Surface Water Drainage Design Report

Former Bus Depot

High Street

Herne Bay

CT6 5LE

Coastal Developments Ltd

12th December 2018

RMB Consultants (Civil Engineering) Ltd
39 Cossington Road
Canterbury
Kent
CT1 3HU

Tel 01227 472128
www.rmbconsultants.co.uk

RMB eng.co.uk

1. Introduction

The following surface water drainage design report has been produced for the development at the Former Bus Depot, High Street, Herne Bay, CT6 5LE. The development consists of the demolition of the bus depot and the construction of retail space and residential dwellings at the former bus depot site.

This design parameters document provides details for the discharge of Condition 3 of Planning Permission 17/02055.

Condition 3

No development (other than demolition) shall take place until details of the means of foul and surface water disposal, including a detailed sustainable surface water drainage scheme for the site based on the submitted Flood Risk Assessment by Herrington Consulting Limited dated December 2017 that is compliant with the non-statutory technical standards for sustainable drainage and shall demonstrate the surface water run off generated up to and including the 100yr critical storm (including allowance for climate change) will not exceed the run off from the undeveloped site following the corresponding rainfall event, and so as not to increase the risk of flooding both on- or off-site, and including details for the implementation and long term management I maintenance of all surface water drainage infrastructure on site, the provision of measures to prevent the discharge of surface water onto the highway and the adequate management of silt and pollutants from the site use and construction to ensure there is no pollution risk to receiving waters, and a Verification Report pertaining to it have been submitted to and agreed in writing by the Local Planning Authority. The development shall be carried out in accordance with such details as are agreed and thereafter maintained.

Reason: *To ensure adequate drainage provision, prevent pollution and protect water quality on / off site, in accordance with policies CC11, CC12, CC13 and QL12 of the Canterbury District Local Plan 2017 and the National Planning Policy Framework.*

2. Local Development Documents

Canterbury District Local Plan Adopted July 2017

The following Policies are relevant to the foul and surface water drainage design:

Policy CC11 Sustainable Drainage Systems

All development applications should include drainage provision. This will ensure that surface water is appropriately controlled within the development site, manage flood risk on-site and off-site, and not exacerbate any existing flood risk in the locality. Within major[1] development sustainable drainage systems that deliver other benefits, such as biodiversity, water quality improvements and amenity, are expected to be included, except where they are demonstrated to be inappropriate. All developments should achieve as close to possible to the City Council's stipulated greenfield runoff rates, mimic natural flows and drainage pathways and ensure that surface water run-off is managed as close to its source as possible using the following hierarchy:

1. *Discharge into the ground*
2. *Discharge to a surface water body*
3. *Discharge to a surface water sewer, highway drain or other drainage system.*
4. *Discharge to a combined sewer where there are absolutely no other options, and only where agreed in advance with the relevant sewage undertaker.*

Any drainage scheme must manage all sources of surface water, including exceedance flows and surface flows from offsite, provide for emergency ingress and egress and ensure adequate drainage connectivity. It will not be acceptable for surface water runoff to enter the foul water system.

SuDS or other appropriate measures should:

a. *Maintain public safety;*
b. *Provide sufficient attenuation to surface water flows as appropriate;*
c. *Ensure that there is adequate treatment of surface water flows, such that there is no diminution in quality of any receiving watercourse;*
d. *Ensure protection of groundwater; and*
e. *Provide or enhance wetland habitat and biodiversity where possible.*

On major and strategic developments it should be shown how this infrastructure will be delivered over the different building phases to ensure that schemes are delivered as envisaged and that ongoing and future flood risk is managed.

Approval of the design and long term management and maintenance of SuDS will be required prior to the development commencing.

Footnote: [1] As defined in Article 2 of the Town and Country Planning (Development Management Procedure) (England) Order 2015 (no.595) or any later amendment

Policy CC12 Water Quality

The City Council will require that new development incorporates well designed mitigation measures to ensure that the water environment does not deteriorate, both during construction and during the lifetime of the development. Furthermore, the City Council will seek to ensure that every opportunity is taken to enhance existing aquatic environments and ecosystems. This will include the restoration of natural river features (including riverbanks) and removal of barriers to fish passage when appropriate opportunities arise.

Any new development should not compromise Water Framework Directive objectives.

Policy CC13 Water Resources

The City Council will ensure that development is phased using appropriate time scales for the construction of any necessary water and/or wastewater infrastructure associated with development proposals. The City Council will consult in detail with water companies and the Environment Agency to ensure the need for new water services infrastructure is understood and planned for.

All new housing or commercial development will need to incorporate suitable arrangements for the disposal of foul water into a sewerage system, at the nearest point of adequate capacity, in consultation with the service provider. Development should minimise water use as far as practicable by incorporating appropriate water efficiency and water recycling measures. In new homes, the City Council will seek a required level of 110 litres maximum daily allowable usage per person in accordance Regulation 36(2)(b) of the Building Regulations 2010 (as amended).

Policy QL12 Potentially Polluting Development

When granting planning permission for development which could potentially result in pollution, the City Council will impose conditions or seek agreements to ensure subsequent mitigation measures are undertaken.

Guidance Note – Canterbury City Council, Surface Water Drainage Pro-forma

Canterbury City Council has published a guidance note covering surface water drainage for new development within the district. This splits the district into four Drainage Zones. The site lies within Drainage Zone 1.

For brownfield sites, all developments must make best endeavours to reduce the post development discharge rates to greenfield rates, under all return period rainfall events. Only if it can be demonstrated that it is not possible to achieve the greenfield runoff rate(s), can the rate of surface water discharged from a brownfield development be higher than greenfield runoff rates. In this case the proposals must never exceed 50% of the existing discharge rate for the site, including the appropriate allowance for climate change.

For sites within Drainage Zone 1 the greenfield limiting discharge rate has been set to a specific rate of 4 l/s/ha, which must be achieved for all return period events.

Kent County Council Drainage and Planning Policy Statement

This policy statement sets out how Kent County Council, as Lead Local Flood Authority and statutory consultee, will review drainage strategies and surface water management provisions associated with applications for major development.

For brownfield sites the following policy applies:

SuDS Policy 4: Seek to Reduce Existing Flood Risk

New development should be designed to take full account of any existing flood risk, irrespective of the source of flooding.

Where a site or its immediate surroundings have been identified to be at flood risk, all opportunities to reduce the identified risk should be investigated at the masterplanning stage of design and subsequently incorporated at the detailed design stage.

For brownfield sites, and unless demonstrated to be reasonably impracticable, we would expect a 50% reduction in the peak runoff rate.

3. Site Characteristics

Location - The site is located in Herne Bay Town Centre. It is bounded by roads on three sides with the High Street to the north, Richmond Street to the west and Hanover Street to the south, Figure 1.

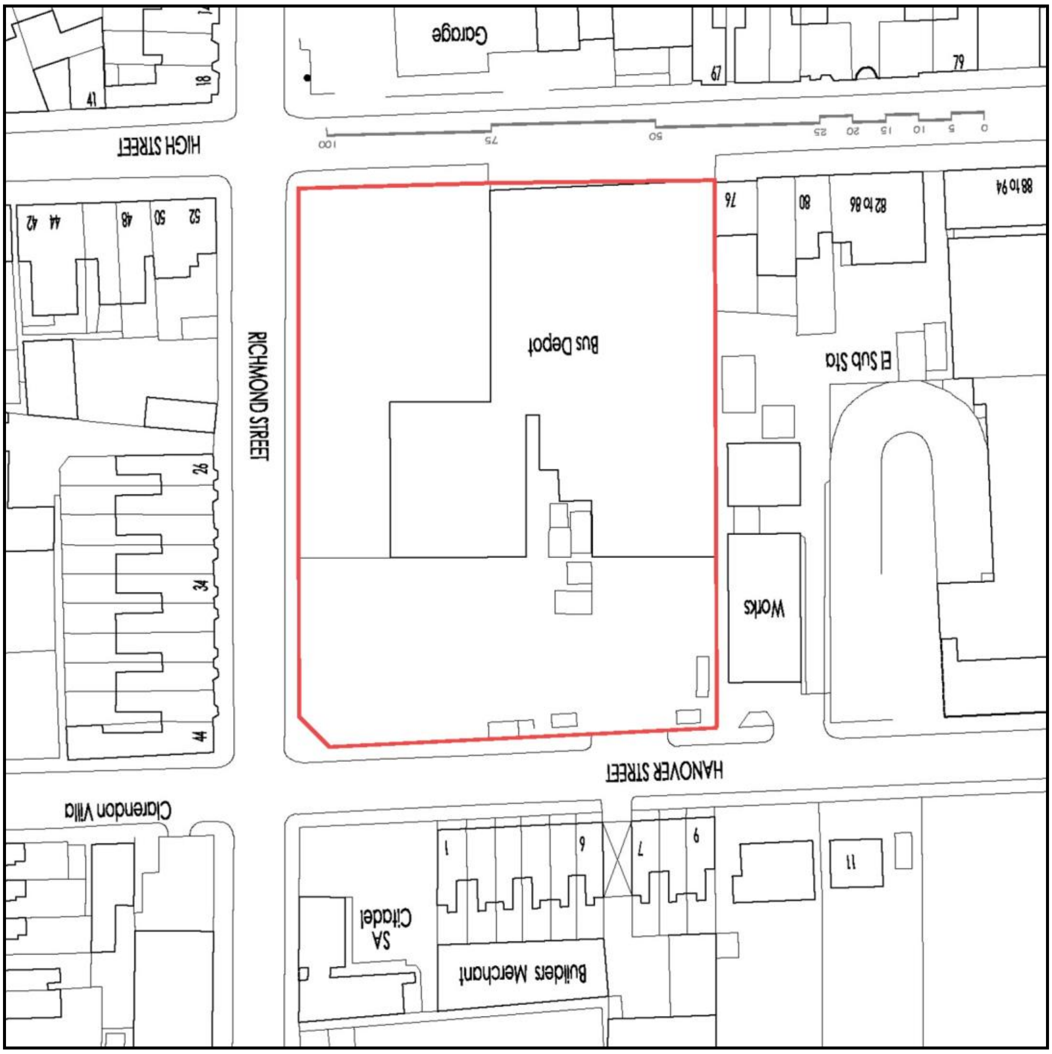

Figure 1. Site location.

