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Proposed Development

Tuners Lane, Crudwell



Flood Risk & Drainage Strategy

Project Number 1513
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At a Glance – Summary

- The development comprises 25 residential properties sited on existing greenfield land off Tuners Lane, Crudwell.
- The type of development proposed is classified as ‘More Vulnerable’ according to the current NPPF Technical Guidance.
- The development site is in Flood Zone 1 with less than 0.1% annual probability of fluvial flooding.
- Flood Risk from all other potential sources is considered to be low.
- Preliminary site infiltration tests have been carried out and these indicate that infiltration will not be a viable means of stormwater management for the site.
- Stormwater management for the site will be provided in attenuation basins which will discharge to the adjacent watercourse at no greater than Greenfield Rate.
- A preliminary site drainage layout is included showing how the system will be provided.
- Climate change will be addressed through an additional 40% allowance in the rainfall figures used for stormwater source control design.
- Foul drainage is provided in a new system which will connect to the existing public foul system within the site boundary under a Section 104 agreement with Wessex Water.
- Residual flood risks are summarised and ongoing maintenance responsibilities are identified.

1 Introduction

1.1 This assessment has been prepared in support of a planning application to construct a development of 25 properties on land off Tuners Lane, Crudwell, Wiltshire, SN16 9EN as layout in Figure 1.



Figure 1 – Proposed Site Layout

1.2 Based on Annex 3. of the NPPF guidance, the vulnerability classification of the development will be '*More Vulnerable'*, which includes the following categories; *'Buildings used for dwelling houses, student halls of residence, drinking establishments, nightclubs and hotels'.*

1.3 This assessment is based on the requirements in Section 14 of the National Planning Policy Framework (NPPF) (July 2021 version) by the Department of Communities & Local Government together with the accompanying technical guidance published on the Gov.uk website.

The general requirement for a Flood Risk Assessment (FRA) is stated in the NPPF and footnote 55 states that;

A site-specific flood risk assessment should be provided for all development in Flood Zones 2 and 3. In Flood Zone 1, an assessment should accompany all proposals involving: sites of 1 hectare or more; land which has been identified by the Environment Agency as having critical drainage problems; land identified in a strategic flood risk assessment as being at increased flood risk in future; or land that may be subject to other sources of flooding, where its development would introduce a more vulnerable use.

By reference to the EA flood map for planning extract in Figure 2, the site is considered to be in Flood Zone 1. The nearest fluvial flooding is 40m south of the site, which is associated with the Swill Brook. The requirement for an FRA is therefore due to the size of the overall site being greater than 1 hectare.

2 Flood Hazard – Possible Sources & Probabilities of Flooding

2.1 *Fluvial Flooding –* The EA online 'Flood Map for Planning' (shown in Figure 2) confirms the site is in Zone 1 with an annual probability of fluvial flooding of less than 0.1%. The map evidence and the relative levels of the site compared to any adjacent watercourses confirm that fluvial flood risk is **very low.**

2.2 *Flooding from Drains, Sewers and Burst Water Mains –* The site is currently an agricultural field with no discernible drainage infrastructure.

2.3 As clarified in section 4, Surface water drainage from the proposed development will mimic the existing surface water drainage regime by discharging across adjacent land at greenfield runoff rate via an attenuation control structures. Design parameters for the new attenuation storage will ensure there is no surface flooding resulting from peak flows from all storms up to a 100yr return period (1% annual probability) event including climate change allowances.

2.4 Taking all of the above factors into account; flood risk from drains, sewers and burst water mains is considered to be **low.**

2.5 *Groundwater Flooding –* The site is entirely laid within the outcrop of the Forest Marble Foundation (FMB). This comprises of interbedded grey oolitic limestones along with greenish grey siliceous mudstone, grading into clay. Infiltration testing carried out on the site found the site to be impermeable. Testing identified clay to around 3.45m bgl and there was no evidence of the water table. The site is located around 40mm to the north of the Swill Brook and approximately 3m higher in elevation, according to the OS Map. There are no basements that might be vulnerable to external groundwater pressures and the contours of the site would direct any groundwater seepages away from the buildings. Taking all these factors into account, groundwater flood risk is considered to be **low.**

2.6 *Pluvial Flooding & Flooding from Land –* Figure 3 is an extract from the EA surface water flood map, which shows the site to be remote from any surface water flood routes with the exception of a small area adjacent to the south east corner of the site where an existing ditch crosses under Tuners Lane by a culvert. This is a localised depression which will be considered in the drainage strategy for the site and will be utilised as a wetland aera for biodiversity. Overland flood routing is shown on the site plan in Figure 5 and with the measures described the overall flood risk due to pluvial and overland flow from adjacent land is considered to be **low**.

2.7 *Flooding from Other Artificial Sources –* The reservoir flood map published by the EA has been checked and there is no risk of reservoir flooding in the area. Flood risk due to artificial sources is therefore considered to be **low.**

