals and associated strategy is suitable for the wider Outline permitted site.

Further Reserved Matters application will provide the specific drainage strategy for the layout for the north-west parcel when this comes forward.

This report outlines the development of the Surface Water Drainage and SuDS Strategy following on from the Flood Risk Assessment (FRA) produced by C&A Consultants Ltd (Report dated December 2016) which formed part of the outline planning submission.

The purpose of this strategy is currently not to seek to discharge the current planning conditions relating to the surface water and SuDS of the Outline Planning Notice (P/134/16/OUT) but rather to support the Reserved Matters application and to demonstrate that a surface water drainage solution can feasibly be delivered to support the detailed layout.

Further details, including detailed hydraulic calculations, detailed drainage layouts and associated drainage construction details will be developed and submitted as part of a separate and future Discharge of Conditions application.

The drainage strategy outlined and presented in this report build on the principles of the following:

- Flood Risk Assessment by C&A Consulting Engineers Ltd (December 2016);
- Groundwater Report by RSK – Report reference 28756L01EH (18th October 2017;

-
- Geotechnical Ground Investigation Report by RSK, Report Reference 28756R01 (December 2016)
 - Supplementary Hydrogeological Site Assessment by RSK, Report Reference 305035 L01 (March 2019)
 - Existing Drainage and CCTV survey by Active Pump Services (September 2016)

2.0 Existing Site

The site is located north west of Bognor Regis, adjacent to Sefter Road (Refer to **Figure 1** below). The development is bounded to the north by an existing ditch and farmlands to the east and south by existing residential properties and existing commercial yard and to the west by farm lands

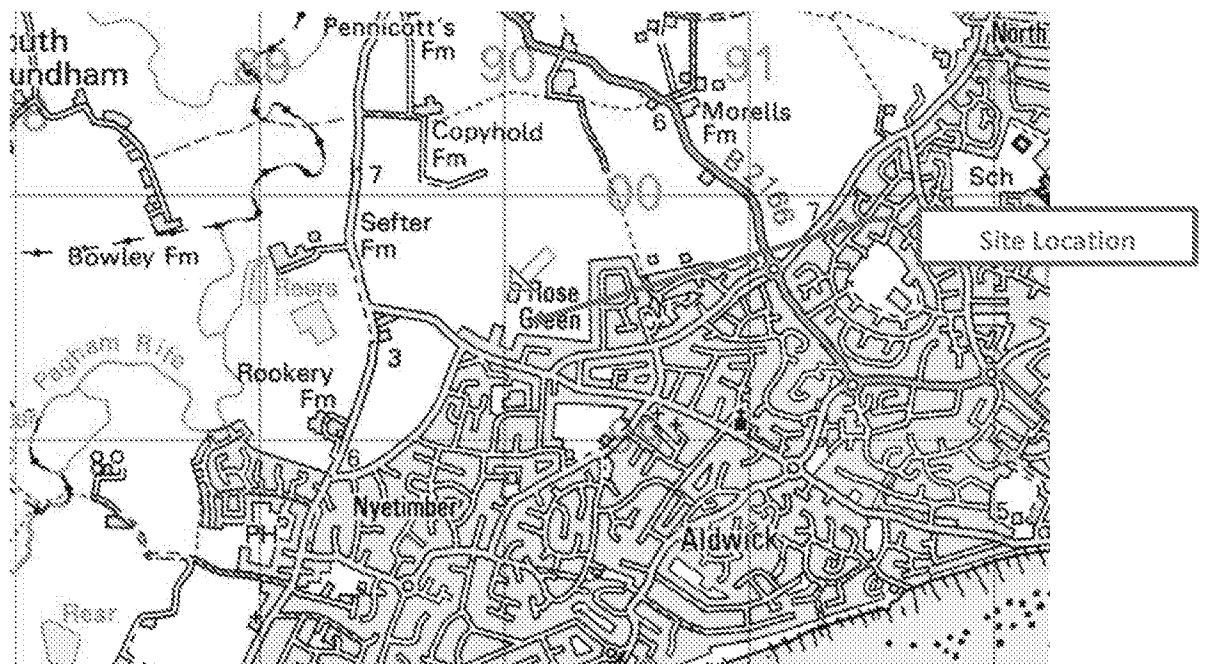


Figure 1: Site Location

The existing site proposed for development covers approximately 13.3ha of greenfield land comprising of open grassed field and farmland. The approximate centre of the site is at Ordnance Survey (OS) Grid Reference 490214; 99535.

The application site comprises of three catchment areas. The first catchment area in the south west falls in a northerly direction towards the existing “anti-tank” ditch, the second catchment located in the north west falls in a southerly direction and the third catchment in the east falls in a south easterly direction. An overview of the change in topography in this part of the wider site is presented as **Figure 2** overleaf. A copy of the topographical survey can be found in **Appendix A**.

