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MULTIDISCIPLINARY ENGINEERING CONSULTANTS

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TECHNICAL NOTE

Project:	**Inglewood Urban Extension**	**WB03590-TN01(V1)**
Subject:	TN01 - Drainage Strategy	Page 1 of 9
Prepared by	Andy Jenner BEng CEng MICE (Associate Director)	
Approved by	Seymour D'Oyley (Associate Director)	15-12-2017

Executive Summary

This Technical Note has been prepared to answer direct and detailed questions asked by the Councils specialist Drainage Engineer. It is, by definition, a technical detailed engineering response to specific and technical questions concerning the design parameters employed in the derivation of the drainage strategy accompanying the outline planning application.

This document shows that the design employs parameters derived from testing and has applied suitable factors of safety and design philosophies to ensure that the present design is robust such that at the time a more detailed design is undertaken the philosophies and strategy will continue to be viable even if more detailed testing shows poorer percolation rates than have been determined to date.

Introduction

This report is provided for the benefit of the Client. We do not accept responsibility in the event that the report contents are used in whole or in part by a third party and we exercise no duty of care to any such third party.

Abacus Projects and Deeley Freed Estates have appointed Clarkebond to undertake Civil and Structural engineering, including Hydrology and Flood Risk Assessments for a development at White Rock adjacent to the A3022 Brixham Road in Paignton.

The development proposals have been submitted for Planning and as part of the consultation process comments have been received in respect of the Drainage Strategy requiring further clarification as to the design parameters employed.

The purpose of this Technical Note is to provide the supporting calculations related to the preliminary design and to document the assumptions and factors included in the design process.

The comment received from the Council states:

> *There are no hydraulic calculations included within the flood risk assessment for the proposed soakaways, permeable paving, infiltration ponds, storage ponds or the controlled discharge off the site. As a result it is impossible for me to confirm whether or not the proposed drainage strategy complies with the requirements of the Torbay Critical Drainage Area or that there is no risk of flooding to properties on the site or increased risk of flooding to adjacent properties or land for the critical 1 in 100 year plus 40% for climate change.*

In an additional section of the consultation response the Council also state:

> *Where infiltration testing has demonstrated that the use of infiltration drainage is not feasible will the developer be allowed to discharge to the surface water system at a controlled discharge rate. As Torbay is a Critical Drainage Area any surface water discharge rate from the site must be limited to the 1 in 10 year Greenfield run off rate from the proposed impermeable area of the development discharging to the surface water system. The proposed surface water system including attenuation must be designed in order that there is no risk of flooding to properties on the site or increased*

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risk of flooding to adjacent properties and land for the critical 1 in 100 year storm event plus 40% for climate change.

Drainage Strategy

The drainage strategy is outlined in the FRA, but as a summary the site is designed based on the initial test results available to drain in 4 basic ways:

- To on plot individual soakaways in areas of good percolation;
- To communal on plot soakaways in areas of good percolation but where plot densities prevent soakaways being sited more than 5m adjacent buildings;
- To communal soakage basins where the plots are not located in areas of good percolation with separate basins for the development and the adopted highways to allow adoption of the highway drainage; and
- By attenuation to the existing surface water drainage system in areas where there is inadequate percolation and topography prevents drainage to a soakaway basin in a more favourable location

Figure 1, below, illustrates the current outline masterplan and outlines the areas draining by the different mechanisms listed above.

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Figure 1 - Drainage Masterplan

A number of percolation tests have been undertaken over the site with a range of results. The location of these tests are shown in Appendix A, having been extracted from the ground Investigation report. Table 1 summarises the results.

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Table 1 - Soakaway Results

Test Reference	Depth of Test (mbgl)	Corresponding Strata	Infiltration Rate (m/s)
TP1	0.38-1.1	Saltern Cove - Mudstone	3.38E-05
TP2	1.23-2.0	Saltern Cove - Mudstone	4.56E-06
TP3	1.17-2.2	Saltern Cove - Mudstone	4.65E-04
TP4	1.03-2.0	Saltern Cove - Mudstone	1.09E-05
TP5	0.96-1.9	Saltern Cove - Mudstone	7.22E-06
TP6	1.58-2.7	Saltern Cove - Mudstone	6.44E-06
TP8	1.54-2.5	Saltern Cove - Mudstone	3.94E-05
TP9	0.38-1.1	Brixham Limestone	3.43E-05
TP101	0.87-2.2	Brixham Limestone	7.94E-05
TP102	1.3-2.4	Saltern Cove - Mudstone	3.04E-05
TP103	0.8-1.1	Brixham Limestone	3.63E-04
TP104	0.85-1.9	Brixham Limestone	3.46E-05

For the purposes of the drainage strategy, the site has been split into a variety of areas utilising the applicable percolation rates from the table above. Soakaways have been designed using Micro Drainage WinDes

The full results are contained within Appendix B.