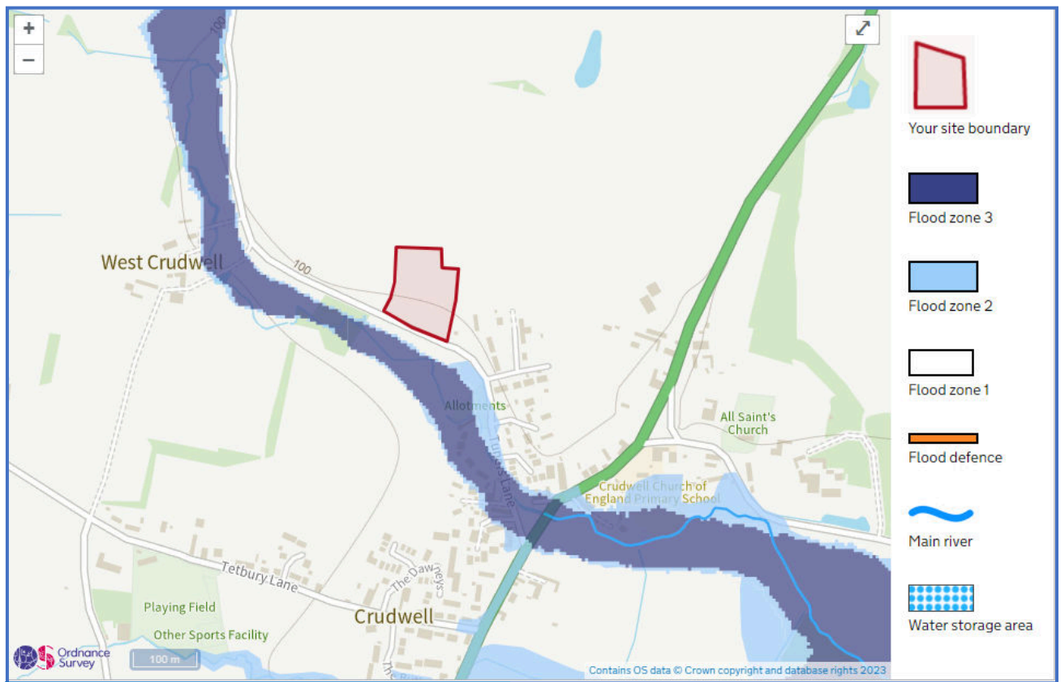

Figure 2 – EA Flood Map for Planning

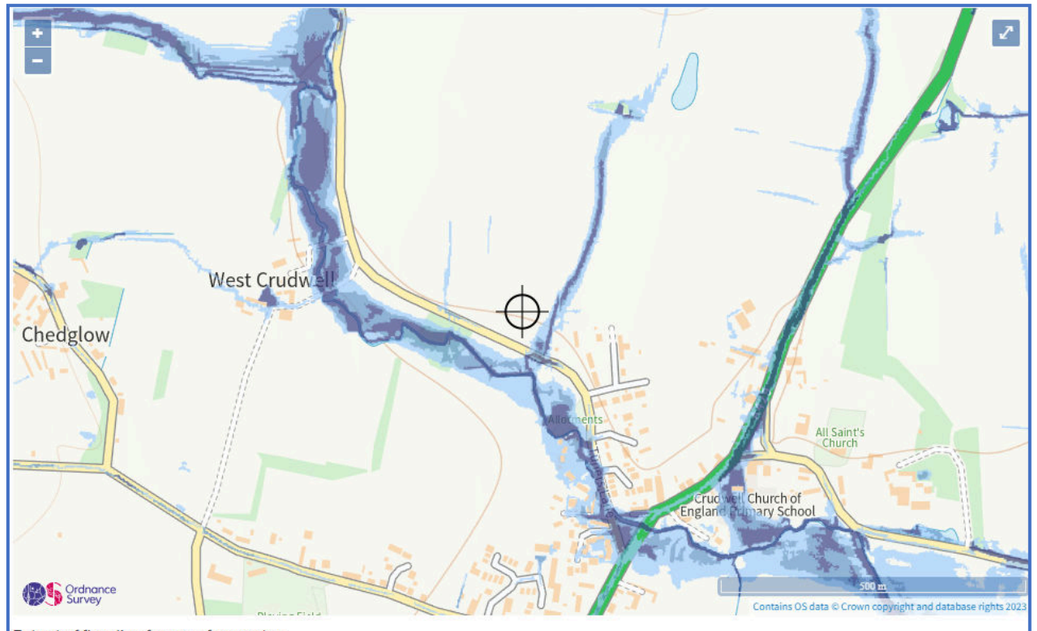

Figure 3 – EA Surface Water Flooding Map

3 Stormwater Run-off

3.1 In addition to flood risk to the development itself, the impact of flooding in the downstream catchment due to stormwater run-off needs to be addressed in order to meet sustainable drainage obligations cited in the NPPF.

3.2 The site is currently a sloping field 1.367 hectares in area, which would generate stormwater run-off at so called 'greenfield' rates southwards towards the Swill Brook once the site soils have become sufficiently saturated to generate a surface flow.

3.3 In line with current best practice in the design of sustainable drainage (SuDS) together with EA and LLFA advice, a hierarchical approach should be taken for the disposal of surface water from the site, referencing in order of priority:

Harvesting. Infiltration systems.

Disposal to a watercourse or surface water sewer

Disposal to a combined sewer, only as a last resort

3.4 With reference to the hierarchy, rainwater recycling systems from roof areas has been considered, however there is concern about the sustainability of roof water recycling systems given the ongoing maintenance issues and cost thereof together with water quality concerns etc. which have resulted in a significant number of installed systems for typical housing developments being disconnected, and thereby having a net detriment in terms of environmental benefit.

3.5 Trial pits were undertaken by Wilson Associates as Appendix A. Testing identified clayey material consistent with the Forest Marble Formation (FMB). Falling head percolation tests were undertaken in locations SA1 - SA4. Due to negligible percolation, it is not possible to calculate an infiltration rate and therefore true source control through infiltration is not a viable means of surface water disposal for the site.