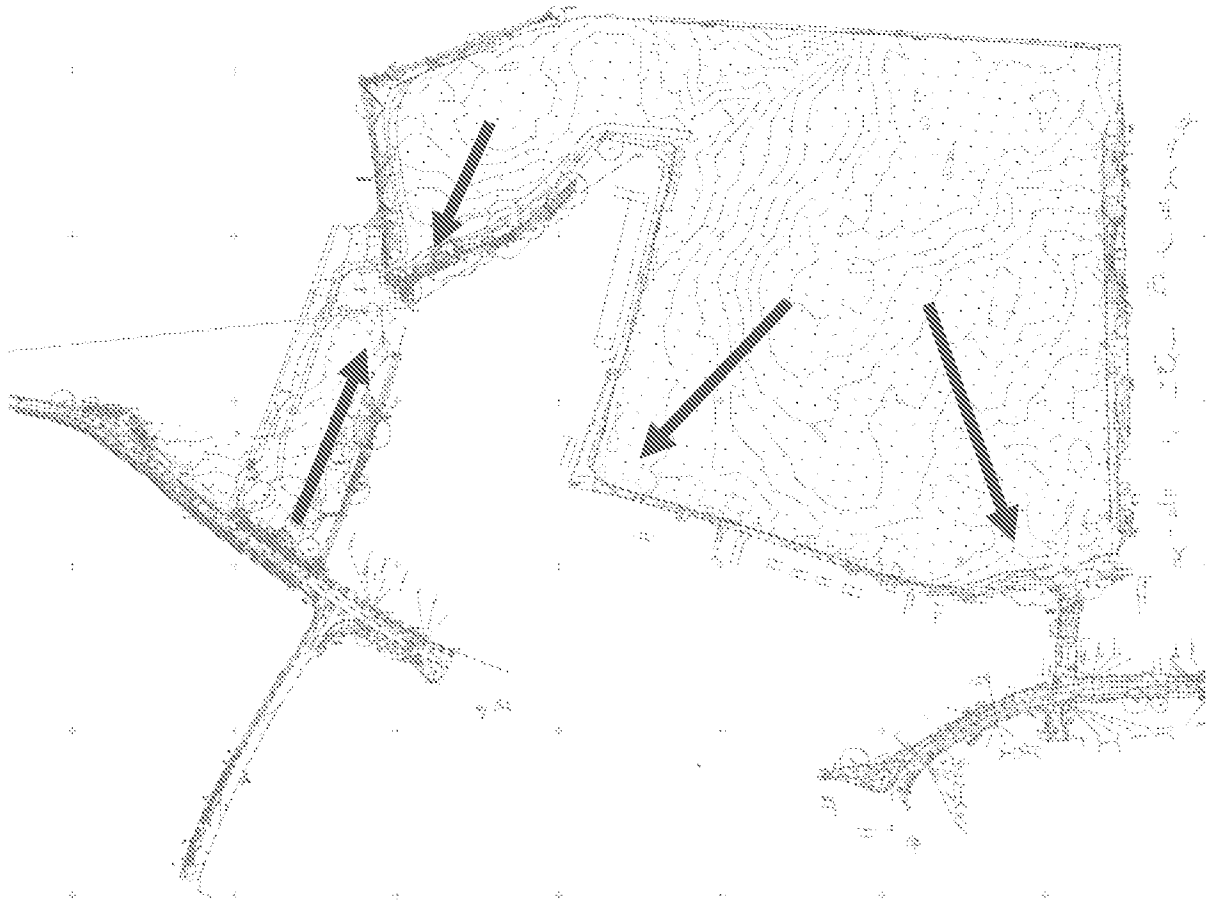


Figure 2: Site Topography

2.1 Geotechnical

The current review of the geotechnical aspects of the site are based on the following documents:

- Groundwater Report by RSK – Report reference 28756L01EH (18th October 2017;
- Geotechnical Ground Investigation Report by RSK, Report Reference 28756R01 (December 2016)
- Supplementary Hydrogeological Site Assessment by RSK, Report Reference 305035 L01 (March 2019)

2.2 Ground Conditions

BGS geological maps indicate that the site is underlain by the London Clay Formation with River Terrace Deposits superficial deposits.

Intrusive investigations carried out by RSK indicate that the site consists of Topsoil or Made Ground over the River Terrace Deposits. below ground.

Winter groundwater monitoring was carried out over the Winter of 2018/2019 indicates the presence of shallow groundwater across the site varying from 0.00mbgl to 1.31mbgl. Winter infiltration testing to BRE 365 was carried out to investigate the potential feasibility for both shallow and deeper infiltration drainage techniques. The majority of the tests across the site failed with only two locations achieving very low permeability results at very shallow depths. As such it was concluded that infiltration drainage techniques (including shallow systems) would not be suitable for this site. ranging from 9.5×10^{-7} to 1.1×10^{-5} m/s.

A copy of the RSK Supplementary Hydrogeological Site Assessment is contained in **Appendix B**.

2.3 Hydrology

There is an existing ordinary watercourse which runs along the north western boundary of the site as well as along the south western side of the site.

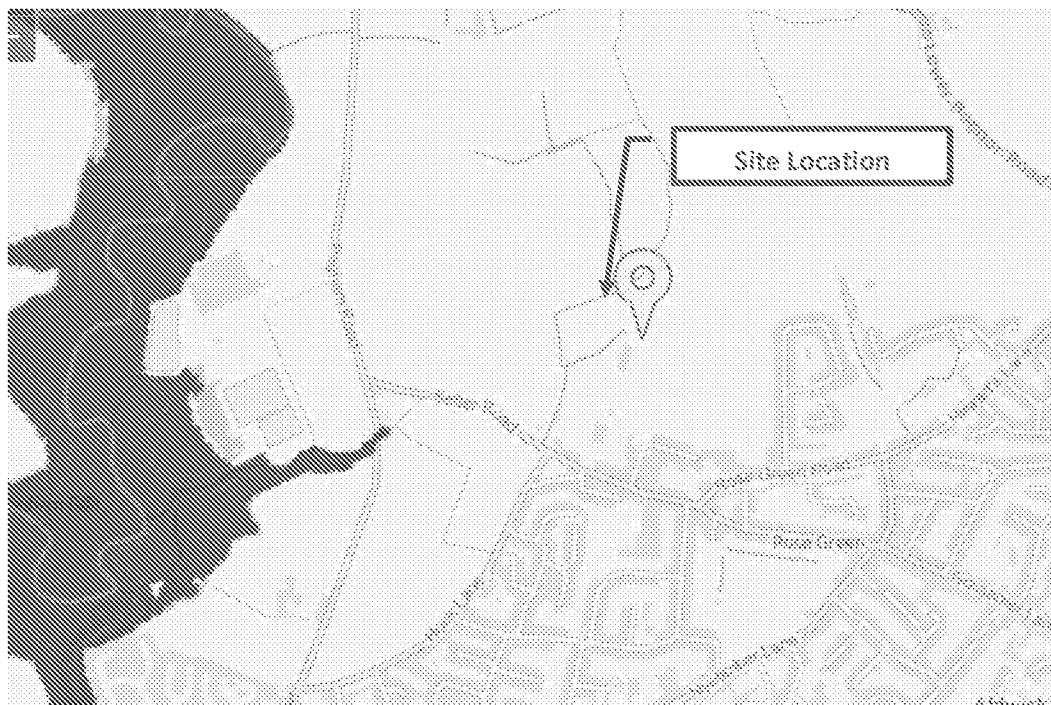


Figure 3: Extract of Flood Map from the EA's website

2.4 Hydrogeology

Groundwater mapping published by the EA indicates that the site is located over a and Unproductive Stratum Bedrock and Secondary A Superficial Deposit designation respectively. The site does not lie within a groundwater source protection.

3.0 Flood Risk and Existing Surface Water Drainage

This report reviews the existing risk of flooding to the site and requirements for a compliant drainage strategy by interrogating the following information:

- Available topographic survey information;
- Arun District Council Strategic Flood Risk Assessment (SFRA);
- West Sussex LLFA Policy for the Management of Surface Water;
- Available mapping from the Environment Agency's website;
- Existing Southern Water sewer service records;
- Flood Risk Assessment by C&A Consulting Engineers Ltd (December 2016)

Based on a review of the EA's Flood Zone maps (see **Figure 3**), the development site appears to lie wholly within Flood Zone 1, considered to be at low risk from fluvial and tidal flooding.