Area 1 represents the northern area of the site where on plot soakaways are considered viable. The preliminary design adopts a percolation factor of $3.38x10^{-5}$m/s. The individual plots have been designed on the basis of $90m^2$ per plot. No allowance has been made for base percolation in line with the recommendations in BRE Digest 365 and to further ensure a conservative design is utilised a factor of safety of 2 has been applied to the side percolation rate. A crate soakaway measuring 4.2m x 2.4m x 0.61m has been shown to have adequate performance

Area 3 represents the area to the south and west of the proposed school where on plot soakaways are considered viable. The preliminary design adopts a percolation factor of $4.65x10^{-4}$m/s. The individual plots have been designed on the basis of $90m^2$ per plot. No allowance has been made for base percolation in line with the recommendations in BRE Digest 365 and to further ensure a conservative design is utilised a factor of safety of 2 has been applied to the side percolation rate. A crate soakaway measuring 3.0m x 1.8m x 0.61m has been shown to have adequate performance

The school plot in the centre of the site adopts a percolation factor of $4.65x10^{-4}$m/s in the design. The plot has been designed on the basis of $4570m^2$ based on the indicative layout and no allowance has been made for base percolation in line with the recommendations in BRE Digest 365 and to further ensure a conservative design is utilised a factor of safety of 2 has been applied to the side percolation rate. A crate soakaway of 14.6m x 12.8m x 1.22m has been shown to have adequate performance.

The remote basin for the residential areas adopts a percolation factor of $3.94x10^{-5}$m/s in the design. The impermeable area draining to this basin is estimated to be $9000m^2$ based on an allowance of $90m^2$ per plot and a potential 91 plots plus a 10% allowance. Base and side percolation have been

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included in the design as appropriate to the type of structure, however to ensure that a conservative design is prepared a factor of safety of 5 has been applied to the base and side percolation. The basin is sized to provide a base area of 572.5m^2 and an area assuming a Top Water level of 1m above the base of 962m^2. A freeboard of 300mm above the TWL is expected to be provided. The WinDes preliminary calculations indicate that the actual Top Water Level should be about 800mm above the base.

The adoptable remote basin for the adopted highway utilises a percolation factor of 3.94x10^{-5}m/s in the design. The impermeable area draining to this basin is estimated to be 18690m^2. Base and side percolation have been included in the design as appropriate to the type of structure, however to ensure that a conservative design is prepared a factor of safety of 5 has been applied to the base and side percolation. The basin is sized to provide a base area of 1110m^2 and an area assuming a Top Water level of 1m above the base of 1633m^2. A freeboard of 300mm above the TWL is expected to be provided. The WinDes preliminary calculations .indicate that the actual Top Water Level should be about 925mm above the base.

The remaining area of the site is situated in a region where the observed percolation rates are not suitable for percolation drainage and where the prevailing topography prevents draining to a remote basin. In these areas it is proposed to drain the development impermeable area to the adjoining public sewer with an attenuated discharge rate with a suitable attenuation basin.

The estimation of the greenfield runoff rate is presented in Appendix C. In summary the Micro Drainage WinDes modelling estimates that the 1:10 year greenfield runoff rate is 4.8l/s/ha.

The area drained through the attenuation basin amounts to circa 107 plots based on the current masterplan plus 610m of highway assumed to be 2 no. 2.0m footways plus a 5.5m carriageway amounting to 5795m^2. Therefore the total impermeable area amounts to 107 plots at an assumed 90m^2/plot plus the highway making a total of 15425m^2.

Based on 4.8l/s/ha as a limiting runoff; the total estimated area of 15425m^2 should be limited to 7.4l/s,. A Quick Store estimate suggests that a total attenuation of 1132m^3 – 1653m^3.

The pond provides 744m^3 of storage, in addition the underground attenuation tank provides around 679m^3 bringing the total volume of attenuation to 1423m^3 being just over the median of the potential storage range. When coupled with in network storage it should be possible to provide sufficient attenuation.

