CALCULATION SHEET

Client			Job Title	Job No
GOWER HOMES			**PROPOSED RESIDENTIAL DEVELOPMENT, THE SIDINGS, RAILWAY ROAD, WREXHAM**	**3916**
By **RW**	Date **05.14**	Chkd	Element **SURFACE WATER DRAINAGE DESIGN TRENCH SOAKAWAY: ROOFS & PARKING**	Sheet No **CP5-6 1**

DATA	CALCULATIONS	RESULTS

1. PURPOSE

The purpose of these calculations is to determine the size of the geocellular soakaways required to disperse the run-off from the shared private access roads, parking areas and roofs which are to be constructed as part of the above development. Separate Soakaways are to be constructed to disperse run-off from the adoptable access roads.

2. SITE LAYOUT

The layout of the development site is shown on drawing Nº 3916/ 02 and 03 (as revised)

This drawing shows the proposed location of the geocellular soakaway in the public open space in Phase 1 and within the shared parking areas of Phase 2 including the impermeable area draining to these facilities.

3. POROSITY TESTS

Porosity tests were carried out by Groundsolve Ltd in November 2013. The results of their investigations and percolation tests are included in their Geo-environmental Report issued December 2013 Ref:1432.

The applicable results of these tests are summarised in Section 6

This geo-environmental report and investigation is limited to Phase 1 of the site with the exception of one trial pit TP7 excavated within Phase 2 of the development to the south.

4. METHODOLOGY

Current best practice/design advice recommends that infiltration drainage systems should be designed to store the run-off from a 10% annual probability storm (1 in 10 year return period) and to half empty (by percolation) in a twenty-four hour period (CIRIA Report 156: Infiltration drainage - Manual of good practice). This latter requirement allows the system to cater for a succession of severe storm events

However in order to achieve consistency between conventional drainage techniques (as set out in Sewers for Adoption), recent recommendations (CIRIA Report Nº C609: Sustainable drainage systems - Hydraulic, structural and water quality advice) suggest that SUDS should be analysed for a 3.3% annual probability storm event (1 in 30 year return period) to ensure that internal flooding of properties and/or serious external flooding (SEF) does **not** occur.

In addition, the Environment Agency, in pursuance of the requirements of TAN 15 (in Wales) and PPG25 (in England), recommends that greenfield run-off rates and volumes should be maintained after development for storm events up to a 1% annual probability (1 in 100 year return period).

The additional water resulting from these severe storm events does not necessarily have to be stored within the SUDS, provided it can be contained by localised flooding of car parks and landscaped areas for short periods of time without adversely effecting residential or commercial property.

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4. **METHODOLOGY** (continued)

These calculations therefore adopt the following methodology:

1. Rainfall intensities for different storm conditions are to be determined using the Wallingford Procedure

2. The infiltration device is to be sized to store the run-off from a 10% annual probability storm **below** the level of the incoming pipe(s)

3. The infiltration device is to be analysed to ensure that the run-off from a 3.3% annual probability storm is contained without the system flooding (ie that there is sufficient storage provided within the facility)

4. The system is to be further tested against 1% annual probability storm events to assess the volume of flooding and to confirm that it will not adversely effect residential or commercial property

5. **METHOD OF ANALYSIS**

These calculations adopt the method of analysis for 3-D Infiltration Systems set out in CIRIA Report Nº 156: Infiltration systems - Manual of good practice.

For a vertically sided structure (ie a soakaway or infiltration trench) the maximum depth of water (h_{max}) can be calculated by solving the following equation

$$h_{max} = a\,(e^{(-bD)} - 1)$$

where $a = (A_b / P) - (Adi / Pq)$ and $b = (Pq) / (nA_b)$

The time to half empty ($t_{½}$) can be determined from the following equation:

$$t_{½} = \frac{n\,A_b}{q\,P}\ \mathrm{Log}_e \left\{ \frac{h_{max} + A_b / P}{h_{max}/2 + A_b / P} \right\}$$

The required inputs are:

A_b	area of base of infiltration device	(m^2)
P	perimeter of infiltration device	(m)
A_D	area to be drained	(m^2)
f	infiltration rate from percolation tests	(m/h)
i, D	intensity and duration of rainfall events with the required return period at the site location	(m/h, h)
n	porosity of fill material (void volume/total volume)	

The results of these calculations are set out below

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6. **PERCOLATION TEST RESULTS**

Porosity tests were carried out in October 2013 by GroundSolve Ltd to determine the infiltration rates within the underlying glacial sands and gravel's which are present at varying depths across the site. The location of the trial pits is shown on Figure 4 in their report.