Topography - A detailed topographical survey has been undertaken. The site falls from north to south. The High Street is at approximately 4.64mAOD (Above Ordnance Datum). Hanover Street is at approximately 3.31mAOD, Figure 2.

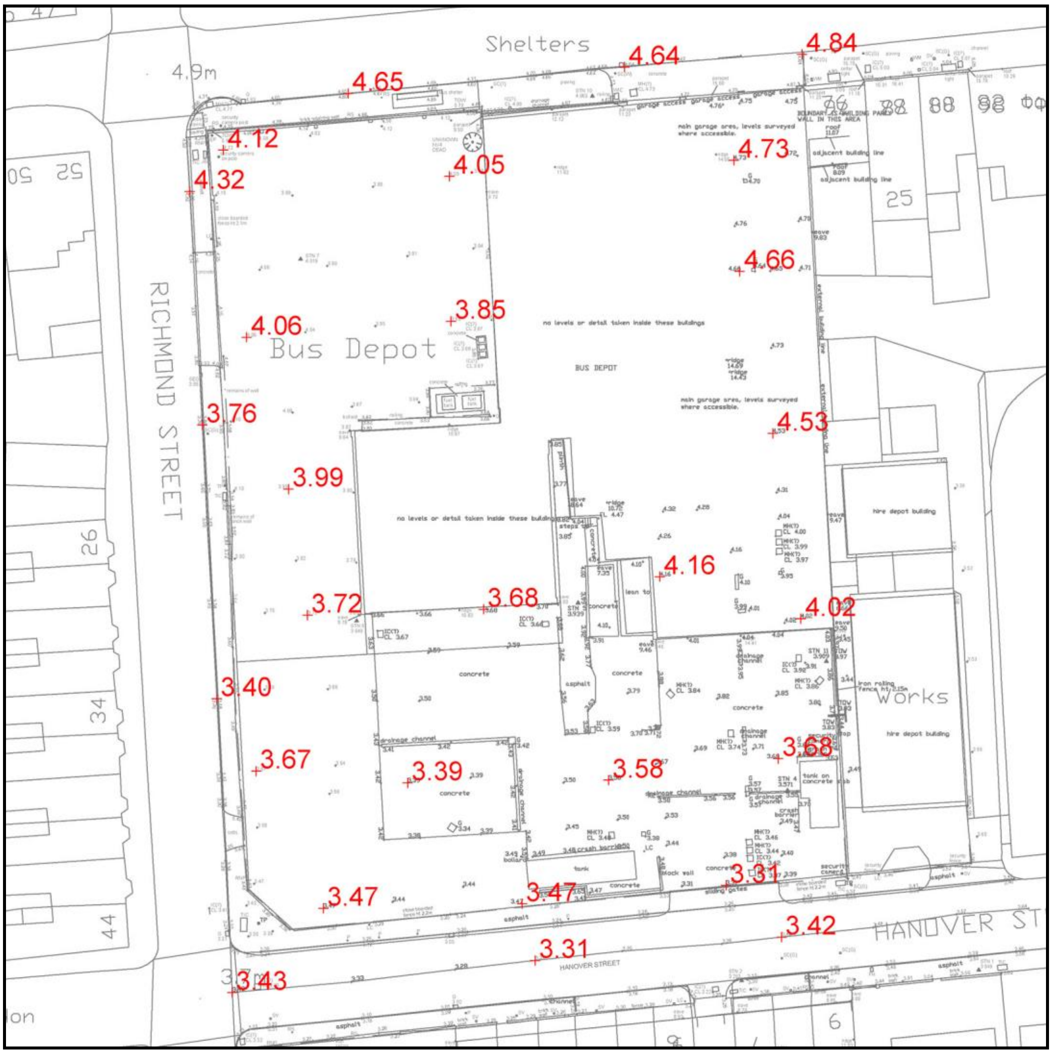

Figure 2. Local topography.

Geology - The bedrock geology consists of London Clay, clay and silt. Superficial deposits are recorded over the far north west corner of the site and consist of Head, clay and silt. Soils are classified as loamy soils with naturally high groundwater, draining to local shallow groundwater.

Groundwater - The site does not lie within any groundwater source protection zones. Records of boreholes sunk near the site indicate that resting groundwater is close to the surface.

Rainfall Data - Point rainfall data has been obtained from the Flood Estimation Handbook (FEH) Web Service. The FEH 2013 XML rainfall data has been used in the surface water drainage design. This provides rainfall data for return periods greater than 2 years.

Sewer Record - The site is served by public foul and surface water sewers, Figure 3. A surface water sewer runs west to east along Hanover Street, south of the site. Foul sewers run along the High Street and Richmond Street. The majority of these sewers are likely to be combined sewers taking surface water as well as foul water.

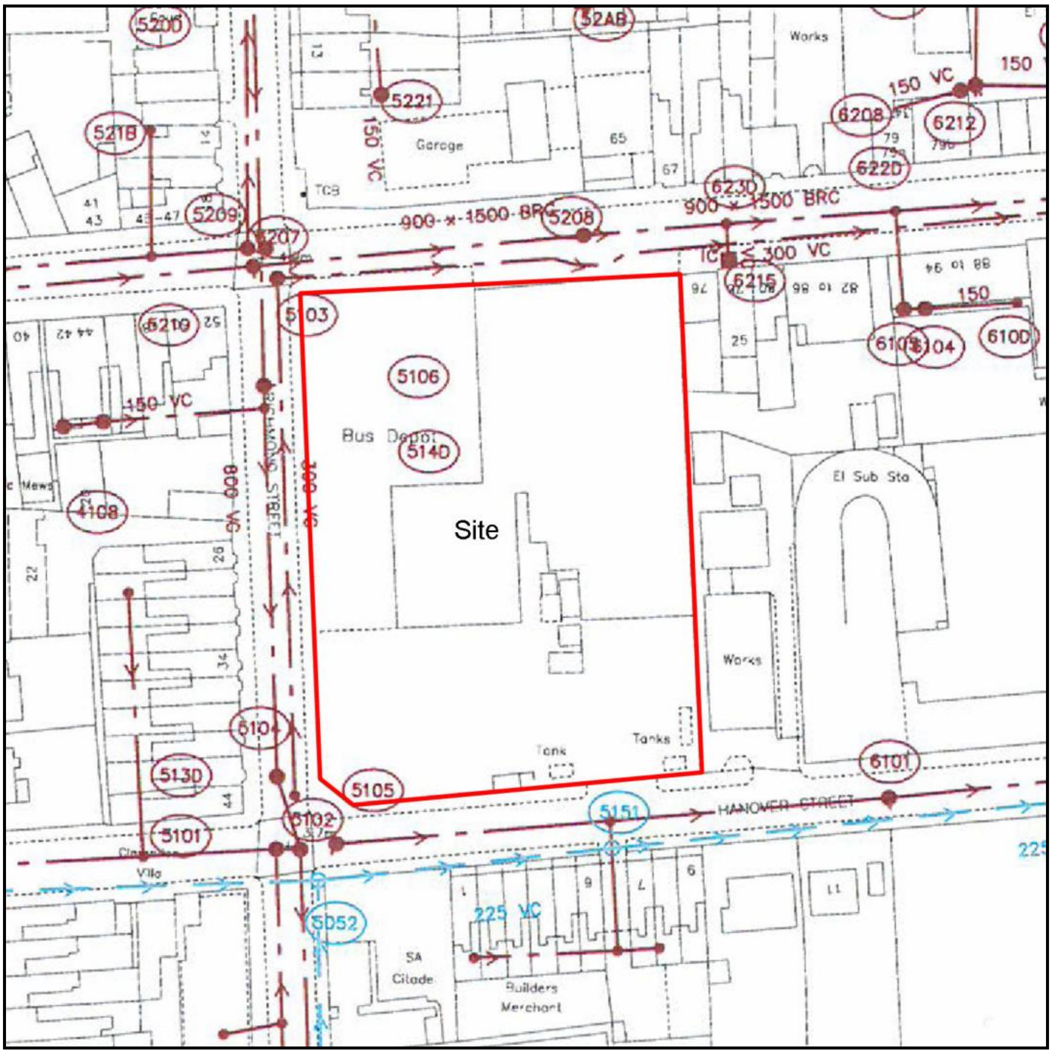

Figure 3. Public sewer record.