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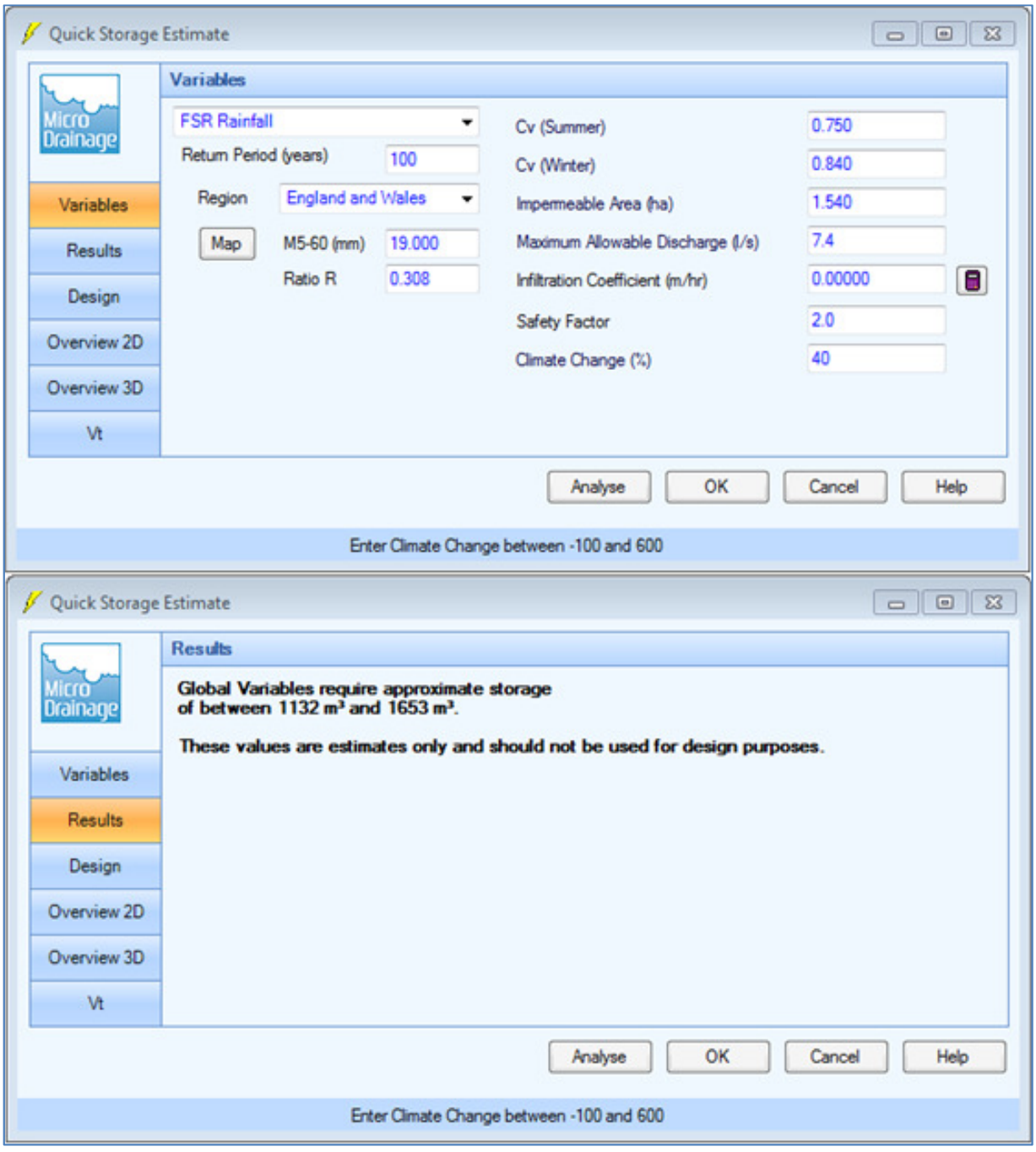

Figure 2 - Quick Store Estimate

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Appendix A

Trial Pit Locations

Legend Key

Trial Pit Location

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Exploratory Hole Location Plan

Project Number: WB03590

Project Name: Inglewood, Paignton

Figure: **3.1**

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Appendix B

Windes Calculations for Soakaways

Summary of Results for 100 year Return Period (+40%)

Half Drain Time : 481 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	0.207	0.207	0.0	2.0	O K
30 min Summer	0.281	0.281	0.1	2.7	O K
60 min Summer	0.362	0.362	0.1	3.5	O K
120 min Summer	0.440	0.440	0.1	4.2	O K
180 min Summer	0.477	0.477	0.1	4.6	O K
240 min Summer	0.495	0.495	0.1	4.7	O K
360 min Summer	0.513	0.513	0.1	4.9	O K
480 min Summer	0.524	0.524	0.1	5.0	O K
600 min Summer	0.531	0.531	0.1	5.1	O K
720 min Summer	0.535	0.535	0.1	5.1	O K
960 min Summer	0.537	0.537	0.1	5.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	119.177	0.0	19
30 min Summer	81.881	0.0	33
60 min Summer	53.779	0.0	64
120 min Summer	34.054	0.0	122
180 min Summer	25.620	0.0	182
240 min Summer	20.762	0.0	240
360 min Summer	15.458	0.0	310
480 min Summer	12.515	0.0	372
600 min Summer	10.612	0.0	434
720 min Summer	9.269	0.0	500
960 min Summer	7.478	0.0	636