The risk of flooding from pluvial sources has been assessed and based on the mapping information provided by the EA is deemed low to medium for the site. Based on the mapping as well as observations made during a site visit during Winter, there are areas of standing surface water in the south east part of the site. This is due to a localised low point in the site topography which would allow potential exceedance flows from site to accumulate. The risk to the future development as well as neighbouring properties will be mitigated through consideration of proposed finished levels of the development as well as seeking to locate the new SuDS basins in this part of the site. As the water ponding in this part of the site derives from overland flow from within the site, the development of the land will include for a new surface water drainage system with attenuation storage basins, this will ensure that the water is adequately captured, stored and conveyed back into the local watercourses at controlled predevelopment rates. Thus ensuring that the risk of flooding downstream is not increased.

3.1 Existing Site Drainage

A review of the existing topographic information, sewer records and drainage survey has been carried out to assess the existing surface water drainage regime of the site.

Details of the outcomes of the review as well as the recommendation for further investigations and remedial works as to existing headwalls on some of the ditches is provided in **Appendix D**.

4.0 Surface Water Management

The surface water management section should ensure that there is no adverse impact on flood risk elsewhere as a result of a change in the surface water runoff regime from the re-development.

4.1 Design Principles

Key design principles in the following guidance documents steer the approach to managing surface water runoff at sites:

- Building Regulations hierarchy of drainage (H3);
- Interim Code of Practice for SuDS; and
- CIRIA best practice guidance, including the use of the 'SuDS management train'.

Building Regulations hierarchy of drainage outlines the preferred methods for the disposal of surface water with infiltration methods being the preferred option. If this is not possible the next favoured option is to drain to an existing watercourse. If neither of these options are feasible, the regulations state that rainwater discharge should be directed to a sewer.

The Interim Code of Practice for SuDS provides guidance about the hydraulic design criteria for Sustainable drainage systems. This in general refers to both peak rate of runoff and the volume of runoff, post development. Prior to mitigation measures such as the use of SuDS attenuation features, both the volume and peak rate of runoff may increase post development.

The design principles for surface water management extend beyond simple hydraulic criteria. CIRIA guidance promotes the use of the SuDS management train, a concept where SuDS techniques are used to treat, convey and store surface water runoff. This approach is considered as part of the SuDS selection methodology.

4.2 Sustainable Drainage Systems

To drain the development in a sustainable manner whilst complying with the requirements of the NPPF, the scheme should seek to adopt an appropriate form(s) of sustainable urban drainage systems (SuDS).

SuDS techniques comprise of implementation of attenuation basins, swales and below ground storage tanks provide temporary storage of surface water run-off.

4.3 Surface Water Drainage Strategy

In view of the requirements of the NPPF, PPG, WSCC and ADC along with the design parameters and constraints associated with redeveloping this site, a surface water drainage strategy design has been devised and hydraulically modelled to demonstrate that the scheme can be suitably implemented without increasing the level of flood risk, when the surface water drainage system experiences a 1:100 year rainfall event (including 40% climate change allowance) and 10% allowance for urban creep

The surface water drainage scheme has been designed to ensure:

- A reduction in the pre development site discharge for peak storm events.
- Sustainable Urban Drainage systems are wholly incorporated within the scheme.
- Consideration is given for the improvement of water quality within the design.
- The designed drainage scheme can satisfactorily retain a critical 1 in 100 Year storm event with climate change.

The proposed surface water drainage for the development is split into three separate catchments which seek to follow the falls of the existing topography.

Run-off from the access roads and plots will be conveyed to a new below ground surface water drainage network which will direct flows into the new onsite attenuation basins and swales per the respective catchments prior to discharging at the Annual Average Greenfield Run-off rate (Qbar) to existing anti-tank ditch culvert.

The new attenuation basins and swales will be lined and part filled with granular material to counter the effect of the shallow groundwater.

It must be noted that the strategy layout and calculations presented at this stage is to demonstrate that the detailed layout can feasibly be drained in terms of surface water. The full details of the drainage layouts including construction details for permeable paving, swales and attenuation basins will be provided as part of the separate Discharge of Conditions application of the Outline Consent.

4.4 Flow Control

The hydraulic models of the proposed surface water network, incorporating the SuDS attenuation basins and flow control devices can be found in **Appendix F**.

The hydraulic calculations have been simulated under various scenarios up to and including the critical 1 in 100 Year storm event with additional 40% allowance for climate change and 10% allowance for urban creep.

Discharge from the site from the overall proposed to be restricted to the Qbar rate all storm events up to and including the 1 in 100 year plus climate change.

The simulations confirm that the storm can be managed and contained within the curtailment of the site, with small volumes of surface flooding, during peak storm events contained at surface in areas of low risk to people or property.

Catchment	Impermeable Development Area (Ha)	Q1 Year (L/sec)	Q30 Year (L/Sec)	Q100 Year Plus Climate (L/Sec)	Discharge Volume (m3) (360min Winter)
1	4.071	6.9	8.7	9.1	529.570
2	0.85	2.5	2.9	2.9	116.900
3	0.554	2.8	2.9	2.9	117.033

Table 2: Summary of Post Development Run-off with mitigation measures

4.5 Water Quality

It is important to address issues with regards to quality when considering surface water management. As part of the surface water is proposed to be discharge to the existing downstream watercourses, treatment is proposed as part of a SuDS Management Train in accordance with the recommendations of the SuDS Manual (CIRIA 753) and as required by the LLFA.

This SuDS management train will be achieved through the use of permeable paving, swales and attenuation basins.

Chapter 26 of the CIRIA SuDS Manual (2015) provides guidance on methods that should be used to design SuDS to meet the water quality design criteria and good practice design standards. Diffuse urban pollution is a significant factor in compromising groundwater and receiving water standards that are required under the EA Water Framework Directive. Chapter 4 of the SuDs Manual summarises factors, which influence pollution levels in urban run-off. This summary is presented in **Table 1 overleaf**

Factors influencing pollution levels in urban run-off
The amount and type of pollution washed off a surface will depend on many things including: • Planning activities on, above and adjacent to the surface that affect the deposition of pollutants, their retention on the surface and the extent to which they are mixed with runoff (including pollution prevention strategies) • Unplanned activities (accidents and spillages) that can cause temporary unexpected high pollution concentrations • The surface location and type, affecting wash-off rates and contaminant movement mechanisms • The drainage path • The length of the dry weather period before the rainfall event • The intensity and the duration of the rainfall, and the associated flow velocities Any further pollutant transformations occurring during residence and conveyance within gullies, chambers, pipe or channel networks, gravels, soils and vegetation and quiescent bodies of water.

Table 1: Extract of Box 4.1 of the SuDS Manual (CIRIA 753)

Table 4.3 of the SuDS Manual classifies the pollution hazard level for residential sites, including residential car parks, low traffic roads as being “low” and thus only requiring a “Simple index approach” in terms of the requirements for the discharge to surface waters, including coasts and estuaries.