Below is a summary of the lowest infiltration rates derived from four trial pits where tests were undertaken including the existing Phase 1 soakaway. The results from the existing soakaway SA2 in Phase 2 have been ignored as the tests were abandoned due to heavy siltation.

Trial Pit	**Measured Soil Infiltration Rate f (m/s)**
TP 2 Test 1	3.24E-06
TP 4 Test 2	1.34E-05
TP 5 Test 2	2.42E-04
TP 7 Test 1	6.44E-05
Ex SA1 Test 1	8.21E-05
	Applicable Infiltration Rate
Average	**8.10E-05**

7. **DRAINED AREA: Roofs & Parking**

The following impermeable areas drain to each of the geocellular soakaways

Description	**Drained Area (m^2)**
Phase 1 - POS	1725.654
Phase 2 - North	1052.534
Phase 2 - Central	740.425
Phase 2 - South	659.332
Total	**1725.654**

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DATA	CALCULATIONS	RESULTS

7. **RAINFALL DATA**

Ratio (M5-60min/M5-2day)	r	32.7	%
M5-2day Rainfall	M5-2day	55.04	mm
M5-60min Rainfall	M5-60	18.00	mm
M5-D Rainfall	M5-D	Z1(M5-60)	
MT-D Rainfall	MT D	Z2(M5-D)	
Rainfall Intensity	I	(MT-D)/D	mm/hr

D	Z1	M5	10 Year Return			30 Year Return			100 Year Return		
			Z2	M10	I	Z2	M30	I	Z2	M100	I
(min)		(mm)		(mm)	(mm/hr)		(mm)	(mm/hr)		(mm/hr)	(mm/hr)
5	0.35	6.28	1.2	7.54	90.45	1.44	9.05	108.54	1.82	11.43	137.18
10	0.50	8.98	1.21	10.87	65.20	1.48	13.29	79.75	1.89	16.97	101.85
15	0.61	10.94	1.22	13.35	53.40	1.50	16.41	65.66	1.93	21.12	84.48
20	0.67	11.97	1.23	14.72	44.16	1.50	17.95	53.86	1.94	23.22	69.66
25	0.72	12.99	1.23	15.98	38.36	1.51	19.62	47.09	1.96	25.47	61.13
30	0.78	14.02	1.24	17.39	34.77	1.52	21.31	42.62	1.97	27.62	55.24
45	0.89	16.01	1.24	19.85	26.47	1.53	24.49	32.66	2.00	32.02	42.69
60	1.00	18.00	1.24	22.32	22.32	1.54	27.72	27.72	2.01	36.18	36.18
90	1.12	20.09	1.24	24.91	16.60	1.54	30.93	20.62	2.03	40.77	27.18
120	1.23	22.17	1.24	27.50	13.75	1.54	34.15	17.07	2.02	44.79	22.40
240	1.53	27.61	1.23	33.96	8.49	1.52	41.97	10.49	1.99	54.94	13.74
360	1.74	31.23	1.22	38.10	6.35	1.51	47.15	7.86	1.96	61.20	10.20
600	2.05	36.86	1.2	44.23	4.42	1.48	54.55	5.46	1.92	70.77	7.08
1440	2.62	47.23	1.18	55.73	2.32	1.43	67.53	2.81	1.83	86.43	3.60

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8.	**DESIGN DATA**				
From porosity tests	Measured infiltration rate		f	**2.92E-01** m/hr	
CIRIA C697 Pg. 4-31	Factor of safety	(major inconvenience - roads)	Fs	**10.0**	
CIRIA C697 Pg. 4-31	Porosity	(geocellular units)	n	**0.95**	
From Plan	Area to be drained		A_D	**740.43** m^2	
	Assume a filter drain in a rectangular excavation filled with clean stone				
	Length, say		L	**13.00** m	
	Width, say		W	**2.00** m	
9.	**SOAKAWAY DESIGN**				
By Calculation, q = f/Fs	Effective infiltration coefficient (measured infiltration rate/factor of safety)		q	0.029 m/hr	
From Plan	Area to be drained		A_D	740 m^2	
By Calculation, $A_b = L * W$	Base Area of Filter Drain		A_b	26.00 m^2	
By Calculation, P = 2L + 2W	Perimeter of Soakaway		P	30.00 m	
CIRIA 156 Pg. 57 Factor a = $(A_b/P) - (iA_D/Pq)$	Factor a		a	varies	
CIRIA 156 Pg. 57 Factor b = (Pq/nA_b)	Factor b		b	0.035	