3.6 As a result the lack of infiltration capacity, discharge to the local watercourse will be utilised with a restricted discharge rate and 2No. grassed attenuation basins, as Figure 5. The basins have been designed as impervious and therefore the negligible infiltration that does occur will be a betterment. The site is connected to the Swill Brook by a network of existing ditches and an existing culverted section routing it under Tuners Lane. This connection has been inspected and is also clearly visible by the orientation of the OS contours and the drainage network (ditch) heading South as shown on the surface water flooding map in Figure 3.

3.7 The layout and levels of the site are such that attenuation basin SUDs features that can be included, with a single final discharge point into the local watercourse. As the entrance bellmouth from Tuners Lane is at the lowest level, this is taken to a separate small basin so the main basin can be retained at a higher elevation. To achieve control, the two separate basins utilise attenuation areas where they are physically viable (depth and location), as per Catchment A and B shown on the design plan in Figure 5. The combined discharge of Catchment A and Catchment B is **5.4 l/s**, which is the Greenfield QBar flow rate for the site. The solution is therefore mimicking the existing greenfield run off rates from the site, and development of the site will therefore maintain the status-quo and not increase off site run off.

Catchment A is the majority of the site and will be served by the larger basin to the south of the site. The downstream flow controller is set at **4.4 l/s.**

Catchment B is a small area of proposed highway which is at lower elevation. The levels of this area of highway dictate that it cannot connect to the main storage basin, the levels would be such that during a storm event, the highway gully's would surcharge. It has been designed so that all run off from catchment B can be attenuated within basin 2 and discharged into the surface water drainage system at **1.0 l/s**, thus allowing basin 1 to operate at a higher level and provide the required storage.

3.8 The 2 basins shown are grass basins, side slopes are set at max 1:6 allowing amenity and ease of mowing.

3.9 Upstream of the basins, the main access road will be adoptable under a Section 38 highways agreement. Therefore the drainage which takes both adopted highway and residential storm will need to be adopted

under a Section 104 drainage agreement with the water company, in this case, Wessex Water. Adopted roads must impermeable surface (tarmacadam) to the local authority specification.

3.10 All parking spaces and the shared driveways are private and can therefore be constructed in pervious paving. The porous paving will provide additional attenuation, losses in discharge volume and an additional level of water quality improvement. The porous sub-base to these areas is collected in perforated drainage at the low edge and connected to the main drainage pipes in the adoptable highway before discharging into the storage basins. The additional attenuation properties for these porous surfaces are not included in the current drainage modelling calculations for this strategy but can be implemented during later design stages if additional storage is required

3.11 The design principle is that existing greenfield runoff rates are established. MicroDrainage software will then be used to design the drainage network, associated flow controllers and attenuation basin sizes to ensure a robust drainage strategy can be adequately provided within the site constraints.

3.12 The primary aim of the drainage design will be to mitigate any increase in downstream flood risk that would otherwise be generated by the introduction of the areas of impermeable roads and paving. Proposed stormwater runoff from the site will be limited to no more than the existing Greenfield runoff rates. Greenfield Runoff calculations are as Appendix B, based on a contributing area of 1.367ha. These rates are summarised in Table 1.

3.13 As described above, given the topography for design purposes the site must be cascade using separate attenuation systems. Allowing a practical sized discharge control to minimise blockage risk and maximising the attenuation volume available it has been possible to restrict the total site discharge rate of **5.4 l/s**. This rate is the QBar for greenfield runoff events and uses a vortex flow control device in the flow control chamber for Basin 1, restricting the flows to **4.4 l/s**. A second vortex flow control device in the flow control chamber for Basin 2 shall restrict the flow to **1.0 l/s**. The flows combine to make the final discharge **5.4 l/s** for a 100 year +40% CC event.
The greenfield run-off rates are shown in table 1 below.

	Peak Run-off QBar	Peak Run-off 1 year	Peak Run-off 30 year	Peak Run-off 100 year
Greenfield Run-off l/s	5.4	4.6	12.3	17.3

Table 1 – Greenfield Runoff Rates

3.14 Based on the above constraints, the following stormwater drainage strategy has been developed and presented in Figure 5:

- All areas of parking and shared driveway, will be constructed in porous surfacing to provide water quality improvement .
- The majority of impermeable areas will be routed via Basin 1 (and attenuation for Catchment A) to distribute water to the watercourse adjacent to the site via a vortex flow control device. The basin sizes and design discharge rates are as Figure 5.
- A small lower area of road entrance will be attenuated in Basin2, as Figure 5.
- Small areas of paving will tip to soft landscape.
- There will be additional losses of flow/volume from the porous paving's and basins which have not been included in the calculations but which will provide some additional benefit. Any could be utilised in the detailed design.

4 Climate Change

4.1 Climate change consideration is relevant to the design life, and for residential that is to be a minimum lifetime of 100 years. GOV.CO.UK utilises a local catchment approach rather than the national scale application. The 'Peak Rainfall Intensity' climate allowance for this catchment from the GOV.CO.UK website is shown in Figure 4.