The SuDS Manual summarises the steps for the simple index approach:

Step 1 – *Allocate suitable pollution hazard indices for the proposed land use*

Step 2 – *Select SuDS with a total pollution mitigation index that equals or exceeds the pollution index*

Step 3 – *Where the discharge to a protected surface waters or groundwater, consider the need for a more precautionary approach*

The SuDS Manual describes “protected surface waters” as protected surface water resources, which include those designated for drinking water abstraction or for other environmental protection reasons

Table 26.2 of the SuDS manual notes the following pollution hazard indices for residential land use development:

Land Use	Pollution Hazard Level	Total suspended solids (TSS)	Metals	Hydrocarbons
Residential roofs	Very low	0.2	0.2	0.05
Individual property driveways, residential car parks, low traffic roads (eg. cul-de sacs, home zones and general access roads) and non-residential car parking with infrequent change (eg schools, offices) ie. Less than 300 vehicle movements/day	Low	0.5	0.4	0.4
Commercial yard and delivery areas, non-residential car parking with frequent change (eg hospital, retail), all roads except low traffic roads and trunk roads/ motorways	Medium	0.7	0.6	0.7

Table 2: Extract of Table 26.2 of SuDS Manual (2015)

Table 26.3 of the SuDS Manual provides details of the SuDS pollution mitigation indices for various types of SuDS components

Type of SuDS component	Mitigation indices		
	TSS	Metals	Hydrocarbons
Filter Strip	0.4	0.4	0.5
Filter Drain	0.4	0.4	0.4
Swale	0.5	0.6	0.6
Bioretention system	0.8	0.8	0.8
Permeable Paving	0.7	0.6	0.7
Detention Basin	0.5	0.5	0.6
Pond	0.7	0.7	0.5
Wetland	0.8	0.8	0.8

Table 3: Extract of Table 26.3 of SuDS Manual (2015)

As such the total SuDS mitigation index (figure 5) must be greater than the pollution hazard index (figure 4), furthermore when used in combination of two or more SuDS components, a factor of 0.5 is used to account for the reduced performance of the secondary or tertiary components associated with the already reduced inflow of concentration, therefore:

Total SuDS mitigation index = mitigation index₁ + 0.5 (mitigation index₂)

The use of the the combination of the attenuation basins and swales will provide the minimum required level of SuDS mitigation index to the run off from the development.

4.6 Long Term Maintenance

Consideration will need to be given to the long-term maintenance of the proposed drainage structures. Permeable paving, swales, attenuation basins and all associated external pipework, chambers and manholes within the demise of each plot ownership boundaries will be the responsibility of the future occupants. Elsewhere, the surface water networks below the access roads and open space will be the responsibility of the Management Company. Details of the Maintenance Plan will be provided as part of the separate Discharge of Conditions application of the Outline Consent.

4.7 Exceedance

Whilst the drainage system has been designed to a very high standard (1 in 100 Year storm event including climate change), it is possible that a more extreme event will occur and that the design standard for the system will be exceeded. It is best practice to design the drainage system to shed water, primarily into landscaped and other areas, therefore reducing the risk of flooding areas of built development during extreme events.

A strategy for directing overland flows for the site will be confirmed using overland flow modeling and provided as part of the separate Discharge of Conditions application.

5.0 Foul Drainage

The proposed foul water discharge generated by the site has been calculated at 11.57 l/s (based on 250 dwellings at 4000l/dwelling/day) in accordance with Sewers for Adoption 7th Edition.

In accordance with the approved Outline Consent, the foul water drainage will be conveyed via a new below ground foul sewer network through development and onto a new adoptable foul water pumping station to be located in the northern part of the site. A new rising main will convey the pumped discharge to the existing public foul water sewer located in Sefter Road.

All domestic foul drainage will be designed in accordance with Part H of the Building Regulations.

6.0 Conclusion

A surface water drainage strategy has been prepared and demonstrates that the development proposal can be successfully implemented and designed to withstand the impact of a 1:100-year rainfall event (including climate change), in accordance with the NPPF, PPG, WSCC and ADC requirements.

In view of this assessment, the report concludes that:

- i. The Development can be drained in a sustainable manner utilizing SuDS techniques;
- ii. The Development will satisfactorily manage and maintain a 1 in 100 Year storm event with an allowance for climate change;
- iii. The detailed drainage strategy generally follows the principles of the approved FRA and Surface Water Drainage Strategy and SuDS Statement;
- iv. The findings of this report identify the opportunity to promote the sustainable re-use of existing resources and potential to implement an appropriate SuDS strategy.

Appendix (A)

Topographic Survey



- Notes:
1. GRID AND LEVELS BASED ON ORDNANCE DATUM. DERIVED FROM THE NATIONAL SPOT NETWORK. LOCAL SCALE FACTOR IS 0.99970 APPLIED.
 2. DRAINAGE INFORMATION HAS BEEN DETERMINED WITHOUT MAN ENTRY INTO CHAMBERS AND WHILE EVERY EFFORT HAS BEEN MADE TO CORRECTLY IDENTIFY THIS INFORMATION, IT SHOULD ALWAYS BE CHECKED IN AREAS THAT ARE CRITICAL TO THE FUTURE PROPOSAL.
 3. ALL SEWERS ARE PRESUMED TO BE STRAIGHT BETWEEN CHAMBERS WITH ROUTES CONNECTIVITY OBTAINED USING ACOUSTIC METHODS ONLY. THESE ARE TO BE CONSIDERED ASSUMED AND SHOULD BE INVESTIGATED FURTHER IN CRITICAL AREAS.
 4. TREE AND HEDGE SPECIES HAVE BEEN IDENTIFIED AS ACCURATELY AS POSSIBLE BUT SHOULD BE CROSS CHECKED IN CRITICAL AREAS.
 5. BACKGROUND INFORMATION (SHOWN IN BLUE) IS CURRENT ORDNANCE SURVEY DIGITAL DATA. CROWN COPYRIGHT. ALL RIGHTS RESERVED. LICENCE NUMBER 10002432.