Existing Drainage - The site lies within the Plenty Brook catchment. The Plenty Brook outfalls to the sea north of the site. The watercourse has been culverted and forms part of the public surface water sewerage network within the town centre.

The site covers 5,350m^2. The entire site is covered with impermeable materials.

Greenfield Runoff - The peak greenfield runoff for the critical storm duration for the site has been calculated using the IH124 method from the greenfield runoff rate estimation tool published online by HR Wallingford at uksuds.com. The peak runoff is shown in Table 1 for 1ha and for the site area.

Return Period	Runoff Rate Q l/s	
	per ha.	Site (0.535 ha)
QBar	3.9	2.1
1	3.3	1.8
30	8.9	4.8
100	12.3	6.6

Table 1. Greenfield runoff rate for the site.

4. Proposed Development

The proposed development consists of the construction of four blocks and a bin store. Impermeable surfaces will cover 4,200m^2, consisting of 2,250m^2 of roof and 1,950m^2 of paving, Figure 4.

Figure 4. Proposed impermeable areas.

The peak rate of runoff and volume of runoff for the critical storm duration for the existing and proposed site, is shown in Table 2.

Storm Return Period (years)	Peak Runoff (Q l/s)		Volume of Runoff 360 minute duration storm (m^3)	
	Existing (5,350m^2)	Proposed (4,200m^2)	Existing (5,350m^2)	Proposed (4,200m^2)
2	50	39	121	96
30	114	90	240	188
100	147	115	326	256
100 + 20%	176	139	392	308
100 + 40%	205	162	457	359

Table 2. Peak rate of runoff and volume of runoff from the existing and proposed site.

5. Surface Water Management Strategy

The London Clay geology and high groundwater level means that an attenuated discharge to the public surface water sewer is the most appropriate surface water management strategy.

Canterbury City Council drainage guidance requires best endeavours to achieve a discharge rate of 4 l/s/ha. Only if it can be demonstrated that it is not possible to this rate, can the rate of surface water discharged from a brownfield development be higher. In this case the proposals must never exceed 50% of the existing discharge rate for the site, including the appropriate allowance for climate change.

For an impermeable site area of 0.42ha the limiting discharge is 1.7 l/s. The guidance states that if the attenuated flow rate is too low, this could result in blockages in flow control device. In this case an alternative discharge rate of 2 l/s is acceptable.

The site is subject to several constraints which reduce the opportunities for limiting discharge from the site:

1. The depth to invert of the existing connection to the surface water sewer within Hanover Street is shallow, 1m deep.
2. The levels need to match the existing street levels on three sites. This further constrains the depth at which any attenuation can be provided, particularly along the Hanover Street frontage.
3. Refuse vehicle access is required to the main access, increasing the cover required for attenuation crates.

It is not practical to provide one attenuation structure to serve the whole development and limit runoff to 2 l/s. The only effective way to do this would be to provide storage crates at least 800mm deep and there is insufficient depth at the outlet to achieve this. Given that the existing site is 100% covered with impermeable materials and the site constraints it is not considered practical to limit discharge from the site to greenfield runoff rates. This strategy aims to limit runoff to 25% of the existing site runoff, 12.5 l/s. This is better than the requirements set out by Canterbury City Council and Kent County Council which require a minimum reduction in existing runoff of 50%.

The site has been split into three catchments.

A. Covering the relatively flat area over the north and east of the site.
B. The western and southern parts of the site fronting Richmond Street and Hanover Street, west of the access.
C. The part of the site fronting Hanover Street east of the access.

Permeable paving and attenuation crates are proposed. The levels mean that attenuation is required within the access road. As sufficient cover for standard crates, generally 800mm, cannot be provided due to the shallow invert level of the outfall, Permavoid subbase replacement crates are proposed. These can be laid with a cover of 300mm.

Catchment A

The proposal is to discharge surface water runoff from roofs and paved areas to permeable paving. The catchment is shown in Figure 5.

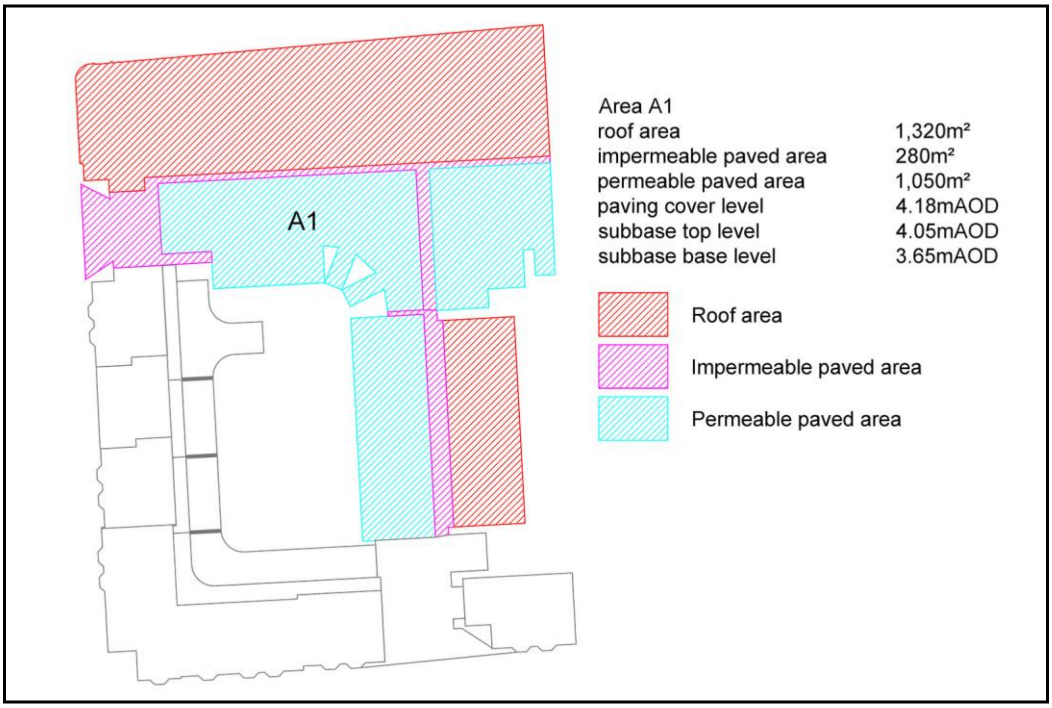

Figure 5. Catchment A.

The design parameters are shown in Table 3. The paving has been analysed using MicroDrainage Source Control published by XP Solutions. The analysis for the 1 in 100 year plus 20% allowance for climate change event is shown in Appendix A.

Parameter	Catchment A - Permeable Paving				
Rainfall return period	2 year	30 year	100 year	100 year + 20%	100 year + 40%
Contributing area	2,650m^2	2,650m^2	2,650m^2	2,650m^2	2,650m^2
Paving area	1,050m^2	1,050m^2	1,050m^2	1,050m^2	1,050m^2
Subbase Depth	0.4m	0.4m	0.4m	0.4m	0.4m
Porosity	30%	30%	30%	30%	30%
Hydrobrake control	5 l/s	5 l/s	5 l/s	5 l/s	5 l/s
Maximum discharge	4.2 l/s	4.5 l/s	4.7 l/s	4.9 l/s	5.3 l/s
Maximum water depth	0.055m	0.175m	0.256m	0.341m	0.539m
Half drain time	38 minutes	113 minutes	149 minutes	195 minutes	233 minutes
Flood volume	-	-	-	-	9.2 m^3

Table 3. Design parameters for Catchment A permeable paving.

Catchment B

The proposal is to discharge surface water runoff from roofs and paved areas to permeable paving and Permavoid subbase replacement storage crates. The catchment is shown in Figure 6.