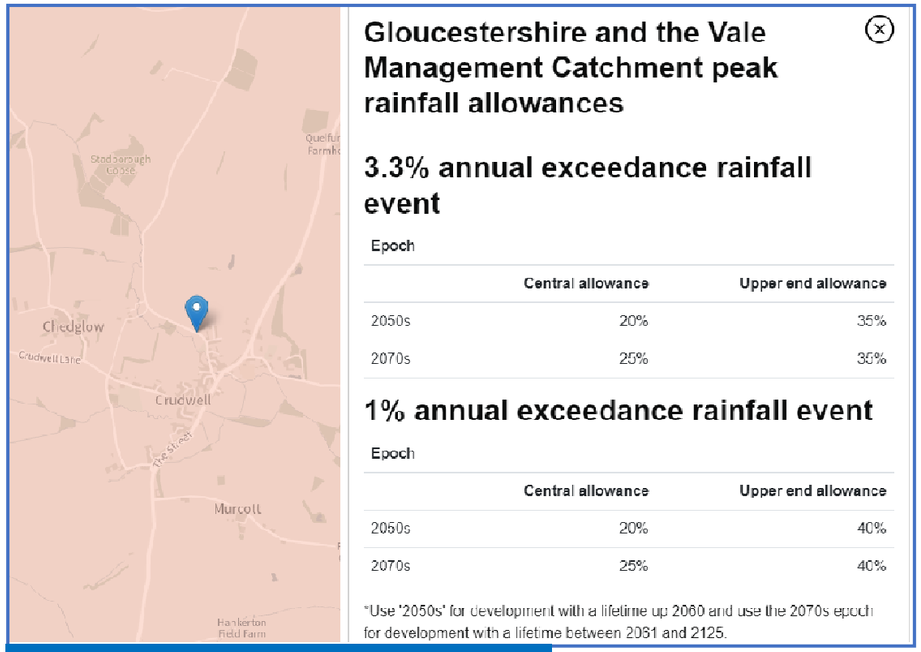

Figure 4 – Climate Change Allowance

4.2 For residential with a lifetime of 100 years, the annual exceedance probability events for the 2070s epoch (2061-2125) must be used. Therefore, climate change allowance of 40%CC increase in peak rainfall intensity has been used in the calculations.

5 Flood Risk Management Measures

5.1 The proposed site drainage systems will be designed so that they are easy to inspect and simple to clean with plenty of access points and facilities for the use of conventional jetting equipment. The main storm drainage and controls will be offered for adoption. If basin adoption is not permitted then the attenuation basins will be operated and maintained by a private facilities management company created for the development with residents paying a service change to maintain the basins and other private open space areas.

5.2 Potential issues that will need to be addressed in order to sustain the low level of flood risk on the site will be:

- Checking of catchpit/inspection chambers to ensure the function of the flow control is not compromised by silt accumulation.
- Maintenance of attenuation basins.
- Periodical inspection and jetting of drain runs.
- Clearing of gutters and rainwater downpipe gullies to prevent carry-over of debris into the attenuation system. Where necessary leaf guards should be fitted to gutters and downpipe outlets to prevent the ingress of leaves and moss etc.

- Inspection and clearance of overland flood/flow exceedance routes as shown on Figure 5 to ensure no obstructions have been introduced.

Where regular checks are required a maintenance schedule has been prepared, as Appendix E. It is advised that initially inspections are carried out at short intervals for the drainage, and the need for checking would be reviewed on an ongoing basis depending on how the various elements are performing.

6 Off Site Impacts

6.1 Potential off-site impacts are addressed by the design in section 3. With the proposed attenuated drainage measures in place together with the drainage management procedures described, it is considered that the flow rate will generate no increase rate in flood risk to off-site receptors, including for the effects of climate change. In fact there will be a betterment in reduced run off for all events beyond QBar (which is considered approximately a 2 year event). For instance the 100 year event is currently 17.3 l/s greenfield runoff, and this will be reduced to 5.4 l/s, so by developing the site this will increase downstream discharge rate.

6.2 In addition to the above, therefore will also be additional losses in the porous paving's, which have currently not been allowed for in the calculations.

7 Residual Flood Risks

7.1 The residual flood risks following development taking account of climate change effects are considered to be as follows:

- Less than 0.1% annual probability of fluvial flooding to the development site.
- 1% annual risk of exceedance flows due to surcharged drain systems within the site but negligible risk of flood damage from this source bearing in mind the relationship of proposed floor levels to site levels.
- Risk of downstream flooding due to run-off from the development is maintained at pre-development levels for all storm events up to the worst case 100yr event through sustainable drainage measures, with 40% capacity allowance for climate change.

Overall residual flood risk post development is therefore considered to be **low.**

8 Foul Drainage

8.1 Foul drainage will be provided in a new system connected to the existing 150mm diameter public foul sewer to the southwest of the development, as shown in the Wessex Water public sewer records, Appendix F.

8.2 Connection of the foul drainage will be carried out under a Section 106 connection application, any elements of the drainage which the client wishes to offer for adoption will be submitted under a Section 104 adoption agreement with Wessex Water.

8.3 All drainage design will comply with Part H of the building regulations and/or Sewers for Adoption 7th edition. And Sewerage Sector Guidance, Design & Construction Guidance.