Coordinate Table				
Station	Description	Easting	Northing	Level
S1	ROAD NAIL	490180.953	99266.802	6.469
S2	ROAD NAIL	490307.896	99328.681	6.063
S3	ROAD NAIL	490310.026	99368.028	6.208
S5	PEG	490339.723	99429.381	6.358
S6	PEG	490280.945	99553.342	6.550
S7	PEG	490189.709	99623.112	6.821
S8	PEG	490053.272	99685.099	5.942
S9	PEG	489955.391	99614.244	5.578
S10	ROAD NAIL	489953.568	99580.359	5.371
S11	PEG	489870.189	99583.878	5.962
S12	PEG	489829.258	99448.381	6.204
S20	ROAD NAIL	490381.603	99322.184	6.163
S50	PEG	490331.368	99647.971	6.870
S70	PEG	490072.987	99511.484	6.235
S71	PEG	490259.775	99436.250	6.272
S100	ROAD NAIL	490086.490	99279.077	6.266
S101	ROAD NAIL	489914.540	99354.280	6.335
S102	ROAD NAIL	489887.012	99382.008	6.306
S103	PEG	489793.444	99421.732	5.993
S104	ROAD NAIL	489721.522	99489.008	5.201
S120	PEG	489873.227	99520.432	5.926
S121	PEG	489788.945	99472.879	5.859

TOPOGRAPHICAL KEY

SURVEY STATION

BANKING

HEDGE SPREADS

WOODLAND CANOPY

JUNCTION ON STREET

RAMP

DIRECTION LINES

GATE

KORB CHANNEL

ROAD UNBESIDED

FOOTPATH

CHANGE IN SURFACE

FENCE

OVERHEAD ELECTRIC

OVERHEAD TELECOM

POUL SEWER

SURFACE SEWER

P-TRAP

BACK DROP (EXTERNAL)

BACK DROP (INTERNAL)

BUILDING

OPEN SIDED BUILDING

OVERHANG / CANOPY

GLASSHOUSE

CONTOUR

SPOT LEVEL

SOUND LEVEL

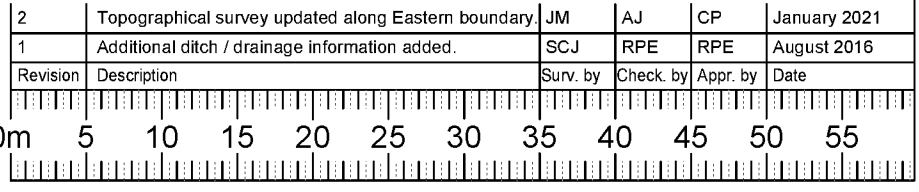
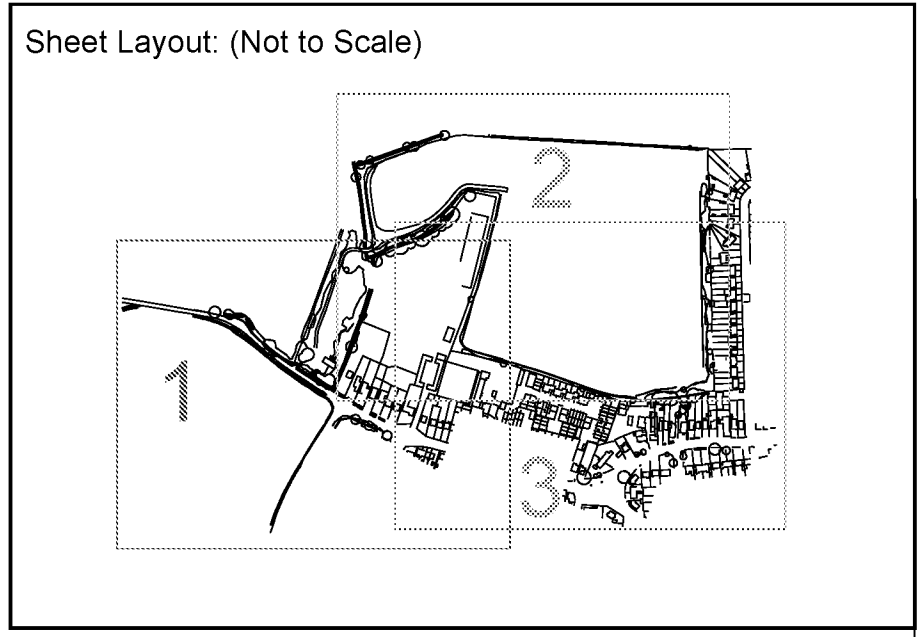
BREASTHOLE

WATER OUTF

TRAIL HOLE

GENERAL ABBREVIATIONS

FENCE ABBREVIATIONS



mksurveys

Tel 01908 965661
01908 965675
Tel 0115 2644152
0115 2644153
Tel 01492 242162

Miles Kaynes
01908 965661
0115 2644152
0115 2644153
01492 242162

enquiries@mksurveys.co.uk
sales@mksurveys.co.uk
www.mksurveys.co.uk
mksurveys@bt.com

www.mksurveys.com

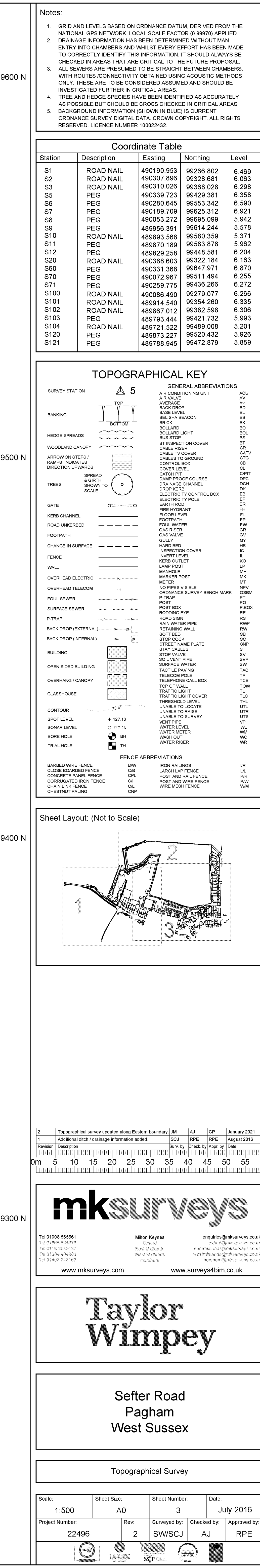
www.surveys4bm.co.uk

Taylor Wimpey

Sefton Road
Pagham
West Sussex

Topographical Survey

Scale: 1:500	Sheet Size: A0	Sheet Number: 1	Date: July 2016
Project Number: 22496	Rev: 2	Surveyed by: SW/SCJ	Checked by: AJ
		Approved by: RPE	



Scale: 1:500	Sheet Size: A0	Sheet Number: 3	Date: July 2016
Project Number: 22496	Rev. 2	Surveyed by: SW/SCJ	Checked by: AJ Approved by: RPE
			

Appendix (B)

Geotechnical Information (Extract)



RSK Unit 25
Abbey Enterprise Centre
Primer Way
Rumley
SO21 8AQ

Our Ref: 305035 L01 (00) DRAFT

1st March 2019

Taylor Wimpey (Southern Counties)

Colvedene Court

Wessex Business Park

Wessex Way

Colden Common

Winchester

SO21 1WP

For the attention of David Seer

Dear David,

**RE: SEFTER ROAD, BOGNOR REGIS, PO21 3EE
SUPPLEMENTARY HYDROGEOLOGICAL SITE ASSESSMENT**

1. BACKGROUND

RSK Environment Limited (RSK) was commissioned by Taylor Wimpey (Southern Counties) Ltd (the client) on 10th January 2019 to carry out a supplementary hydrogeological site assessment of land at Sefter Road, Bognor Regis, PO21 3EE (the site). The majority of the site currently comprises undeveloped fields, with a scout hut, associated car park and area of soft landscaped communal open space in the west of the site. A site location plan is given in **Figure 1**.