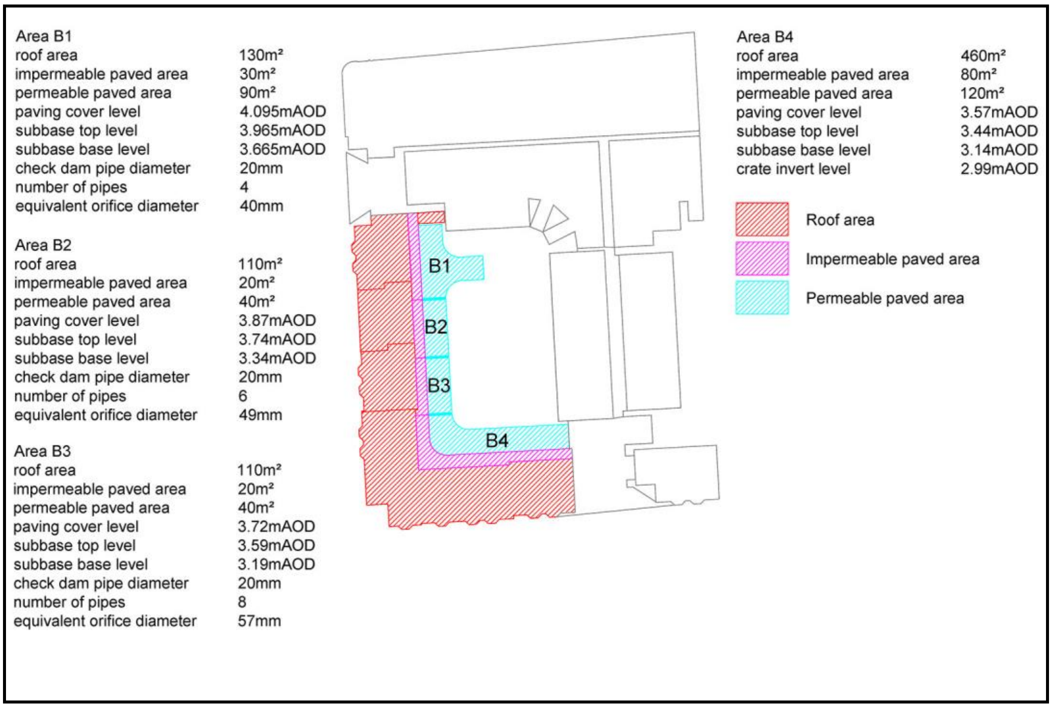

Figure 6. Catchment B.

The catchment has been modelled as four sub-catchments with check dams between them to maximise water storage. The check dams have been modelled as a single office but will be constructed with 20mm diameter holes as set out in Table 4.

Catchment	Number of 20mm diameter holes	Equivalent diameter orifice
B1	4	40mm
B2	6	49mm
B3	8	57mm

Table 4. Check dam modelling.

Catchment B4 consists of permeable paving and attenuation crate storage. To model this in Source Control the volume of storage has been converted to an increased depth in the attenuation storage. The permeable paving is 300mm deep and covers 120m^2. At 30% voids this equates to 10.8m^3 of storage. The attenuation crates are 4.248m x 17.700m x 150mm deep. The crates cover 75.2m^2. The void space within the crates is 95%. The storage volume has been increased to 11.4m^3 to allow for this. This increased volume, 11.4m^3 over 75.2m^2 equates to an increased depth of 150mm.

The design parameters for Catchment B are shown in Table 5. The catchment has been analysed as cascading ponds using MicroDrainage Source Control published by XP Solutions. The analysis for the 1 in 100 year plus 20% allowance for climate change event is shown in Appendix B.

Parameter	Catchment B - Permeable Paving/Attenuation Crates				
Rainfall return period	2 year	30 year	100 year	100 year + 20%	100 year + 40%
Contributing area	1,250m^2	1,250m^2	1,250m^2	1,250m^2	1,250m^2
Paving area	290m^2	290m^2	290m^2	290m^2	290m^2
Crate area	75.2m^2	75.2m^2	75.2m^2	75.2m^2	75.2m^2
Hydrobrake control	5 l/s	5 l/s	5 l/s	5 l/s	5 l/s
Maximum discharge	3.5 l/s	4.1 l/s	4.6 l/s	4.9 l/s	5.9 l/s
Maximum water depth	0.029m	0.157m	0.245m	0.338m	0.584m
Half drain time	5 minutes	26 minutes	37 minutes	45 minutes	47 minutes
Flood volume	-	-	-	-	4.1 m^3

Table 5. Design parameters for Catchment B permeable paving/attenuation crates.

Catchment C

The proposal is to discharge surface water runoff from roofs and paved areas to Permavoid subbase replacement storage crates. The catchment is shown in Figure 7.

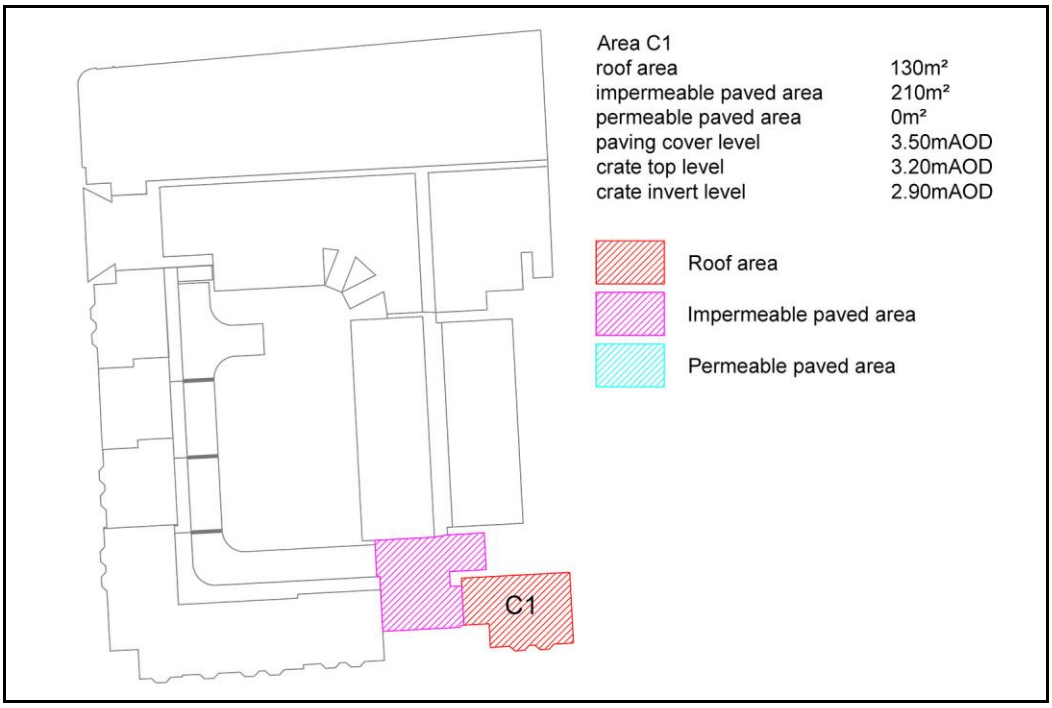

Figure 7. Catchment C.

The design parameters are shown in Table 6. The crates have been analysed using MicroDrainage Source Control published by XP Solutions. The analysis for the 1 in 100 year plus 20% allowance for climate change event is shown in Appendix C.

Parameter	**Catchment C - Attenuation Crates**				
Rainfall return period	2 year	30 year	100 year	100 year + 20%	100 year + 40%
Contributing area	280m^2	280m^2	280m^2	280m^2	280m^2
Crate area	19.3m^2	19.3m^2	19.3m^2	19.3m^2	19.3m^2
Crate depth	0.3m	0.3m	0.3m	0.3m	0.3m
Hydrobrake control	2.5 l/s	2.5 l/s	2.5 l/s	2.5 l/s	2.5 l/s
Maximum discharge	1.7 l/s	2.1 l/s	2.3 l/s	2.5 l/s	3.1 l/s
Maximum water depth	0.023m	0.153m	0.230m	0.298m	0.600m
Half drain time	3 minutes	13 minutes	18 minutes	22 minutes	23 minutes
Flood volume	-	-	-	-	0.5 m^3

Table 6. Design parameters for Catchment C attenuation crates.

The peak discharge from the existing and proposed site is shown in Table 7.

Development	2 year	30 year	100 year	100 year + 20%	100 year + 40%
Existing	50 l/s	114 l/s	147 l/s	176 l/s	205 l/s
Proposed	9.4 l/s	10.7 l/s	11.6 l/s	12.3 l/s	14.3 l/s

Table 7. Peak discharge from the existing and proposed site.

The proposed surface water drainage strategy reduces peak runoff from the site to below 12.5 l/s under all storm events up to and including the 1 in 100 year with a 20% allowance for climate change. This is 25% of the peak runoff under the 2 year event for the existing site.

The drainage layout is shown on drawings *857/301A Foul and Surface Water Drainage Layout* and *857/302A Permeable and Impermeable Paving Layout*.

The above demonstrates that a suitable surface water drainage scheme has been designed to serve the proposed development in accordance with Condition 3 of the planning permission.

6. Water Quality

The SuDS Manual gives the following as standards of good practice for water quality:

Water quality standard 1: Prevent runoff from the site to receiving surface waters for the majority of small rainfall events.

No runoff should be discharged from the site to receiving surface waters or sewers for the majority of small (eg < 5 mm) rainfall events. This is termed Interception.

Water quality standard 2: Treat runoff to prevent negative impacts on the receiving water quality.

Runoff should be adequately treated to protect the receiving water body from:

1. Short-term acute pollution that may result from accidental spills or temporary high pollution loadings within the catchment area.
2. Long-term chronic pollution from the spectrum of runoff pollutant sources within the urban environment.

Water Quality Standard 1 - Interception

The use of permeable paving will allow runoff under smaller events to be retained on site. This promotes evaporation. The proposed strategy therefore meets the interception standard.