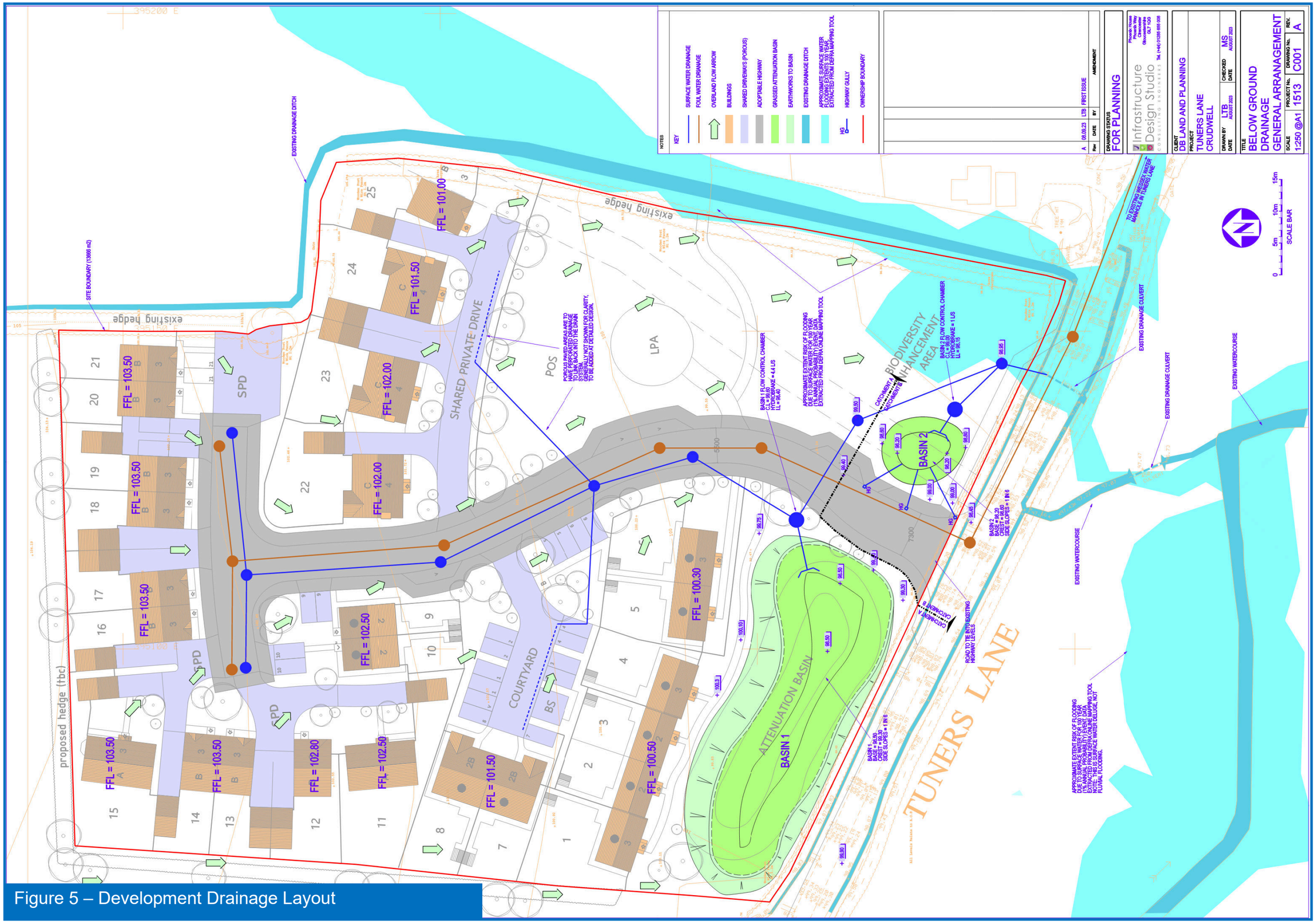

Figure 5 – Development Drainage Layout

Appendix A – Infiltration Testing Results

Wilson Associates

Job No. 4805
Page No. 17

Percolation Testing - Soakaway Feasibility

7.12 Four full scale soakaway test were undertaken at variable depth within trial pits SA1-4. The Forest Marble Formation was found to be consistent throughout the site, identified as predominantly silty clay, grading with depth to a gravelly and very gravelly clay. Summary results of the four test undertaken are shown in Table 8 below. Due to negligible percolation it has not been possible to calculate soil infiltration rates or undertake repeat test within either of the four test locations.

TABLE 7: SUMMARY OF PERCOLATION TEST RESULT

Trial pit No.	Test Zone Depth (m)	Approximate Soil Infiltration Rate (m/sec)	Approximate time to drain to 50% storage (hours)
SA1	1.22 – 1.88	N/A	>24
SA2	1.28 – 0.88		
SA3	1.49 – 1.01		
SA4	1.90 – 0.96		

7.13 BRE guidance states that soakaways should be feasible where infiltration rates indicate that water would drain to 50% effective storage capacity within a period of 24 hours. Due to insufficient infiltration this was not achieved within any of the test holes and the results in Table 8 are considered to be representative of the entire site. The foregoing suggests that the site is not suitable for adoption of a soakaway (SUDS) drainage system and it is therefore recommended that alternative drainage options are sought; it is understood that specialist design is being undertaken by Infrastructure Design Studies.

Recommendations for Monitoring of Ground Conditions during Construction

7.14 Despite the absence of made ground across the site, in view of the importance of founding on undisturbed natural ground a careful watch must be maintained during all foundation excavations to ensure that this requirement has been satisfied.

7.15 Since the requisite depth of some foundations will be influenced by the proximity of boundary/off-site trees, and the existing desiccation may vary seasonally, inspection should ensure that no root activity or evidence of desiccation is visible at foundation

Appendix B – Greenfield Run-off Rates

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31 Dyer Street Cirencester Glos GL7 2PP	1513 - TUNERS LANE, CRUDWELL GREENFIELD RUN-OFF RATES	
Date 01/08/2023 File	Designed by LTB Checked by MS	
Causeway	Source Control 2020.1	

ICP SUDS Mean Annual Flood

Input

Return Period (years)	100	Soil	0.400
Area (ha)	1.367	Urban	0.000
SAAR (mm)	800	Region Number	Region 6

Results	l/s
QBAR Rural	5.4
QBAR Urban	5.4
Q100 years	17.3
Q1 year	4.6
Q30 years	12.3
Q100 years	17.3

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Appendix C – Basin 1 MicroDrainage Calculations (Catchment A)

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31 Dyer Street Cirencester Glos GL7 2PP	1513 - TUNER LANE, CRUDWELL ATTENUATION BASIN 1 100 YEAR +40%	Micro Drainage
Date 01/09/2023 File Storage Basin 100 year ...	Designed by LTB Checked by MS	
Causeway	Source Control 2020.1	