RSK has previously undertaken a geotechnical assessment of the site and groundwater monitoring regime. These are:

- RSK, 28756-R01 (01) 'Geotechnical Ground Investigation', Sefter Road, Bognor Regis, Dec 2016; and
- RSK, 28756-L01 (01) EH 'Review of Groundwater Conditions', Sefter Road, Bognor Regis, Nov 2017.

A summary of the November 2017 report is provided below, although it is recommended that this letter be read in conjunction with the previous two reports.

1.1 RSK, 28756-L01 (01) EH 'Review of Groundwater Conditions', Sefter Road, Bognor Regis, Nov 2017

12 groundwater monitoring visits were carried out monthly from September 2016 to August 2017. Generally, groundwater levels in the four wells varied throughout the monitoring period, with groundwater flow estimated towards the northwest (i.e. towards the land drain along the northern field boundary). Groundwater levels were deepest from September to November 2016, and shallowest from February to March 2017. The latter dates coincided with surface flooding in the southeast corner of the site. Across



INVESTORS
IN PEOPLE

RSK Environment Ltd
Registered office
60 Sussex Street • Glasgow • Scotland • G41 1DX • UK
Registered in Scotland No. 115880

the monitoring wells BH1 to BH4, groundwater levels were found to be shallower than 1.00 mbgl on at least one occasion throughout the monitoring period.

Therefore, it was concluded that adopting soakaways or having run-off directed towards areas of landscaping may result in areas of localised to widespread flooding during periods of prolonged rainfall.

1.2 Concurrent groundwater monitoring works at the site

As per a request dated 1st October 2018, 7 additional monthly groundwater monitoring visits of BH1 to BH4 were proposed over the winter period from October 2018 to April 2019. Measurements from these visits have been amalgamated into this letter report. .

1.3 Rationale for supplementary hydrogeological site assessment

It is understood that Arun District Council (ADC) requested further information relating to the potential for infiltration drainage to be utilised as far as possible in the proposed development strategy. Rogers Cory Partnership Ltd (RCP) – on behalf of Taylor Wimpey – scoped an additional intrusive ground investigation comprising a further 23 trial pit soakaway tests and 11 groundwater monitoring well installations, followed by twice-monthly groundwater monitoring visits from completion of the site works until the end of April. Of the 23 trial pit soakaway tests, it was initially proposed that 15 locations were to be to c. 1.5 mbgl (or groundwater level if shallower) and 8 locations were to be to c. 0.5 mbgl, however due to shallow groundwater conditions, only 11 locations could be completed to c. 1.5 mbgl, with 12 locations completed to c. 0.5 mbgl, as detailed in **Section 2**. The positions of all new locations in addition to those from previous investigations are given in **Figure 2**. All new locations were surveyed to Ordnance Datum by GPS, with this data shown in **Appendix B**.

The site is planned for residential redevelopment comprising traditional low-rise residential properties with associated infrastructure and soft landscaping, a Local Equipped Area for Play (LEAP), a Primary School, a Scout Hut and an Ambulance Station. The proposed redevelopment plan is given in **Figure 3**.

This letter report is subject to the service constraints laid out in **Appendix A**.

2. SITE INVESTIGATION METHODOLOGY

RSK carried out intrusive investigation work on 21st to 25th January 2019, excavating 23 trial pits and undertaking soakaway tests within, and completing 11 further boreholes with groundwater monitoring well installations. Prior to breaking ground, Technics Group Ltd completed a service clearance of every location, and also surveyed each location to Ordnance Datum. The rationale for the position of each exploratory location, as provided by RCP, is indicated in **Table 1** below:

Table 1: Exploratory location rationale

Location type	Location ID	Rationale
Trial pit soakaway test to 1.5 m bgl or resting groundwater, whichever was the shallower	TP201, TP202, TP204, TP205, TP207, TP209, TP211, TP212*, TP213*, TP215, TP216, TP218, TP219, TP221 and TP222	Testing infiltration properties across the site

Location type	Location ID	Rationale
Trial pit soakaway test to 0.5 m bgl	TP203, TP206, TP208, TP210, TP214, TP217, TP220, TP223	Testing infiltration properties in areas of proposed permeable paving
Groundwater monitoring wells	BH201 to BH211	Allowing groundwater levels to be measured twice monthly until end April 2019
Notes: Soakaway tests were completed in broad accordance with BRE 365, with the exception that due to slow infiltration rates, only one soakaway test was completed in most locations. *: TP212 and TP213 were proposed as trial pit soakaway tests to 1.5 m bgl. However due to substantial standing water in the vicinity of these locations which ran continuously into the pits, these were terminated at a shallower depth without a soakaway test undertaken. The rising level of water within these pits was measured over a period of 1 hour.		

3. GROUND CONDITIONS

A summary of ground conditions encountered during this phase of intrusive works is outlined in the following sections. Generally the site was underlain by Topsoil or Made Ground over River Terrace Deposits, with the London Clay Formation at depth. These exploratory logs are summarised in **Table 2**, and reported in detail in **Appendix B**. A selection of photographs taken during the investigation are included in **Appendix C**.

Table 2: General succession of strata

Strata	Exploratory holes encountered	Range of depths to top of stratum (mbgl)	Range of thickness (m)
Topsoil	TP202, TP204 to TP223, and BH201 to BH211	Ground level	0.15 to 0.40
Made Ground	TP201 and TP203	Ground level	0.40 to 0.45
River Terrace Deposits – cohesive	TP201 to TP223, and BH201 to BH211	0.15 to 0.45	0.20 to 2.80
River Terrace Deposits – granular	TP204, BH201 to BH205, BH206 to BH210	0.80 to 1.60	0.20 to 2.10
London Clay Formation	BH204, BH206 and BH210	2.30 to 2.77	0.33 to 0.90^
Note: mbgl: metres below ground level; ^ : maximum proven thickness as base of this stratum was not encountered during this investigation			

3.1 Topsoil

Topsoil was identified across the site in TP202, TP204 to TP223 and BH201 to BH211 and comprised brown slightly gravelly sandy CLAY, where sand is fine, gravel is subangular to subrounded fine to medium flint and with frequent rootlets. This stratum ranged from 0.15 to 0.40 m in thickness.