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
1440 min Summer	0.527	0.527	0.1	5.1	O K
2160 min Summer	0.501	0.501	0.1	4.8	O K
2880 min Summer	0.472	0.472	0.1	4.5	O K
4320 min Summer	0.421	0.421	0.1	4.0	O K
5760 min Summer	0.381	0.381	0.1	3.7	O K
7200 min Summer	0.348	0.348	0.1	3.3	O K
8640 min Summer	0.321	0.321	0.1	3.1	O K
10080 min Summer	0.300	0.300	0.1	2.9	O K
15 min Winter	0.232	0.232	0.1	2.2	O K
30 min Winter	0.315	0.315	0.1	3.0	O K
60 min Winter	0.406	0.406	0.1	3.9	O K
120 min Winter	0.494	0.494	0.1	4.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
1440 min Summer	5.512	0.0	910
2160 min Summer	4.052	0.0	1316
2880 min Summer	3.252	0.0	1704
4320 min Summer	2.380	0.0	2468
5760 min Summer	1.909	0.0	3232
7200 min Summer	1.610	0.0	3968
8640 min Summer	1.401	0.0	4680
10080 min Summer	1.245	0.0	5448
15 min Winter	119.177	0.0	19
30 min Winter	81.881	0.0	33
60 min Winter	53.779	0.0	62
120 min Winter	34.054	0.0	120

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
180 min Winter	0.536	0.536	0.1	5.1	O K
240 min Winter	0.557	0.557	0.1	5.3	O K
360 min Winter	0.578	0.578	0.1	5.5	O K
480 min Winter	0.587	0.587	0.1	5.6	O K
600 min Winter	0.593	0.593	0.1	5.7	O K
720 min Winter	0.595	0.595	0.1	5.7	O K
960 min Winter	0.589	0.589	0.1	5.7	O K
1440 min Winter	0.565	0.565	0.1	5.4	O K
2160 min Winter	0.521	0.521	0.1	5.0	O K
2880 min Winter	0.478	0.478	0.1	4.6	O K
4320 min Winter	0.409	0.409	0.1	3.9	O K
5760 min Winter	0.357	0.357	0.1	3.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
180 min Winter	25.620	0.0	176
240 min Winter	20.762	0.0	232
360 min Winter	15.458	0.0	338
480 min Winter	12.515	0.0	380
600 min Winter	10.612	0.0	456
720 min Winter	9.269	0.0	534
960 min Winter	7.478	0.0	684
1440 min Winter	5.512	0.0	980
2160 min Winter	4.052	0.0	1404
2880 min Winter	3.252	0.0	1812
4320 min Winter	2.380	0.0	2592
5760 min Winter	1.909	0.0	3352

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
7200 min Winter	0.318	0.318	0.1	3.1	O K
8640 min Winter	0.287	0.287	0.1	2.8	O K
10080 min Winter	0.262	0.262	0.1	2.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
7200 min Winter	1.610	0.0	4112
8640 min Winter	1.401	0.0	4848
10080 min Winter	1.245	0.0	5552

Rainfall Details

Rainfall Model	FSR	M5-60 (mm)	19.000	Winter Storms	Yes	Shortest Storm (mins)	15
Return Period (years)	100	Ratio R	0.308	Cv (Summer)	0.750	Longest Storm (mins)	10080
Region	England and Wales	Summer Storms	Yes	Cv (Winter)	0.840	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.009

Time (mins) From:	To:	Area (ha)
0	4	0.009

Model Details

Storage is Online Cover Level (m) 1.600

Cellular Storage Structure

Invert Level (m) 0.000 Infiltration Coefficient Side (m/hr) 0.12168 Porosity 0.95
Infiltration Coefficient Base (m/hr) 0.00000 Safety Factor 2.0

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	10.1	0.0	0.610	10.1	8.1

Summary of Results for 100 year Return Period (+40%)

Half Drain Time : 27 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	0.321	0.321	0.7	1.6	O K
30 min Summer	0.387	0.387	0.9	2.0	O K
60 min Summer	0.430	0.430	1.0	2.2	O K
120 min Summer	0.429	0.429	1.0	2.2	O K
180 min Summer	0.402	0.402	0.9	2.1	O K
240 min Summer	0.372	0.372	0.8	1.9	O K
360 min Summer	0.326	0.326	0.7	1.7	O K
480 min Summer	0.290	0.290	0.7	1.5	O K
600 min Summer	0.262	0.262	0.6	1.3	O K
720 min Summer	0.240	0.240	0.5	1.2	O K
960 min Summer	0.205	0.205	0.5	1.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	119.177	0.0	16
30 min Summer	81.881	0.0	24
60 min Summer	53.779	0.0	42
120 min Summer	34.054	0.0	74
180 min Summer	25.620	0.0	108
240 min Summer	20.762	0.0	140
360 min Summer	15.458	0.0	202
480 min Summer	12.515	0.0	262
600 min Summer	10.612	0.0	324
720 min Summer	9.269	0.0	384
960 min Summer	7.478	0.0	504