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	98.913	0.413	4.4	132.5	O K
30 min Summer	98.997	0.497	4.4	172.9	O K
60 min Summer	99.070	0.570	4.4	212.5	Flood Risk
120 min Summer	99.128	0.628	4.4	246.8	Flood Risk
180 min Summer	99.152	0.652	4.4	261.6	Flood Risk
240 min Summer	99.161	0.661	4.4	267.7	Flood Risk
360 min Summer	99.163	0.663	4.4	268.9	Flood Risk
480 min Summer	99.155	0.655	4.4	263.9	Flood Risk
600 min Summer	99.143	0.643	4.4	256.3	Flood Risk
720 min Summer	99.132	0.632	4.4	249.4	Flood Risk
960 min Summer	99.113	0.613	4.4	237.7	Flood Risk
1440 min Summer	99.079	0.579	4.4	217.7	Flood Risk
2160 min Summer	99.028	0.528	4.4	189.3	Flood Risk
2880 min Summer	98.970	0.470	4.4	159.4	O K
4320 min Summer	98.846	0.346	4.4	104.1	O K
5760 min Summer	98.737	0.237	4.4	63.7	O K
7200 min Summer	98.649	0.149	4.4	36.3	O K
8640 min Summer	98.585	0.085	4.3	19.3	O K
10080 min Summer	98.543	0.043	4.1	9.3	O K
15 min Winter	98.948	0.448	4.4	149.0	O K
30 min Winter	99.038	0.538	4.4	194.7	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	133.068	0.0	136.8	19
30 min Summer	87.827	0.0	180.7	34
60 min Summer	55.250	0.0	227.4	64
120 min Summer	33.583	0.0	276.3	122
180 min Summer	24.758	0.0	305.5	182
240 min Summer	19.820	0.0	326.4	242
360 min Summer	14.428	0.0	356.3	360
480 min Summer	11.519	0.0	379.5	480
600 min Summer	9.666	0.0	397.8	548
720 min Summer	8.371	0.0	413.6	606
960 min Summer	6.667	0.0	439.2	730
1440 min Summer	4.829	0.0	477.0	996
2160 min Summer	3.492	0.0	517.3	1408
2880 min Summer	2.771	0.0	547.5	1816
4320 min Summer	1.998	0.0	592.4	2548
5760 min Summer	1.582	0.0	625.2	3232
7200 min Summer	1.320	0.0	652.2	3888
8640 min Summer	1.137	0.0	674.4	4504
10080 min Summer	1.003	0.0	693.7	5152
15 min Winter	133.068	0.0	153.3	19
30 min Winter	87.827	0.0	202.4	33

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31 Dyer Street Cirencester Glos GL7 2PP	1513 - TUNER LANE, CRUDWELL ATTENUATION BASIN 1 100 YEAR +40%	Micro Drainage
Date 01/09/2023 File Storage Basin 100 year ...	Designed by LTB Checked by MS	
Causeway	Source Control 2020.1	

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	99.117	0.617	4.4	239.8	Flood Risk
120 min Winter	99.181	0.681	4.4	280.5	Flood Risk
180 min Winter	99.209	0.709	4.4	298.9	Flood Risk
240 min Winter	99.221	0.721	4.4	307.6	Flood Risk
360 min Winter	99.229	0.729	4.4	312.9	Flood Risk
480 min Winter	99.226	0.726	4.4	310.9	Flood Risk
600 min Winter	99.217	0.717	4.4	304.9	Flood Risk
720 min Winter	99.205	0.705	4.4	296.6	Flood Risk
960 min Winter	99.180	0.680	4.4	279.8	Flood Risk
1440 min Winter	99.137	0.637	4.4	252.3	Flood Risk
2160 min Winter	99.067	0.567	4.4	210.5	Flood Risk
2880 min Winter	98.984	0.484	4.4	166.2	O K
4320 min Winter	98.788	0.288	4.4	81.5	O K
5760 min Winter	98.629	0.129	4.4	31.0	O K
7200 min Winter	98.539	0.039	4.1	8.4	O K
8640 min Winter	98.510	0.010	3.7	2.1	O K
10080 min Winter	98.500	0.000	3.2	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	55.250	0.0	254.6	62
120 min Winter	33.583	0.0	309.8	120
180 min Winter	24.758	0.0	342.5	180
240 min Winter	19.820	0.0	365.7	238
360 min Winter	14.428	0.0	399.3	352
480 min Winter	11.519	0.0	424.9	464
600 min Winter	9.666	0.0	445.7	572
720 min Winter	8.371	0.0	463.3	676
960 min Winter	6.667	0.0	491.8	770
1440 min Winter	4.829	0.0	534.4	1080
2160 min Winter	3.492	0.0	579.8	1536
2880 min Winter	2.771	0.0	613.3	1988
4320 min Winter	1.998	0.0	663.5	2676
5760 min Winter	1.582	0.0	700.4	3280
7200 min Winter	1.320	0.0	730.2	3816
8640 min Winter	1.137	0.0	755.2	4408
10080 min Winter	1.003	0.0	777.0	0

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31 Dyer Street Cirencester Glos GL7 2PP	1513 - TUNER LANE, CRUDWELL ATTENUATION BASIN 1 100 YEAR +40%	
Date 01/09/2023 File Storage Basin 100 year ...	Designed by LTB Checked by MS	
Causeway	Source Control 2020.1	

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	19.500	Shortest Storm (mins)	15
Ratio R	0.389	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.549