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9. **SOAKAWAY DESIGN (continued)**

Duration		10 Year Return			30 Year Return			100 Year Return		
min	hr	i m/hr	Factor a	Max Depth m	i m/hr	Factor a	Max Depth m	i m/hr	Factor a	Max Depth m
5	0.083	0.090	-76.1	0.223	0.109	-91.5	0.268	0.137	-115.9	0.340
10	0.167	0.065	-54.6	0.320	0.080	-67.0	0.392	0.102	-85.8	0.502
15	0.250	0.053	-44.6	0.391	0.066	-55.0	0.482	0.084	-71.0	0.623
20	0.333	0.044	-36.7	0.429	0.054	-45.0	0.525	0.070	-58.4	0.682
25	0.417	0.038	-31.8	0.463	0.047	-39.2	0.571	0.061	-51.2	0.745
30	0.500	0.035	-28.7	0.501	0.043	-35.4	0.618	0.055	-46.1	0.806
45	0.750	0.026	-21.7	0.565	0.033	-26.9	0.702	0.043	-35.5	0.925
60	1.000	0.022	-18.1	0.627	0.028	-22.7	0.786	0.036	-29.9	1.036
90	1.500	0.017	-13.3	0.683	0.021	-16.7	0.859	0.027	-22.3	1.146
120	2.000	0.014	-10.8	0.737	0.017	-13.7	0.929	0.022	-18.2	1.238
240	4.000	0.008	-6.4	0.836	0.010	-8.1	1.060	0.014	-10.8	1.422
360	6.000	0.006	-4.5	0.864	0.008	-5.8	1.109	0.010	-7.8	1.489
600	10.000	0.004	-2.9	0.860	0.005	-3.8	1.121	0.007	-5.2	1.531
1440	24.000	0.002	-1.1	0.633	0.003	-1.5	0.872	0.004	-2.2	1.254

For 1 in 10 year return period storm

From Table — Maximum depth of water h_{max} **0.864 m**

By calculation — Time for half emptying $t_{1/2}$ **8.15 hr** — <24 hrs

For 1 in 30 year return period storm

Depth of storage required additional to 1 in 10 year return period **0.257 m**

Total depth of geocellular unit soakaway to be provided. Overall depth to suit drainage strata with 0.8m of cells into strata. **1.200 m**

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9. **SOAKAWAY DESIGN (continued)**

For 1 in 100 year return period storm

Potential flood volume (in excess of storage provided) **8.172 m^3**

Assume flooding takes place uniformly over length of filter drain to a width of 1m, then average depth of flooding: **0.314 m**

The actual flood depth will be less as the flooded area will be larger. No allowance has been made for additional storage provided in the geocells, pipework and catchpits which will reduce this depth. The flooding will be contained within the car park and not effect the properties.

10. **SUMMARY**

The results of the analysis indicate the following:

Required depth of Filter Drain below lowest incoming pipe (ie depth for a 10% annual probability storm event) **0.864 m**

Minimum depth above incoming pipe invert and below ground level (ie additional storage for a 3.3% annual probability storm event) **0.257 m**

Potential flood volume from a 1% annual probability storm event **8.172 m^3**

Total depth of trench soakaway to be provided **1.200 m**

11. **Additional Storage Provided For More Severe Events & Climate Change**

Additional depth is provided in the soakaway above the 1 in 30 year event level. The stone surround, 1.2m diameter catchpits and 150mm diameter pipework is not included in the calculations. The volume of storage will therefore be greater reducing the potential flood volume under 1 in 100 year return period storms and makes an allowance for climate change. Additional Storage Provided:

	Within geocellular units	1.950 m^3
2 No at	2.05 m min deep (at say 60% volume)	2.775 m^3
1.0 m at	0.15 m diameter within trench (at say 60% volume)	0.011 m^3
		4.736 m^3