Water Quality Standard 2 - Treatment

The extent of treatment required depends on the land use, the level of pollution prevention in the catchment and for groundwater the natural protection afforded by underlying soil layers. High hazard sites will have a higher potential pollution load and higher potential maximum pollution concentrations. They therefore tend to require more treatment than low hazard sites in order to deliver discharges of an acceptable quality.

The SuDS Manual sets out minimum water quality management requirements for discharges to receiving surface waters and groundwater for various land use types, Table 8. The site consists of two land use types:

1. Roofs classed as *residential roofs*, very low pollution hazard.
2. The access and parking areas classed as *property driveways/low traffic roads*, low pollution hazard.

Land use	Pollution hazard level	Requirements for discharge to:	
		surface waters	groundwater
Residential roofs	Very low	Removal of gross solids and sediments only	
Individual property driveways, roofs (excluding residential), residential car parks, low traffic roads (eg cul de sacs, home zones, general access roads), non-residential car parking with infrequent change (eg schools, offices)	Low	Simple index approach Note: extra measures may be required for discharges to protected resources	
Commercial yard and delivery areas, non-residential car parking with frequent change (eg hospitals, retail), all roads except low traffic roads and trunk roads/motorways	Medium	Simple index approach Note: extra measures may be required for discharges to protected resources	In England and Wales, Risk Screening must be undertaken first to determine whether consultation with the environmental regulator is required.
Trunk roads and motorways	High	Follow the guidance and risk assessment process set out in HA (2009)	
Sites with heavy pollution (eg haulage yards, lorry parks, highly frequented lorry approaches to industrial estates, waste sites), sites where chemicals and fuels are to be delivered, handled, stored, used or manufactured, industrial sites	High	Discharges may require an environmental licence or permit. Obtain pre-permitting advice from the environmental regulator. Risk assessment is likely to be required.	
Note 1. Filter drains can remove coarse sediments, but their use for this purpose will have significant implications with respect to maintenance requirements, and this should be taken into account in the design and Maintenance Plan. Note 2. Ponds and wetlands can remove coarse sediments, but their use for this purpose will have significant implications with respect to the maintenance requirements and amenity value of the system. Sediment should normally be removed upstream, unless they are specifically designed to retain sediment in a separate part of the component, where it cannot easily migrate to the main body of water. Note 3. Where a wetland is not specifically designed to provide significantly enhanced treatment, it should be considered as having the same mitigation indices as a pond.			

Table 8. Minimum water quality management requirements.

For each land use type a simple index approach is appropriate which involves the following steps:

1. Allocate suitable pollution hazard indices for the proposed land use, Table 9.
2. Select SuDS with a total pollution mitigation index that equals or exceeds the pollution hazard index, Table 10.
3. Where the discharge is to protected surface waters or groundwater, consider the need for a more precautionary approach.

Land Use	Pollution hazard level	Total suspended solids	Metals	Hydro-carbons
Residential Roofs	Very low	0.2	0.2	0.05
Other roofs (commercial/industrial)	Low	0.3	0.2[1]	0.05
Individual property driveways, residential car parks, low traffic roads and non-residential car parking with infrequent change (eg schools, offices) <300 traffic movements/day	Low	0.5	0.4	0.4
Commercial yard and delivery areas, non-residential car parking with frequent change (eg hospitals, retail), all roads except low traffic roads and trunk roads/motorways	Medium	0.7	0.6	0.7
Sites with heavy pollution (eg haulage yards, lorry parks, highly frequented lorry approaches to industrial estates, waste sites, sites where chemicals and fuels are to be delivered, handled, stored, used or manufactured, industrial sites, trunk roads and motorways[2]	High	0.8[3]	0.8[3]	0.9[3]
Note 1. Up to 0.8 where there is potential for metals to leach from the roof. Note 2. Motorways and trunk roads should follow the guidance and risk assessment process set out in Highways Agency (2009) Note 3. These should only be used if considered appropriate as part of a detailed risk assessment.				

Table 9. Pollution hazard indices for different land use classifications.

To deliver adequate treatment, the selected SuDS components should have a total pollution mitigation index, for each contaminant type, that equals or exceeds the pollution hazard index, for each contaminant type. Where the mitigation index of an individual component is insufficient, two components, or more, in series will be required. A factor of 0.5 is used to account for the reduced performance of secondary or tertiary components.

For residential roofs the removal of gross solids and sediments only, is required. This will be done by using silt traps. Permeable paving has a pollution mitigation index that is greater than the pollution hazard index for all pollutants for the land use types, Table 11. The impermeable paved area within catchment C will pass through trapped gullies or the Permachannel, a linear treatment system that combines run-off collection, silt and effluent interception and water treatment functions.

All runoff from the site will therefore receive an appropriate level of water quality treatment.

Type of SuDS component	Total suspended solids	Metals	Hydro-carbons
Filter strip	0.4	0.4	0.5
Filter drain	0.4[1]	0.4	0.4
Swale	0.5	0.6	0.6
Bioretention system	0.8	0.8	0.8
Permeable pavement	0.7	0.6	0.7
Detention basin	0.5	0.5	0.5
Pond	0.7[2]	0.7	0.5
Wetland[3]	0.8[2]	0.8	0.8
Proprietary treatment system	These must demonstrate that they can address each of the contaminant types to acceptable levels for frequent events up to approximately the 1in 1 year return period event, for inflow concentrations relevant to the contributing drainage area.		
Note 1. Filter drains can remove coarse sediments, but their use for this purpose will have significant implications with respect to maintenance requirements, and this should be taken into account in the design and Maintenance Plan. Note 2. Ponds and wetlands can remove coarse sediments, but their use for this purpose will have significant implications with respect to the maintenance requirements and amenity value of the system. Sediment should normally be removed upstream, unless they are specifically designed to retain sediment in a separate part of the component, where it cannot easily migrate to the main body of water. Note 3. Where a wetland is not specifically designed to provide significantly enhanced treatment, it should be considered as having the same mitigation indices as a pond.			

Table 10. Indicative SuDS mitigation indices for discharge to surface waters.

Indices	Total suspended solids	Metals	Hydro-carbons
Roofs			
Maximum hazard index	0.2	0.2	0.05
Minimum SuDS mitigation index (permeable paving)	0.7	0.6	0.7
Appropriate treatment	✓	✓	✓
Access road and parking areas			
Maximum hazard index	0.5	0.4	0.4
Minimum SuDS mitigation index (Pond)	0.7	0.6	0.7
Appropriate treatment	✓	✓	✓

Table 11. Pollution hazard indices and SuDS mitigation indices for the development.

7. Implementation

The permeable paving, attenuation crates and control structures will be installed before the occupation of the development. As 100% of the existing site is covered with impermeable materials the development will not increase runoff during the construction period.

8. Management and Maintenance

A Sustainable Urban Drainage Systems Management and Maintenance Plan is attached at Appendix D.

Appendix A - Catchment A

Summary of Results for 100 year Return Period (+20%)

Half Drain Time : 195 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	3.806	0.156	0.0	4.5	4.5	49.2	O K
30 min Summer	3.857	0.207	0.0	4.6	4.6	65.0	O K
60 min Summer	3.897	0.247	0.0	4.7	4.7	77.6	O K
120 min Summer	3.921	0.271	0.0	4.7	4.7	85.3	O K
180 min Summer	3.928	0.278	0.0	4.7	4.7	87.5	O K
240 min Summer	3.931	0.281	0.0	4.8	4.8	88.4	O K
360 min Summer	3.937	0.287	0.0	4.8	4.8	90.4	O K
480 min Summer	3.942	0.292	0.0	4.8	4.8	92.0	O K
600 min Summer	3.944	0.294	0.0	4.8	4.8	92.4	O K
720 min Summer	3.942	0.292	0.0	4.8	4.8	91.7	O K
960 min Summer	3.930	0.280	0.0	4.7	4.7	88.0	O K
1440 min Summer	3.890	0.240	0.0	4.7	4.7	75.4	O K
2160 min Summer	3.821	0.171	0.0	4.5	4.5	53.9	O K
2880 min Summer	3.762	0.112	0.0	4.4	4.4	35.1	O K
4320 min Summer	3.681	0.031	0.0	4.2	4.2	9.8	O K
5760 min Summer	3.650	0.000	0.0	4.1	4.1	0.0	O K
7200 min Summer	3.650	0.000	0.0	3.4	3.4	0.0	O K
8640 min Summer	3.650	0.000	0.0	2.9	2.9	0.0	O K
10080 min Summer	3.650	0.000	0.0	2.5	2.5	0.0	O K
15 min Winter	3.829	0.179	0.0	4.5	4.5	56.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	119.734	0.0	54.0	25
30 min Summer	78.587	0.0	72.5	38
60 min Summer	49.133	0.0	92.1	66
120 min Summer	30.027	0.0	113.7	122
180 min Summer	22.733	0.0	129.7	164
240 min Summer	18.777	0.0	143.2	196
360 min Summer	14.518	0.0	167.0	264
480 min Summer	12.171	0.0	187.0	336
600 min Summer	10.603	0.0	204.0	406
720 min Summer	9.453	0.0	218.5	476
960 min Summer	7.821	0.0	241.4	616
1440 min Summer	5.867	0.0	271.2	884
2160 min Summer	4.294	0.0	297.2	1264
2880 min Summer	3.404	0.0	312.9	1620
4320 min Summer	2.422	0.0	331.8	2296
5760 min Summer	1.895	0.0	343.7	0
7200 min Summer	1.565	0.0	352.3	0
8640 min Summer	1.338	0.0	358.9	0
10080 min Summer	1.172	0.0	364.1	0
15 min Winter	119.734	0.0	61.1	25