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
1440 min Summer	0.162	0.162	0.4	0.8	O K
2160 min Summer	0.125	0.125	0.3	0.6	O K
2880 min Summer	0.103	0.103	0.2	0.5	O K
4320 min Summer	0.077	0.077	0.2	0.4	O K
5760 min Summer	0.062	0.062	0.1	0.3	O K
7200 min Summer	0.052	0.052	0.1	0.3	O K
8640 min Summer	0.046	0.046	0.1	0.2	O K
10080 min Summer	0.041	0.041	0.1	0.2	O K
15 min Winter	0.360	0.360	0.8	1.8	O K
30 min Winter	0.433	0.433	1.0	2.2	O K
60 min Winter	0.469	0.469	1.1	2.4	O K
120 min Winter	0.445	0.445	1.0	2.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
1440 min Summer	5.512	0.0	750
2160 min Summer	4.052	0.0	1104
2880 min Summer	3.252	0.0	1472
4320 min Summer	2.380	0.0	2204
5760 min Summer	1.909	0.0	2936
7200 min Summer	1.610	0.0	3672
8640 min Summer	1.401	0.0	4400
10080 min Summer	1.245	0.0	5064
15 min Winter	119.177	0.0	16
30 min Winter	81.881	0.0	25
60 min Winter	53.779	0.0	44
120 min Winter	34.054	0.0	80

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
180 min Winter	0.401	0.401	0.9	2.1	O K
240 min Winter	0.361	0.361	0.8	1.8	O K
360 min Winter	0.300	0.300	0.7	1.5	O K
480 min Winter	0.258	0.258	0.6	1.3	O K
600 min Winter	0.226	0.226	0.5	1.2	O K
720 min Winter	0.202	0.202	0.5	1.0	O K
960 min Winter	0.168	0.168	0.4	0.9	O K
1440 min Winter	0.127	0.127	0.3	0.6	O K
2160 min Winter	0.094	0.094	0.2	0.5	O K
2880 min Winter	0.076	0.076	0.2	0.4	O K
4320 min Winter	0.056	0.056	0.1	0.3	O K
5760 min Winter	0.045	0.045	0.1	0.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
180 min Winter	25.620	0.0	112
240 min Winter	20.762	0.0	146
360 min Winter	15.458	0.0	208
480 min Winter	12.515	0.0	270
600 min Winter	10.612	0.0	332
720 min Winter	9.269	0.0	392
960 min Winter	7.478	0.0	512
1440 min Winter	5.512	0.0	752
2160 min Winter	4.052	0.0	1120
2880 min Winter	3.252	0.0	1472
4320 min Winter	2.380	0.0	2188
5760 min Winter	1.909	0.0	2944

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
7200 min Winter	0.038	0.038	0.1	0.2	O K
8640 min Winter	0.033	0.033	0.1	0.2	O K
10080 min Winter	0.030	0.030	0.1	0.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
7200 min Winter	1.610	0.0	3680
8640 min Winter	1.401	0.0	4312
10080 min Winter	1.245	0.0	5064

Rainfall Details

Rainfall Model	FSR	M5-60 (mm)	19.000	Winter Storms	Yes	Shortest Storm (mins)	15
Return Period (years)	100	Ratio R	0.308	Cv (Summer)	0.750	Longest Storm (mins)	10080
Region	England and Wales	Summer Storms	Yes	Cv (Winter)	0.840	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.009

Time (mins) From:	To:	Area (ha)
0	4	0.009

Model Details

Storage is Online Cover Level (m) 1.600

Cellular Storage Structure

Invert Level (m) 0.000 Infiltration Coefficient Side (m/hr) 1.67400 Porosity 0.95
Infiltration Coefficient Base (m/hr) 0.00000 Safety Factor 2.0

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	5.4	0.0	0.610	5.4	5.9

Summary of Results for 100 year Return Period (+40%)

Half Drain Time : 159 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	0.553	0.553	7.0	98.2	O K
30 min Summer	0.737	0.737	9.4	130.8	O K
60 min Summer	0.911	0.911	11.6	161.7	O K
120 min Summer	1.029	1.029	13.1	182.7	O K
180 min Summer	1.074	1.074	13.7	190.7	O K
240 min Summer	1.091	1.091	13.9	193.7	O K
360 min Summer	1.099	1.099	14.0	195.2	O K
480 min Summer	1.086	1.086	13.8	192.9	O K
600 min Summer	1.064	1.064	13.6	188.9	O K
720 min Summer	1.038	1.038	13.2	184.3	O K
960 min Summer	0.982	0.982	12.5	174.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	119.177	0.0	18
30 min Summer	81.881	0.0	33
60 min Summer	53.779	0.0	62
120 min Summer	34.054	0.0	104
180 min Summer	25.620	0.0	134
240 min Summer	20.762	0.0	168
360 min Summer	15.458	0.0	236
480 min Summer	12.515	0.0	304
600 min Summer	10.612	0.0	372
720 min Summer	9.269	0.0	440
960 min Summer	7.478	0.0	570