Time From:	(mins) To:	Area (ha)
0	4	0.549

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31 Dyer Street Cirencester Glos GL7 2PP	1513 - TUNER LANE, CRUDWELL ATTENUATION BASIN 1 100 YEAR +40%	
Date 01/09/2023 File Storage Basin 100 year ...	Designed by LTB Checked by MS	
Causeway	Source Control 2020.1	

Model Details

Storage is Offline Dividing Weir Level (m) 98.500
Cover Level (m) 99.300

Tank or Pond Structure

Invert Level (m) 98.500

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	207.0	0.800	764.0	0.801	0.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0101-4400-0900-4400
Design Head (m)	0.900
Design Flow (l/s)	4.4
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	101
Invert Level (m)	98.400
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.900	4.4
Flush-Flo™	0.268	4.4
Kick-Flo®	0.583	3.6
Mean Flow over Head Range	-	3.8

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	3.3	1.200	5.0	3.000	7.7	7.000	11.5
0.200	4.3	1.400	5.4	3.500	8.3	7.500	11.9
0.300	4.4	1.600	5.7	4.000	8.8	8.000	12.3
0.400	4.3	1.800	6.1	4.500	9.3	8.500	12.6
0.500	4.1	2.000	6.4	5.000	9.8	9.000	13.0
0.600	3.6	2.200	6.7	5.500	10.3	9.500	13.3
0.800	4.2	2.400	6.9	6.000	10.7		
1.000	4.6	2.600	7.2	6.500	11.1		

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Appendix D – Basin 2 MicroDrainage Calculations (Catchment B)

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31 Dyer Street Cirencester Glos GL7 2PP	1513 - TUNERS LANE, CRUDWELL ATTENUATION BASIN 2 100 YEAR +40%	
Date 01/09/2023 File Highway Basin 100year +...	Designed by LTB Checked by MS	
Causeway	Source Control 2020.1	

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	98.326	0.126	1.0	4.8	Flood Risk
30 min Summer	98.348	0.148	1.0	5.8	Flood Risk
60 min Summer	98.358	0.158	1.0	6.3	Flood Risk
120 min Summer	98.353	0.153	1.0	6.1	Flood Risk
180 min Summer	98.344	0.144	1.0	5.6	Flood Risk
240 min Summer	98.334	0.134	1.0	5.2	Flood Risk
360 min Summer	98.313	0.113	1.0	4.2	Flood Risk
480 min Summer	98.294	0.094	1.0	3.3	O K
600 min Summer	98.276	0.076	1.0	2.6	O K
720 min Summer	98.260	0.060	1.0	2.0	O K
960 min Summer	98.236	0.036	1.0	1.2	O K
1440 min Summer	98.214	0.014	0.8	0.4	O K
2160 min Summer	98.201	0.001	0.7	0.0	O K
2880 min Summer	98.200	0.000	0.5	0.0	O K
4320 min Summer	98.200	0.000	0.4	0.0	O K
5760 min Summer	98.200	0.000	0.3	0.0	O K
7200 min Summer	98.200	0.000	0.3	0.0	O K
8640 min Summer	98.200	0.000	0.2	0.0	O K
10080 min Summer	98.200	0.000	0.2	0.0	O K
15 min Winter	98.341	0.141	1.0	5.5	Flood Risk
30 min Winter	98.367	0.167	1.0	6.8	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	132.346	0.0	5.7	17
30 min Summer	87.582	0.0	7.5	31
60 min Summer	55.250	0.0	9.5	56
120 min Summer	33.670	0.0	11.6	88
180 min Summer	24.854	0.0	12.8	122
240 min Summer	19.911	0.0	13.7	156
360 min Summer	14.516	0.0	15.0	222
480 min Summer	11.600	0.0	16.0	286
600 min Summer	9.741	0.0	16.8	344
720 min Summer	8.441	0.0	17.5	404
960 min Summer	6.728	0.0	18.6	518
1440 min Summer	4.879	0.0	20.2	748
2160 min Summer	3.532	0.0	21.9	1100
2880 min Summer	2.805	0.0	23.2	0
4320 min Summer	2.025	0.0	25.1	0
5760 min Summer	1.605	0.0	26.6	0
7200 min Summer	1.339	0.0	27.7	0
8640 min Summer	1.155	0.0	28.7	0
10080 min Summer	1.018	0.0	29.5	0
15 min Winter	132.346	0.0	6.4	17
30 min Winter	87.582	0.0	8.4	31

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Causeway	Source Control 2020.1	

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	98.380	0.180	1.0	7.5	Flood Risk
120 min Winter	98.374	0.174	1.0	7.2	Flood Risk
180 min Winter	98.361	0.161	1.0	6.5	Flood Risk
240 min Winter	98.346	0.146	1.0	5.7	Flood Risk
360 min Winter	98.314	0.114	1.0	4.2	Flood Risk
480 min Winter	98.284	0.084	1.0	3.0	O K
600 min Winter	98.258	0.058	1.0	2.0	O K
720 min Winter	98.238	0.038	1.0	1.2	O K
960 min Winter	98.217	0.017	0.9	0.5	O K
1440 min Winter	98.201	0.001	0.7	0.0	O K
2160 min Winter	98.200	0.000	0.5	0.0	O K
2880 min Winter	98.200	0.000	0.4	0.0	O K
4320 min Winter	98.200	0.000	0.3	0.0	O K
5760 min Winter	98.200	0.000	0.2	0.0	O K
7200 min Winter	98.200	0.000	0.2	0.0	O K
8640 min Winter	98.200	0.000	0.2	0.0	O K
10080 min Winter	98.200	0.000	0.1	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	55.250	0.0	10.7	58
120 min Winter	33.670	0.0	13.0	96
180 min Winter	24.854	0.0	14.4	134
240 min Winter	19.911	0.0	15.4	170
360 min Winter	14.516	0.0	16.8	238
480 min Winter	11.600	0.0	17.9	300
600 min Winter	9.741	0.0	18.8	358
720 min Winter	8.441	0.0	19.6	412
960 min Winter	6.728	0.0	20.8	514
1440 min Winter	4.879	0.0	22.6	736
2160 min Winter	3.532	0.0	24.6	0
2880 min Winter	2.805	0.0	26.0	0
4320 min Winter	2.025	0.0	28.2	0
5760 min Winter	1.605	0.0	29.8	0
7200 min Winter	1.339	0.0	31.0	0
8640 min Winter	1.155	0.0	32.1	0
10080 min Winter	1.018	0.0	33.0	0