3.2 Made Ground

Made Ground was identified underlying the Scout Hut's car park, and the grassed area to the north of it, in TP202, TP204 to TP223 and BH201 to BH211. Beneath the car park, this stratum comprised ASPHALT underlain by flint gravel SUB-BASE followed by BRICK FILL, with dark grey CLAY containing rare brick and metal pieces followed by greyish brown CLAY under the grassed area. The Made Ground ranged from 0.30 to 0.45 m in thickness.

3.3 River Terrace Deposits

River Terrace Deposits were encountered underlying the Topsoil or Made Ground in each trial pit and borehole location, and consisted of both cohesive and granular material.

3.3.1 Cohesive

Cohesive River Terrace Deposits were identified underlying the Topsoil or Made Ground across the entire site from 0.15 to 0.45 mbgl, in each trial pit and borehole location. It generally comprised stiff orangish brown sandy CLAY, where sand is fine to medium. Occasionally it contained gravel generally of subangular to rounded fine to medium flint. The encountered thickness of this stratum ranged from 0.20 to 2.80 m, although this minimum value is the result of a shallow trial pit terminating within the cohesive River Terrace Deposits.

3.3.2 Granular

Granular Cohesive River Terrace Deposits were identified underlying the cohesive River Terrace Deposits across the western, northern and southern areas of the site, from 0.80 to 1.60 mbgl in TP202, TP204, TP205, TP211, and BH201 to BH210. It generally comprised light orangish brown and light brownish grey clayey fine to medium SAND, or dense orangish brown slightly gravelly silty fine to medium SAND, where gravels are angular to subrounded fine to coarse flint. This stratum ranged from 0.20 to 2.10 m in thickness.

3.4 London Clay Formation

The London Clay Formation was encountered underlying the River Terrace Deposits in the north, east, and centre of the site, from 2.30 to 2.77 mbgl, in BH204, BH206 and BH210. It generally comprised a firm to stiff bluish grey silty CLAY. The base of the London Clay Formation was not proven; however, from borehole records on the BGS website it is considered the London Clay Formation within this area is likely to be approximately 50 m in thickness.

4. GROUNDWATER

Groundwater strikes and seepages were recorded between 0.20 and 2.60 mbgl in BH201 to BH211, and between 0.60 and 1.60 mbgl in TP202, TP204, TP205, TP211, TP214, and TP222. A summary is provided in **Table 3**. Surface water strikes and seepages were encountered in TP212 and TP213 at 0.10 and 0.25 mbgl as shown in **Table 4**.

Table 3: Summary of groundwater strikes/seepages

Location	Groundwater strike/seepage	Depth (mbgl)	Comment
Borehole locations			
BH201	Groundwater strike	1.80	Rising to 1.20 m
BH202	Groundwater strike	1.86	Rising to 1.30 m
BH203	Groundwater strike	1.70	Rising to 1.10 m
BH204	Groundwater strike	1.50	Rising to 1.20 m
BH205	Groundwater seepage	2.50	-
BH206	Groundwater strike	0.20	-
BH207	Groundwater strike	1.80	-
BH208	Groundwater strike	0.90	-
BH209	Groundwater strike	2.60	-
BH210	Groundwater strike	1.80	Rising to 1.20
BH211	Groundwater strike	1.90	-
Trial pit locations			
TP202	Groundwater strike	1.60	At base of trial pit
TP204	Groundwater strike	1.50	At base of trial pit
TP205	Groundwater strike	1.45	-
TP211	Groundwater strike	1.50	-
TP214	Groundwater strike	0.60	-
TP222	Groundwater seepage	0.90	-
Notes: Groundwater was not encountered in TP201, TP203. TP206 to TP210, TP217 to TP221 or TP223			

Table 4: Summary of surface water strikes/seepages

Location	Surface water strike/seepage	Depth (mbgl)	Comment
Trial pit locations			
TP212	Surface water seepage	0.10	Standing water in area around trial pit
TP213	Surface water seepage	0.25	Standing water in area around trial pit

4.1 Soakaway tests

In-situ trial pit soakaway tests were undertaken in TP201 to TP211 and TP14 to TP223, the results of which are given in **Table 5**. Due to high resting groundwater levels in the vicinity of TP212 and TP213, soakaway tests were not undertaken; the natural rising water level was instead recorded over at least 1 hour. The raw data are given in **Table 6**.

Where the infiltration rate had not passed between 75 % to 25 % effective depth during the day, the pit was left open overnight – suitably secured using Heras fencing – to allow for at least a 24-hour test duration in accordance with BRE 365. The tests in TP201 and TP221 were terminated at 23 hours, however the final measured water levels measured immediately prior to test termination were not found to lie close to the 25 % effective depth, as such the decision was taken to backfill to ensure prompt continuation of site works. Over the course of the test, water levels in TP222 fell by only 5 cm. In consort with this, there were many other soakaway tests being undertaken simultaneously that had recorded greater drops in water level. As these locations were of greater importance, and also required secure fencing, the decision was made to terminate the soakaway test in TP22 following 6 hours of measurements. From the graph shown in **Appendix D**, it is RSK's opinion that this test would not have experienced sufficient infiltration over an additional 18 hours to reach the 75 % and 25 % effective depths, and as such did not warrant being left unsecured over this period.

The measured drop in water level in TP220 is within 0.10 m of the 25 % effective depth, however RSK have chosen not to extrapolate this result. Extrapolation can be completed if requested, although this result would not be in full accordance with BRE 365, and would be recorded as a non-standard test.

Table 5: Summary of soakaway test results

Trial pit (test no.)	Base depth (mbgl)	Effective depth (m)	Test duration (hours)	Time to pass between 75 % and 25 % effective depth (seconds)	Infiltration rate (m/s)
TP201	1.80	1.00	23	-	Test fail
TP202	1.48	0.88	24	-	Test fail
TP203	0.50	0.36	41	44000	2.08×10^{-6}
TP204	1.50	0.85	24	-	Test fail
TP205	1.50	0.97	26	-	Test fail
TP206	0.70	0.45	54	-	Test fail
TP207	1.60	0.66	26	-	Test fail
TP208	0.50	0.31	26	-	Test fail
TP209	1.50	0.95	26	-	Test fail
TP210	0.42	0.27	26	-	Test fail
TP211	1.50	1.00	24	-	Test fail
TP214	0.65	0.55	27	-	Test fail

Trial pit (test no.)	Base depth (mbgl)	Effective depth (m)	Test duration (hours)	Time to pass between 75 % and 25 % effective depth (seconds)	Infiltration rate (m/a)
TP215	1.60	0.99	25	-	Test fail
TP216	1.50	1.00	25	-	Test fail
TP217	0.55	0.39	29	-	Test fail
TP218	1.50	1.00	50	-	Test fail
TP219	1.50	1.00	30	-	Test fail
TP220	0.50	0.37	26	-	Test fail
TP221	0.60	0.50	23	-	Test fail
TP222	0.90	0.70	6	-	Test fail
TP223 (1)	0.50	0.42	6	15500	7.13×10^{-6}
TP223 (2)	0.50	0.40	18	38000	2.83×10^{-6}

As shown in **Table 5**, falling water levels the majority of the trial pits did not cross the 75 % / 25 % fill level thresholds as required by BRE 365. Only in TP203 in the west of the site and in TP223 in the centre of the main field did any reportable infiltration occur. It is considered that this is due to localised variations in geology allowing extremely limited capacity for small-scale infiltration. It is furthermore worth noting that both of these locations were shallow 0.50 m trial pit soakaway tests, and therefore would not be suitable locations for development-scale soakaway features.