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
1440 min Summer	0.880	0.880	11.2	156.3	O K
2160 min Summer	0.761	0.761	9.7	135.1	O K
2880 min Summer	0.672	0.672	8.6	119.3	O K
4320 min Summer	0.549	0.549	7.0	97.6	O K
5760 min Summer	0.468	0.468	6.0	83.1	O K
7200 min Summer	0.411	0.411	5.2	73.0	O K
8640 min Summer	0.367	0.367	4.7	65.2	O K
10080 min Summer	0.333	0.333	4.2	59.0	O K
15 min Winter	0.620	0.620	7.9	110.0	O K
30 min Winter	0.827	0.827	10.5	146.9	O K
60 min Winter	1.025	1.025	13.1	181.9	O K
120 min Winter	1.159	1.159	14.8	205.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
1440 min Summer	5.512	0.0	824
2160 min Summer	4.052	0.0	1192
2880 min Summer	3.252	0.0	1560
4320 min Summer	2.380	0.0	2292
5760 min Summer	1.909	0.0	3008
7200 min Summer	1.610	0.0	3752
8640 min Summer	1.401	0.0	4496
10080 min Summer	1.245	0.0	5240
15 min Winter	119.177	0.0	18
30 min Winter	81.881	0.0	32
60 min Winter	53.779	0.0	60
120 min Winter	34.054	0.0	114

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
180 min Winter	1.201	1.201	15.3	213.2	O K
240 min Winter	1.211	1.211	15.4	215.0	O K
360 min Winter	1.198	1.198	15.3	212.7	O K
480 min Winter	1.163	1.163	14.8	206.5	O K
600 min Winter	1.121	1.121	14.3	199.0	O K
720 min Winter	1.077	1.077	13.7	191.2	O K
960 min Winter	0.993	0.993	12.7	176.3	O K
1440 min Winter	0.853	0.853	10.9	151.5	O K
2160 min Winter	0.702	0.702	9.0	124.7	O K
2880 min Winter	0.598	0.598	7.6	106.2	O K
4320 min Winter	0.464	0.464	5.9	82.4	O K
5760 min Winter	0.383	0.383	4.9	68.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
180 min Winter	25.620	0.0	140
240 min Winter	20.762	0.0	178
360 min Winter	15.458	0.0	254
480 min Winter	12.515	0.0	326
600 min Winter	10.612	0.0	398
720 min Winter	9.269	0.0	466
960 min Winter	7.478	0.0	600
1440 min Winter	5.512	0.0	866
2160 min Winter	4.052	0.0	1236
2880 min Winter	3.252	0.0	1616
4320 min Winter	2.380	0.0	2336
5760 min Winter	1.909	0.0	3064

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
7200 min Winter	0.328	0.328	4.2	58.2	O K
8640 min Winter	0.288	0.288	3.7	51.1	O K
10080 min Winter	0.258	0.258	3.3	45.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
7200 min Winter	1.610	0.0	3816
8640 min Winter	1.401	0.0	4504
10080 min Winter	1.245	0.0	5248

Rainfall Details

Rainfall Model	FSR	M5-60 (mm)	19.000	Winter Storms	Yes	Shortest Storm (mins)	15
Return Period (years)	100	Ratio R	0.308	Cv (Summer)	0.750	Longest Storm (mins)	10080
Region	England and Wales	Summer Storms	Yes	Cv (Winter)	0.840	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.457

Time (mins) From:	To:	Area (ha)
0	4	0.457

Model Details

Storage is Online Cover Level (m) 1.600

Cellular Storage Structure

Invert Level (m) 0.000 Infiltration Coefficient Side (m/hr) 1.67400 Porosity 0.95
Infiltration Coefficient Base (m/hr) 0.00000 Safety Factor 2.0

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	186.9	0.0	1.220	186.9	66.9

Summary of Results for 100 year Return Period (+40%)

Half Drain Time : 589 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	0.313	0.313	6.4	196.1	O K
30 min Summer	0.413	0.413	7.0	266.3	O K
60 min Summer	0.515	0.515	7.6	341.9	O K
120 min Summer	0.610	0.610	8.2	415.8	O K
180 min Summer	0.654	0.654	8.5	451.3	O K
240 min Summer	0.676	0.676	8.6	469.2	O K
360 min Summer	0.697	0.697	8.8	486.7	O K
480 min Summer	0.702	0.702	8.8	490.6	O K
600 min Summer	0.702	0.702	8.8	491.4	O K
720 min Summer	0.701	0.701	8.8	489.8	O K
960 min Summer	0.692	0.692	8.7	482.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	119.177	0.0	19
30 min Summer	81.881	0.0	33
60 min Summer	53.779	0.0	64
120 min Summer	34.054	0.0	122
180 min Summer	25.620	0.0	182
240 min Summer	20.762	0.0	242
360 min Summer	15.458	0.0	360
480 min Summer	12.515	0.0	430
600 min Summer	10.612	0.0	490
720 min Summer	9.269	0.0	554
960 min Summer	7.478	0.0	684