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Causeway	Source Control 2020.1	

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	19.500	Shortest Storm (mins)	15
Ratio R	0.383	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.023

Time From:	(mins) To:	Area (ha)
0	4	0.023

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Causeway	Source Control 2020.1	

Model Details

Storage is Online Cover Level (m) 98.600

Tank or Pond Structure

Invert Level (m) 98.200

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	30.0	0.400	94.0	0.401	0.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0054-1000-0450-1000
Design Head (m)	0.450
Design Flow (l/s)	1.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	54
Invert Level (m)	98.150
Minimum Outlet Pipe Diameter (mm)	75
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.450	1.0
Flush-Flo™	0.132	1.0
Kick-Flo®	0.301	0.8
Mean Flow over Head Range	-	0.9

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	1.0	1.200	1.5	3.000	2.4	7.000	3.5
0.200	1.0	1.400	1.7	3.500	2.5	7.500	3.7
0.300	0.8	1.600	1.8	4.000	2.7	8.000	3.8
0.400	0.9	1.800	1.9	4.500	2.8	8.500	3.9
0.500	1.0	2.000	2.0	5.000	3.0	9.000	4.0
0.600	1.1	2.200	2.0	5.500	3.1	9.500	4.1
0.800	1.3	2.400	2.1	6.000	3.3		
1.000	1.4	2.600	2.2	6.500	3.4		

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Appendix E – Drainage Maintenance Schedule

Drainage Maintenance Schedule and Implementation Timetable

The schedule below indicates the recommended minimum maintenance requirement to provide a fully functioning drainage system. It is recommended that this schedule is regularly reviewed by the operator and where necessary the actions and frequency are updated to reflect the ongoing operation of the facility.

Any communal parts of the development, are assumed to have a maintenance and repairing provision included in a 'Deed of Conditions' or similar within each plot's title deeds. A facilities management company will need to be established for ongoing maintenance in line with the deeds.

No man entry is permitted into manholes or enclosed spaces unless performed by fully qualified personnel. Main yearly inspection to be undertaken after leaf fall in Autumn. Approved safety procedures must be followed.

Ref	Maintenance Item	Required Action	Frequency
01	Below Ground Drainage Pipework	All drainage to be fully jetted and inspected for integrity by CCTV survey. Where pipework is damaged or obstructed localised repairs will be needed immediately to ensure operation of drainage systems.	10 yearly As required
02	Manholes	Inspect manholes and for integrity and debris. Remove cover and ensure water is flowing freely and unobstructed. Clean out blockages and repair damage	5 yearly As required
03	Roof Gutters	Visually inspect gutters for leaves and debris. Clearing/jetting of gutters to remove build-up of debris and leaves to prevent carry of material to below ground system. Waste material to be disposed to refuse.	Annually As required
04	External gullies	Inspect surface water gullies and silt traps To be cleaned with vacuum tanker when silt exceeds 50% of catch pit depth	Annually As required
05	Attenuation Basins	Cut grass in and around basin/swale, including; embankment, access routes, across main storage area and amenity areas. Retain grass lengths 75-150mm across main treatment area. Dispose of cuttings to prevent blocking outlet and controls. Inspect inlets and outlets for blockages, and clear if required. Remove sediment or build-up of debris/detritus from basin once deposits exceed 25mm in depth.	Half yearly (spring-before nesting season, and autumn) 6 Monthly Every 5 years or as required
06	Overland flow paths	Inspection of overland flow routes to ensure route not blocked by new structures, furniture, overgrown vegetation, walls or debris. Remove and maintain as necessary	Annually
07	Permeable Paving	Brush regularly and remove excess sweepings from surfaces using light vacuum sweeping if necessary. (Care should be taken in adjusting vacuuming equipment to avoid removal of jointing material. Any lost material should be replaced.) Inspect joints and where required remove silts/ moss/weeds. Replace with clean joint material. Monitor effectiveness of pavement and ability to infiltrate. If infiltration ineffective undertake specialist pressure jetting cleaning as necessary. Where cleaning is not practicable reinstate/replace top layers.	Annually Annually 5 yearly (or as required)
09	Flow Control	Remove cover and inspect, ensuring that water is flowing freely and that the exit route for water is unobstructed. Remove debris and silt.	Annually

Record Keeping

To ensure the above maintenance regime is followed the appropriate management organisation will draw up a suitable maintenance schedule for completion by the relevant operatives and signed off by the relevant manager. The schedule will be based on the above table and will include:

- Date of maintenance inspection.
- 'Undertaken By' boxes to confirm inspection items carried out and by whom.
- A comments column to record condition of items inspected and what maintenance actions need to be taken or procedures to be instigated to correct any non-compliance with the operation strategy
- A column for confirming maintenance and/or rectification works have been carried out.
- An overall signature space for sign off by a competent member of the management team.

Appendix F – Wessex Water Sewer Record