Table 6: Rising surface water levels

Trial pit	Base depth (mbgl)	Initial water level (mbgl)	Final water level (mbgl)	Monitoring period (hours)
TP212	0.71	0.70	0.60	1
TP213	0.57	0.54	0.46	1.5

Rising surface water levels in TP212 and TP213 were recorded over at least 1 hour period in **Table 6**. These trial pits were positioned within an area of very saturated ground, and so were unsuitable for soakaway tests due to the rapidly incoming water.

4.2 Groundwater data loggers

Shallow groundwater monitoring wells were installed at all drive-in sampler borehole positions, with the response zone lying within the River Terrace Deposits, between 1.00 and 3.00 mbgl.

A total of 4 data loggers were installed in BH201, BH204, BH206 and BH209 to provide continuous measurements of groundwater levels. One BaroSCOUT was installed in BH201 to measure air pressure in the area of the site, and one LevelSCOUT was installed in each well to measure water pressure. The difference in the two values, when compared to a known datum, allows the calculation of water head, and therefore the groundwater level in the well. Readings will be taken at 30-minute intervals until the end of

April 2019. Simultaneously, twice-monthly groundwater monitoring visits will be completed to manually measure the groundwater levels in all monitoring wells, and download data recorded by the loggers.

4.3 Groundwater levels

8 groundwater monitoring visits have been completed to-date (including those completed for the groundwater monitoring regime instructed in October 2018). Groundwater levels recorded during these visits are summarised in **Table 7** below and presented in full in **Appendix D**. Groundwater depths (mbgl) and levels (mAOD) measured across the site have varied from 0.00 mbgl in BH3 and BH208 to 1.62 mbgl in BH1, and 4.167 mAOD in BH201 to 6.41 mAOD in BH2.

Table 7: Recorded groundwater levels

Location	Manual measurements			
	Depth (mbgl)		Level (mAOD)	
	Max	Min	Max	Min
BH1	1.62	1.330	5.22	4.928
BH2	0.88	0.505	6.41	6.031
BH3	0.88	0.000	6.11	5.232
BH4	1.30	0.730	5.54	4.966
BH201	1.60	0.995	4.77	4.167
BH202	1.29	0.895	5.06	4.669
BH203	1.08	0.697	5.05	4.669
BH204	1.15	0.140	5.65	4.643
BH205	1.08	0.915	5.90	5.739
BH206	0.35	0.125	6.25	6.025
BH207	0.25	0.010	6.19	5.945
BH208	0.29	0.000	6.08	5.790
BH209	1.08	0.575	5.86	5.356
BH210	1.20	0.610	5.49	4.896
BH211	0.88	0.360	6.35	5.830

Note: These readings detail the full range of groundwater levels recorded at the site as measured during the monitoring visits. The minimum and maximum values across the site are shown in grey.

4.4 Discussion

It is considered that the granular River Terrace Deposits are a shallow, semi-unconfined aquifer underlain by the London Clay Formation. Locally within the cohesive River Terrace Deposits, there may be perched water where cohesive substrata impede downwards percolation of surface water.

As shown in **Table 5**, falling water levels in the majority of the soakaway locations did not cross the 75 % / 25 % fill level thresholds as required by BRE 365. Only in TP203 in the west of the site and in TP223 in the centre of the main field did any reportable infiltration occur. It is considered that this is due to localised variations in geology allowing extremely limited capacity for small-scale infiltration. It is furthermore worth noting that both of these locations were shallow 0.50 m trial pit soakaway tests, and therefore would not be suitable locations for development-scale soakaway features.

Rising surface water levels in TP212 and TP213 were recorded over at least 1 hour period in **Table 6**. These trial pits were positioned within an area of very saturated ground, and so were unsuitable for soakaway tests due to the rapidly incoming water.

Based on the available data, it is not recommended that soakaways or run-off directed towards areas of landscaping are implemented at this site, as this may result in localised to widespread flooding during periods of prolonged rainfall. It is usually advised that at least 1.00 m of unsaturated zone is present beneath the soakaway feature. Given the shallow groundwater levels recorded at the site, this minimum unsaturated thickness is not achieved during periods of sustained heavy rainfall, with localised groundwater flooding in the southeast, and other areas of the site close to flooding.

This draft letter report will be updated upon completion of the final groundwater monitoring round.

We trust that the information provided above meets your requirements. Should you have any queries or require additional information, please do not hesitate to contact the undersigned.

Yours sincerely,

For RSK Environment Limited



Ed Hughes-Phillips

Kirsten Fairall

Geo-environmental Consultant

Principal Geo-environmental Consultant

Enc.

Figures:

Figure 1	Site Location Plan
Figure 2	Exploratory Hole Location Plan
Figure 3	Proposed Development Plan

Appendices:

Appendix A	Service Constraints
Appendix B	Exploratory Hole Logs
Appendix C	Photographic Log
Appendix D	Trial Pit Soakaway Test Data
Appendix E	Groundwater Monitoring Data



FIGURES



Contains Ordnance Survey data © Crown copyright and database right 2013



18 Frogmore Road
Henkel Hempstead
Hertfordshire
HP3 9PT
United Kingdom
Tel: +44 (0) 1442 437500
Fax: +44 (0) 1442 437550
Email: info@rsk.co.uk
Web: www.rsk.co.uk

Client
TAYLOR WIMPEY (SOUTHERN COUNTIES)

Project Title
SEFTER ROAD, BOGNOR REGIS

Drawing Title
SITE LOCATION PLAN

Drawn ASC	Date 29.01.19	Checked EH	Date 29.01.19	Approved KF	Date 29.01.19	Project No. 305035 - L01	Drawing File 305035 - SLP
Scale NTS	Orig Size A4	Dimensions m	Drawing No. FIGURE 1				Rev. A