Summary of Results for 100 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	3.886	0.236	0.0	4.7	4.7	74.1	O K
60 min Winter	3.933	0.283	0.0	4.8	4.8	89.0	O K
120 min Winter	3.967	0.317	0.0	4.8	4.8	99.6	O K
180 min Winter	3.979	0.329	0.0	4.9	4.9	103.6	O K
240 min Winter	3.983	0.333	0.0	4.9	4.9	104.9	O K
360 min Winter	3.988	0.338	0.0	4.9	4.9	106.2	O K
480 min Winter	3.991	0.341	0.0	4.9	4.9	107.2	O K
600 min Winter	3.989	0.339	0.0	4.9	4.9	106.5	O K
720 min Winter	3.982	0.332	0.0	4.9	4.9	104.4	O K
960 min Winter	3.958	0.308	0.0	4.8	4.8	96.9	O K
1440 min Winter	3.893	0.243	0.0	4.7	4.7	76.3	O K
2160 min Winter	3.792	0.142	0.0	4.4	4.4	44.6	O K
2880 min Winter	3.711	0.061	0.0	4.2	4.2	19.3	O K
4320 min Winter	3.650	0.000	0.0	3.8	3.8	0.0	O K
5760 min Winter	3.650	0.000	0.0	2.9	2.9	0.0	O K
7200 min Winter	3.650	0.000	0.0	2.4	2.4	0.0	O K
8640 min Winter	3.650	0.000	0.0	2.1	2.1	0.0	O K
10080 min Winter	3.650	0.000	0.0	1.8	1.8	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	78.587	0.0	82.0	38
60 min Winter	49.133	0.0	103.7	66
120 min Winter	30.027	0.0	128.1	120
180 min Winter	22.733	0.0	145.9	176
240 min Winter	18.777	0.0	161.4	226
360 min Winter	14.518	0.0	187.8	284
480 min Winter	12.171	0.0	210.4	362
600 min Winter	10.603	0.0	229.1	442
720 min Winter	9.453	0.0	245.7	518
960 min Winter	7.821	0.0	271.0	666
1440 min Winter	5.867	0.0	304.6	948
2160 min Winter	4.294	0.0	334.1	1332
2880 min Winter	3.404	0.0	351.8	1676
4320 min Winter	2.422	0.0	373.5	0
5760 min Winter	1.895	0.0	387.1	0
7200 min Winter	1.565	0.0	397.1	0
8640 min Winter	1.338	0.0	404.9	0
10080 min Winter	1.172	0.0	411.2	0

Rainfall Details

Rainfall Model	FEH	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
FEH Rainfall Version	2013	Cv (Winter)	0.840
Site Location	GB 617561 168162	Shortest Storm (mins)	15
Data Type	Point	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+20

Time Area Diagram

Total Area (ha) 0.265

Time From:	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**
0	4	0.105	4	8	0.080	8	12	0.080

Model Details

Storage is Online Cover Level (m) 4.180

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	21.4
Membrane Percolation (mm/hr)	1000	Length (m)	49.0
Max Percolation (l/s)	291.3	Slope (1:X)	0.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	3.650	Cap Volume Depth (m)	0.400

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-CHE-0098-5000-1190-5000
Design Head (m)	1.190
Design Flow (l/s)	5.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	No
Diameter (mm)	98
Invert Level (m)	2.860
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	**Head (m)**	**Flow (l/s)**
Design Point (Calculated)	1.190	5.0
Flush-Flo™	0.241	4.9
Kick-Flo®	0.340	2.8
Mean Flow over Head Range	-	3.7

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	2.6	1.200	5.0	3.000	7.9	7.000	11.9
0.200	4.6	1.400	5.4	3.500	8.5	7.500	12.3
0.300	3.2	1.600	5.8	4.000	9.1	8.000	12.7
0.400	2.9	1.800	6.1	4.500	9.6	8.500	13.1
0.500	3.3	2.000	6.5	5.000	10.1	9.000	13.5
0.600	3.6	2.200	6.8	5.500	10.6	9.500	13.8
0.800	4.1	2.400	7.1	6.000	11.1		
1.000	4.6	2.600	7.3	6.500	11.5		

Appendix B - Catchment B

Cascade Summary of Results for Catchment B1 Permeable Paving 100+20.SRCX

Upstream Structures	Outflow To	Overflow To
(None)	Catchment B2 Permeable Paving 100+20.SRCX	(None)

Half Drain Time : 50 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	3.824	0.159	0.0	1.2	1.2	4.3	O K
30 min Summer	3.865	0.200	0.0	1.4	1.4	5.4	O K
60 min Summer	3.888	0.223	0.0	1.5	1.5	6.0	O K
120 min Summer	3.894	0.229	0.0	1.5	1.5	6.2	O K
180 min Summer	3.890	0.225	0.0	1.5	1.5	6.1	O K
240 min Summer	3.883	0.218	0.0	1.5	1.5	5.9	O K
360 min Summer	3.869	0.204	0.0	1.4	1.4	5.5	O K
480 min Summer	3.855	0.190	0.0	1.4	1.4	5.1	O K
600 min Summer	3.841	0.176	0.0	1.3	1.3	4.7	O K
720 min Summer	3.829	0.164	0.0	1.3	1.3	4.4	O K
960 min Summer	3.806	0.141	0.0	1.2	1.2	3.8	O K
1440 min Summer	3.772	0.107	0.0	1.0	1.0	2.9	O K
2160 min Summer	3.741	0.076	0.0	0.8	0.8	2.1	O K
2880 min Summer	3.725	0.060	0.0	0.7	0.7	1.6	O K
4320 min Summer	3.712	0.047	0.0	0.5	0.5	1.3	O K
5760 min Summer	3.705	0.040	0.0	0.4	0.4	1.1	O K
7200 min Summer	3.701	0.036	0.0	0.3	0.3	1.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	119.734	0.0	5.1	22
30 min Summer	78.587	0.0	6.9	32
60 min Summer	49.133	0.0	8.7	50
120 min Summer	30.027	0.0	10.8	84
180 min Summer	22.733	0.0	12.3	118
240 min Summer	18.777	0.0	13.6	152
360 min Summer	14.518	0.0	15.8	216
480 min Summer	12.171	0.0	17.7	280
600 min Summer	10.603	0.0	19.3	342
720 min Summer	9.453	0.0	20.7	404
960 min Summer	7.821	0.0	22.8	524
1440 min Summer	5.867	0.0	25.7	764
2160 min Summer	4.294	0.0	28.1	1124
2880 min Summer	3.404	0.0	29.6	1472
4320 min Summer	2.422	0.0	31.4	2200
5760 min Summer	1.895	0.0	32.6	2936
7200 min Summer	1.565	0.0	33.4	3672

Cascade Summary of Results for Catchment B1 Permeable Paving 100+20.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
8640 min Summer	3.698	0.033	0.0	0.3	0.3	0.9	O K
10080 min Summer	3.695	0.030	0.0	0.2	0.2	0.8	O K
15 min Winter	3.846	0.181	0.0	1.3	1.3	4.9	O K
30 min Winter	3.893	0.228	0.0	1.5	1.5	6.1	O K
60 min Winter	3.917	0.252	0.0	1.6	1.6	6.8	O K
120 min Winter	3.915	0.250	0.0	1.6	1.6	6.7	O K
180 min Winter	3.904	0.239	0.0	1.6	1.6	6.4	O K
240 min Winter	3.890	0.225	0.0	1.5	1.5	6.0	O K
360 min Winter	3.864	0.199	0.0	1.4	1.4	5.4	O K
480 min Winter	3.842	0.177	0.0	1.3	1.3	4.8	O K
600 min Winter	3.823	0.158	0.0	1.2	1.2	4.2	O K
720 min Winter	3.806	0.141	0.0	1.2	1.2	3.8	O K
960 min Winter	3.779	0.114	0.0	1.0	1.0	3.1	O K
1440 min Winter	3.745	0.080	0.0	0.8	0.8	2.2	O K
2160 min Winter	3.721	0.056	0.0	0.6	0.6	1.5	O K
2880 min Winter	3.713	0.048	0.0	0.5	0.5	1.3	O K
4320 min Winter	3.703	0.038	0.0	0.4	0.4	1.0	O K
5760 min Winter	3.698	0.033	0.0	0.3	0.3	0.9	O K
7200 min Winter	3.694	0.029	0.0	0.2	0.2	0.8	O K
8640 min Winter	3.691	0.026	0.0	0.2	0.2	0.7	O K
10080 min Winter	3.689	0.024	0.0	0.2	0.2	0.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	1.338	0.0	34.1	4384
10080 min Summer	1.172	0.0	34.6	5136
15 min Winter	119.734	0.0	5.8	22
30 min Winter	78.587	0.0	7.8	33
60 min Winter	49.133	0.0	9.8	54
120 min Winter	30.027	0.0	12.1	90
180 min Winter	22.733	0.0	13.8	126
240 min Winter	18.777	0.0	15.3	160
360 min Winter	14.518	0.0	17.8	228
480 min Winter	12.171	0.0	19.9	292
600 min Winter	10.603	0.0	21.7	354
720 min Winter	9.453	0.0	23.2	416
960 min Winter	7.821	0.0	25.6	538
1440 min Winter	5.867	0.0	28.8	772
2160 min Winter	4.294	0.0	31.6	1112
2880 min Winter	3.404	0.0	33.3	1472
4320 min Winter	2.422	0.0	35.3	2208
5760 min Winter	1.895	0.0	36.7	2920
7200 min Winter	1.565	0.0	37.6	3648
8640 min Winter	1.338	0.0	38.4	4368
10080 min Winter	1.172	0.0	39.0	5024