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
1440 min Summer	0.666	0.666	8.6	461.1	O K
2160 min Summer	0.623	0.623	8.3	426.2	O K
2880 min Summer	0.580	0.580	8.0	392.4	O K
4320 min Summer	0.500	0.500	7.5	330.8	O K
5760 min Summer	0.431	0.431	7.1	279.3	O K
7200 min Summer	0.370	0.370	6.7	235.5	O K
8640 min Summer	0.316	0.316	6.4	198.4	O K
10080 min Summer	0.269	0.269	6.1	166.8	O K
15 min Winter	0.348	0.348	6.6	220.0	O K
30 min Winter	0.458	0.458	7.3	299.3	O K
60 min Winter	0.571	0.571	8.0	385.2	O K
120 min Winter	0.677	0.677	8.6	470.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
1440 min Summer	5.512	0.0	966
2160 min Summer	4.052	0.0	1380
2880 min Summer	3.252	0.0	1788
4320 min Summer	2.380	0.0	2592
5760 min Summer	1.909	0.0	3344
7200 min Summer	1.610	0.0	4104
8640 min Summer	1.401	0.0	4840
10080 min Summer	1.245	0.0	5552
15 min Winter	119.177	0.0	19
30 min Winter	81.881	0.0	33
60 min Winter	53.779	0.0	62
120 min Winter	34.054	0.0	120

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
180 min Winter	0.727	0.727	9.0	512.2	O K
240 min Winter	0.754	0.754	9.1	534.7	O K
360 min Winter	0.782	0.782	9.3	559.5	O K
480 min Winter	0.791	0.791	9.4	567.4	O K
600 min Winter	0.791	0.791	9.4	566.6	O K
720 min Winter	0.787	0.787	9.4	563.8	O K
960 min Winter	0.777	0.777	9.3	554.9	O K
1440 min Winter	0.741	0.741	9.1	523.6	O K
2160 min Winter	0.677	0.677	8.6	470.1	O K
2880 min Winter	0.614	0.614	8.2	418.9	O K
4320 min Winter	0.498	0.498	7.5	328.9	O K
5760 min Winter	0.400	0.400	6.9	256.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
180 min Winter	25.620	0.0	178
240 min Winter	20.762	0.0	236
360 min Winter	15.458	0.0	348
480 min Winter	12.515	0.0	456
600 min Winter	10.612	0.0	554
720 min Winter	9.269	0.0	578
960 min Winter	7.478	0.0	732
1440 min Winter	5.512	0.0	1038
2160 min Winter	4.052	0.0	1492
2880 min Winter	3.252	0.0	1908
4320 min Winter	2.380	0.0	2724
5760 min Winter	1.909	0.0	3520

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
7200 min Winter	0.316	0.316	6.4	198.2	O K
8640 min Winter	0.245	0.245	6.0	150.5	O K
10080 min Winter	0.184	0.184	5.6	111.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
7200 min Winter	1.610	0.0	4256
8640 min Winter	1.401	0.0	5016
10080 min Winter	1.245	0.0	5744

Rainfall Details

Rainfall Model	FSR	M5-60 (mm)	19.000	Winter Storms	Yes	Shortest Storm (mins)	15
Return Period (years)	100	Ratio R	0.308	Cv (Summer)	0.750	Longest Storm (mins)	10080
Region	England and Wales	Summer Storms	Yes	Cv (Winter)	0.840	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.900

Time (mins) From:	To:	Area (ha)
0	4	0.900

Model Details

Storage is Online Cover Level (m) 57.740

Infiltration Basin Structure

Invert Level (m) 0.000 Infiltration Coefficient Side (m/hr) 0.14184 Porosity 1.00
Infiltration Coefficient Base (m/hr) 0.14184 Safety Factor 5.0

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	572.0	1.000	962.0

Summary of Results for 100 year Return Period (+40%)

Half Drain Time : 712 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	0.342	0.342	11.5	408.4	O K
30 min Summer	0.455	0.455	12.5	555.3	O K
60 min Summer	0.572	0.572	13.4	715.4	O K
120 min Summer	0.684	0.684	14.4	875.0	O K
180 min Summer	0.738	0.738	14.8	955.4	O K
240 min Summer	0.768	0.768	15.1	999.2	O K
360 min Summer	0.800	0.800	15.4	1048.5	O K
480 min Summer	0.811	0.811	15.5	1065.4	O K
600 min Summer	0.813	0.813	15.5	1068.1	O K
720 min Summer	0.812	0.812	15.5	1067.1	O K
960 min Summer	0.805	0.805	15.4	1056.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	119.177	0.0	19
30 min Summer	81.881	0.0	34
60 min Summer	53.779	0.0	64
120 min Summer	34.054	0.0	122
180 min Summer	25.620	0.0	182
240 min Summer	20.762	0.0	242
360 min Summer	15.458	0.0	360
480 min Summer	12.515	0.0	480
600 min Summer	10.612	0.0	536
720 min Summer	9.269	0.0	598
960 min Summer	7.478	0.0	722