Cascade Rainfall Details for Catchment B1 Permeable Paving 100+20.SRCX

Rainfall Model	FEH	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
FEH Rainfall Version	2013	Cv (Winter)	0.840
Site Location	GB 617561 168162	Shortest Storm (mins)	15
Data Type	Point	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+20

Time Area Diagram

Total Area (ha) 0.025

Time From:	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**
0	4	0.009	4	8	0.008	8	12	0.008

Cascade Model Details for Catchment B1 Permeable Paving 100+20.SRCX

Storage is Online Cover Level (m) 4.095

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	6.8
Membrane Percolation (mm/hr)	1000	Length (m)	13.2
Max Percolation (l/s)	24.9	Slope (1:X)	0.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	3.665	Cap Volume Depth (m)	0.300

Orifice Outflow Control

Diameter (m) 0.040 Discharge Coefficient 0.600 Invert Level (m) 3.665

Cascade Summary of Results for Catchment B2 Permeable Paving 100+20.SRCX

Upstream Structures	Outflow To	Overflow To
Catchment B1 Permeable Paving 100+20.SRCX	Catchment B3 Permeable Paving 100+20.SRCX	(None)

Half Drain Time : 16 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	3.566	0.226	0.0	2.3	2.3	3.0	O K
30 min Summer	3.618	0.278	0.0	2.5	2.5	3.6	O K
60 min Summer	3.645	0.305	0.0	2.7	2.7	4.0	O K
120 min Summer	3.647	0.307	0.0	2.7	2.7	4.0	O K
180 min Summer	3.638	0.298	0.0	2.6	2.6	3.9	O K
240 min Summer	3.627	0.287	0.0	2.6	2.6	3.8	O K
360 min Summer	3.605	0.265	0.0	2.5	2.5	3.5	O K
480 min Summer	3.585	0.245	0.0	2.4	2.4	3.2	O K
600 min Summer	3.567	0.227	0.0	2.3	2.3	3.0	O K
720 min Summer	3.550	0.210	0.0	2.2	2.2	2.8	O K
960 min Summer	3.520	0.180	0.0	2.0	2.0	2.4	O K
1440 min Summer	3.476	0.136	0.0	1.7	1.7	1.8	O K
2160 min Summer	3.436	0.096	0.0	1.3	1.3	1.3	O K
2880 min Summer	3.415	0.075	0.0	1.1	1.1	1.0	O K
4320 min Summer	3.398	0.058	0.0	0.8	0.8	0.8	O K
5760 min Summer	3.390	0.050	0.0	0.6	0.6	0.7	O K
7200 min Summer	3.384	0.044	0.0	0.5	0.5	0.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	119.734	0.0	8.7	22
30 min Summer	78.587	0.0	11.7	32
60 min Summer	49.133	0.0	14.8	50
120 min Summer	30.027	0.0	18.2	84
180 min Summer	22.733	0.0	20.7	118
240 min Summer	18.777	0.0	22.9	150
360 min Summer	14.518	0.0	26.6	216
480 min Summer	12.171	0.0	29.8	278
600 min Summer	10.603	0.0	32.5	340
720 min Summer	9.453	0.0	34.8	402
960 min Summer	7.821	0.0	38.5	522
1440 min Summer	5.867	0.0	43.2	760
2160 min Summer	4.294	0.0	47.4	1116
2880 min Summer	3.404	0.0	50.0	1472
4320 min Summer	2.422	0.0	53.0	2204
5760 min Summer	1.895	0.0	55.0	2904
7200 min Summer	1.565	0.0	56.5	3648

Cascade Summary of Results for Catchment B2 Permeable Paving 100+20.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
8640 min Summer	3.380	0.040	0.0	0.5	0.5	0.5	O K
10080 min Summer	3.377	0.037	0.0	0.4	0.4	0.5	O K
15 min Winter	3.596	0.256	0.0	2.4	2.4	3.4	O K
30 min Winter	3.656	0.316	0.0	2.7	2.7	4.1	O K
60 min Winter	3.682	0.342	0.0	2.8	2.8	4.5	O K
120 min Winter	3.673	0.333	0.0	2.8	2.8	4.4	O K
180 min Winter	3.653	0.313	0.0	2.7	2.7	4.1	O K
240 min Winter	3.632	0.292	0.0	2.6	2.6	3.8	O K
360 min Winter	3.596	0.256	0.0	2.4	2.4	3.3	O K
480 min Winter	3.566	0.226	0.0	2.2	2.2	3.0	O K
600 min Winter	3.540	0.200	0.0	2.1	2.1	2.6	O K
720 min Winter	3.519	0.179	0.0	2.0	2.0	2.3	O K
960 min Winter	3.484	0.144	0.0	1.7	1.7	1.9	O K
1440 min Winter	3.440	0.100	0.0	1.4	1.4	1.3	O K
2160 min Winter	3.409	0.069	0.0	1.1	1.1	0.9	O K
2880 min Winter	3.399	0.059	0.0	0.8	0.8	0.8	O K
4320 min Winter	3.387	0.047	0.0	0.6	0.6	0.6	O K
5760 min Winter	3.381	0.041	0.0	0.5	0.5	0.5	O K
7200 min Winter	3.376	0.036	0.0	0.4	0.4	0.5	O K
8640 min Winter	3.372	0.032	0.0	0.3	0.3	0.4	O K
10080 min Winter	3.369	0.029	0.0	0.3	0.3	0.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	1.338	0.0	57.6	4400
10080 min Summer	1.172	0.0	58.5	5112
15 min Winter	119.734	0.0	9.8	22
30 min Winter	78.587	0.0	13.1	33
60 min Winter	49.133	0.0	16.6	54
120 min Winter	30.027	0.0	20.5	90
180 min Winter	22.733	0.0	23.3	126
240 min Winter	18.777	0.0	25.7	160
360 min Winter	14.518	0.0	29.9	226
480 min Winter	12.171	0.0	33.5	290
600 min Winter	10.603	0.0	36.5	352
720 min Winter	9.453	0.0	39.1	414
960 min Winter	7.821	0.0	43.2	536
1440 min Winter	5.867	0.0	48.6	772
2160 min Winter	4.294	0.0	53.3	1096
2880 min Winter	3.404	0.0	56.2	1468
4320 min Winter	2.422	0.0	59.6	2204
5760 min Winter	1.895	0.0	61.9	2936
7200 min Winter	1.565	0.0	63.6	3632
8640 min Winter	1.338	0.0	64.9	4416
10080 min Winter	1.172	0.0	66.0	5144

Cascade Rainfall Details for Catchment B2 Permeable Paving 100+20.SRCX

Rainfall Model	FEH	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
FEH Rainfall Version	2013	Cv (Winter)	0.840
Site Location	GB 617561 168162	Shortest Storm (mins)	15
Data Type	Point	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+20

Time Area Diagram

Total Area (ha) 0.017

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.004	4	8	0.006	8	12	0.007

Cascade Model Details for Catchment B2 Permeable Paving 100+20.SRCX

Storage is Online Cover Level (m) 3.870

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	4.2
Membrane Percolation (mm/hr)	1000	Length (m)	10.4
Max Percolation (l/s)	12.1	Slope (1:X)	0.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	3.340	Cap Volume Depth (m)	0.400

Orifice Outflow Control

Diameter (m) 0.049 Discharge Coefficient 0.600 Invert Level (m) 3.340

Cascade Summary of Results for Catchment B3 Permeable Paving 100+20.SRCX

Upstream Structures	Outflow To	Overflow To
Catchment B2 Permeable Paving 100+20.SRCX Catchment B1 Permeable Paving 100+20.SRCX	Catchment B4 Attenuation Crates 100+20.SRCX	(None)