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
1440 min Summer	0.781	0.781	15.2	1018.8	O K
2160 min Summer	0.737	0.737	14.8	953.9	O K
2880 min Summer	0.694	0.694	14.5	890.1	O K
4320 min Summer	0.610	0.610	13.8	769.0	O K
5760 min Summer	0.535	0.535	13.1	663.8	O K
7200 min Summer	0.467	0.467	12.6	571.5	O K
8640 min Summer	0.406	0.406	12.0	490.6	O K
10080 min Summer	0.352	0.352	11.6	420.2	O K
15 min Winter	0.381	0.381	11.8	458.2	O K
30 min Winter	0.506	0.506	12.9	624.1	O K
60 min Winter	0.636	0.636	14.0	805.5	O K
120 min Winter	0.761	0.761	15.0	988.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
1440 min Summer	5.512	0.0	994
2160 min Summer	4.052	0.0	1408
2880 min Summer	3.252	0.0	1816
4320 min Summer	2.380	0.0	2636
5760 min Summer	1.909	0.0	3408
7200 min Summer	1.610	0.0	4176
8640 min Summer	1.401	0.0	4928
10080 min Summer	1.245	0.0	5648
15 min Winter	119.177	0.0	19
30 min Winter	81.881	0.0	33
60 min Winter	53.779	0.0	62
120 min Winter	34.054	0.0	120

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
180 min Winter	0.823	0.823	15.6	1082.8	O K
240 min Winter	0.858	0.858	15.9	1136.5	O K
360 min Winter	0.899	0.899	16.2	1201.2	O K
480 min Winter	0.917	0.917	16.4	1230.0	O K
600 min Winter	0.923	0.923	16.4	1238.9	O K
720 min Winter	0.921	0.921	16.4	1235.9	O K
960 min Winter	0.911	0.911	16.3	1220.5	O K
1440 min Winter	0.879	0.879	16.1	1170.6	O K
2160 min Winter	0.816	0.816	15.5	1073.1	O K
2880 min Winter	0.752	0.752	15.0	975.3	O K
4320 min Winter	0.628	0.628	13.9	794.2	O K
5760 min Winter	0.518	0.518	13.0	641.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
180 min Winter	25.620	0.0	178
240 min Winter	20.762	0.0	236
360 min Winter	15.458	0.0	352
480 min Winter	12.515	0.0	462
600 min Winter	10.612	0.0	570
720 min Winter	9.269	0.0	672
960 min Winter	7.478	0.0	760
1440 min Winter	5.512	0.0	1068
2160 min Winter	4.052	0.0	1532
2880 min Winter	3.252	0.0	1964
4320 min Winter	2.380	0.0	2808
5760 min Winter	1.909	0.0	3632

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
7200 min Winter	0.423	0.423	12.2	512.7	O K
8640 min Winter	0.339	0.339	11.5	403.6	O K
10080 min Winter	0.266	0.266	10.9	312.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
7200 min Winter	1.610	0.0	4392
8640 min Winter	1.401	0.0	5112
10080 min Winter	1.245	0.0	5856

Rainfall Details

Rainfall Model	FSR	M5-60 (mm)	19.000	Winter Storms	Yes	Shortest Storm (mins)	15
Return Period (years)	100	Ratio R	0.308	Cv (Summer)	0.750	Longest Storm (mins)	10080
Region	England and Wales	Summer Storms	Yes	Cv (Winter)	0.840	Climate Change %	+40

Time Area Diagram

Total Area (ha) 1.869

Time (mins) From:	To:	Area (ha)
0	4	1.869

Model Details

Storage is Online Cover Level (m) 56.360

Infiltration Basin Structure

Invert Level (m) 0.000 Infiltration Coefficient Side (m/hr) 0.14184 Porosity 1.00
Infiltration Coefficient Base (m/hr) 0.14184 Safety Factor 5.0

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	1110.4	1.000	1633.1

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TECHNICAL NOTE

Project:	**Inglewood Urban Extension**	**WB03590-TN01(V1)**
Subject:	TN01 - Drainage Strategy	
Prepared by	Andy Jenner BEng CEng MICE (Associate Director)	
Approved by	Seymour D'Oyley (Associate Director)	15-12-2017

Appendix C

WinDes Calculations for Greenfield Runoff

ICP SUDS Mean Annual Flood

Input

Return Period (years) 10 SAAR (mm) 1133 Urban 0.000
Area (ha) 1.000 Soil 0.300 Region Number Region 8

Results l/s

QBAR Rural 3.2
QBAR Urban 3.2

Q10 years 4.8

Q1 year 2.5
Q30 years 6.1
Q100 years 7.7