Half Drain Time : 13 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	3.424	0.234	0.0	3.1	3.1	3.1	O K
30 min Summer	3.480	0.290	0.0	3.5	3.5	3.8	O K
60 min Summer	3.511	0.321	0.0	3.7	3.7	4.2	O K
120 min Summer	3.516	0.326	0.0	3.7	3.7	4.3	O K
180 min Summer	3.508	0.318	0.0	3.7	3.7	4.2	O K
240 min Summer	3.498	0.308	0.0	3.6	3.6	4.0	O K
360 min Summer	3.476	0.286	0.0	3.4	3.4	3.7	O K
480 min Summer	3.456	0.266	0.0	3.3	3.3	3.5	O K
600 min Summer	3.436	0.246	0.0	3.2	3.2	3.2	O K
720 min Summer	3.418	0.228	0.0	3.0	3.0	3.0	O K
960 min Summer	3.386	0.196	0.0	2.8	2.8	2.6	O K
1440 min Summer	3.338	0.148	0.0	2.3	2.3	1.9	O K
2160 min Summer	3.295	0.105	0.0	1.9	1.9	1.4	O K
2880 min Summer	3.273	0.083	0.0	1.6	1.6	1.1	O K
4320 min Summer	3.256	0.066	0.0	1.2	1.2	0.9	O K
5760 min Summer	3.247	0.057	0.0	0.9	0.9	0.7	O K
7200 min Summer	3.240	0.050	0.0	0.7	0.7	0.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	119.734	0.0	12.3	23
30 min Summer	78.587	0.0	16.4	33
60 min Summer	49.133	0.0	20.8	52
120 min Summer	30.027	0.0	25.6	86
180 min Summer	22.733	0.0	29.2	118
240 min Summer	18.777	0.0	32.2	152
360 min Summer	14.518	0.0	37.5	216
480 min Summer	12.171	0.0	42.0	280
600 min Summer	10.603	0.0	45.8	342
720 min Summer	9.453	0.0	49.0	404
960 min Summer	7.821	0.0	54.1	524
1440 min Summer	5.867	0.0	60.8	764
2160 min Summer	4.294	0.0	66.7	1124
2880 min Summer	3.404	0.0	70.3	1476
4320 min Summer	2.422	0.0	74.6	2200
5760 min Summer	1.895	0.0	77.4	2936
7200 min Summer	1.565	0.0	79.5	3632

Cascade Summary of Results for Catchment B3 Permeable Paving 100+20.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
8640 min Summer	3.236	0.046	0.0	0.6	0.6	0.6	O K
10080 min Summer	3.232	0.042	0.0	0.6	0.6	0.5	O K
15 min Winter	3.455	0.265	0.0	3.3	3.3	3.5	O K
30 min Winter	3.519	0.329	0.0	3.7	3.7	4.3	O K
60 min Winter	3.551	0.361	0.0	3.9	3.9	4.7	O K
120 min Winter	3.546	0.356	0.0	3.9	3.9	4.7	O K
180 min Winter	3.527	0.337	0.0	3.8	3.8	4.4	O K
240 min Winter	3.506	0.316	0.0	3.6	3.6	4.1	O K
360 min Winter	3.467	0.277	0.0	3.4	3.4	3.6	O K
480 min Winter	3.436	0.246	0.0	3.2	3.2	3.2	O K
600 min Winter	3.408	0.218	0.0	3.0	3.0	2.9	O K
720 min Winter	3.385	0.195	0.0	2.8	2.8	2.6	O K
960 min Winter	3.348	0.158	0.0	2.4	2.4	2.1	O K
1440 min Winter	3.300	0.110	0.0	1.9	1.9	1.4	O K
2160 min Winter	3.268	0.078	0.0	1.5	1.5	1.0	O K
2880 min Winter	3.257	0.067	0.0	1.2	1.2	0.9	O K
4320 min Winter	3.244	0.054	0.0	0.8	0.8	0.7	O K
5760 min Winter	3.237	0.047	0.0	0.7	0.7	0.6	O K
7200 min Winter	3.231	0.041	0.0	0.5	0.5	0.5	O K
8640 min Winter	3.227	0.037	0.0	0.5	0.5	0.5	O K
10080 min Winter	3.223	0.033	0.0	0.4	0.4	0.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	1.338	0.0	81.2	4408
10080 min Summer	1.172	0.0	82.5	5128
15 min Winter	119.734	0.0	13.9	23
30 min Winter	78.587	0.0	18.5	34
60 min Winter	49.133	0.0	23.4	54
120 min Winter	30.027	0.0	28.8	90
180 min Winter	22.733	0.0	32.8	126
240 min Winter	18.777	0.0	36.2	162
360 min Winter	14.518	0.0	42.1	228
480 min Winter	12.171	0.0	47.2	292
600 min Winter	10.603	0.0	51.4	354
720 min Winter	9.453	0.0	55.0	416
960 min Winter	7.821	0.0	60.7	534
1440 min Winter	5.867	0.0	68.3	772
2160 min Winter	4.294	0.0	74.9	1104
2880 min Winter	3.404	0.0	79.0	1480
4320 min Winter	2.422	0.0	83.9	2200
5760 min Winter	1.895	0.0	87.1	2904
7200 min Winter	1.565	0.0	89.5	3696
8640 min Winter	1.338	0.0	91.4	4424
10080 min Winter	1.172	0.0	93.0	5144

Cascade Rainfall Details for Catchment B3 Permeable Paving 100+20.SRCX

Rainfall Model	FEH	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
FEH Rainfall Version	2013	Cv (Winter)	0.840
Site Location	GB 617561 168162	Shortest Storm (mins)	15
Data Type	Point	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+20

Time Area Diagram

Total Area (ha) 0.017

Time From:	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**
0	4	0.004	4	8	0.006	8	12	0.007

Cascade Model Details for Catchment B3 Permeable Paving 100+20.SRCX

Storage is Online Cover Level (m) 3.720

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	4.2
Membrane Percolation (mm/hr)	1000	Length (m)	10.4
Max Percolation (l/s)	12.1	Slope (1:X)	0.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	3.190	Cap Volume Depth (m)	0.400

Orifice Outflow Control

Diameter (m) 0.057 Discharge Coefficient 0.600 Invert Level (m) 3.190

Cascade Summary of Results for Catchment B4 Attenuation Crates 100+20.SRCX

Upstream Structures	Outflow To	Overflow To
Catchment B3 Permeable Paving 100+20.SRCX	(None)	(None)
Catchment B2 Permeable Paving 100+20.SRCX		
Catchment B1 Permeable Paving 100+20.SRCX		

Half Drain Time : 45 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	3.161	0.171	0.0	4.2	4.2	12.2	O K
30 min Summer	3.210	0.220	0.0	4.4	4.4	15.7	O K
60 min Summer	3.245	0.255	0.0	4.6	4.6	18.2	O K
120 min Summer	3.262	0.272	0.0	4.7	4.7	19.5	O K
180 min Summer	3.266	0.276	0.0	4.7	4.7	19.7	O K
240 min Summer	3.267	0.277	0.0	4.7	4.7	19.8	O K
360 min Summer	3.267	0.277	0.0	4.7	4.7	19.8	O K
480 min Summer	3.261	0.271	0.0	4.7	4.7	19.4	O K
600 min Summer	3.250	0.260	0.0	4.6	4.6	18.6	O K
720 min Summer	3.235	0.245	0.0	4.6	4.6	17.5	O K
960 min Summer	3.199	0.209	0.0	4.4	4.4	15.0	O K
1440 min Summer	3.124	0.134	0.0	4.0	4.0	9.6	O K
2160 min Summer	3.036	0.046	0.0	3.5	3.5	3.3	O K
2880 min Summer	2.990	0.000	0.0	3.4	3.4	0.0	O K
4320 min Summer	2.990	0.000	0.0	2.5	2.5	0.0	O K
5760 min Summer	2.990	0.000	0.0	1.9	1.9	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	119.734	0.0	27.1	25
30 min Summer	78.587	0.0	35.8	39
60 min Summer	49.133	0.0	45.1	68
120 min Summer	30.027	0.0	55.3	120
180 min Summer	22.733	0.0	63.0	150
240 min Summer	18.777	0.0	69.4	182
360 min Summer	14.518	0.0	80.7	250
480 min Summer	12.171	0.0	90.0	316
600 min Summer	10.603	0.0	98.3	382
720 min Summer	9.453	0.0	105.1	448
960 min Summer	7.821	0.0	115.9	574
1440 min Summer	5.867	0.0	130.5	816
2160 min Summer	4.294	0.0	143.2	1168
2880 min Summer	3.404	0.0	151.2	0
4320 min Summer	2.422	0.0	161.0	0
5760 min Summer	1.895	0.0	167.5	0

Cascade Summary of Results for Catchment B4 Attenuation Crates 100+20.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
7200 min Summer	2.990	0.000	0.0	1.6	1.6	0.0	O K
8640 min Summer	2.990	0.000	0.0	1.4	1.4	0.0	O K
10080 min Summer	2.990	0.000	0.0	1.2	1.2	0.0	O K
15 min Winter	3.186	0.196	0.0	4.3	4.3	14.0	O K
30 min Winter	3.245	0.255	0.0	4.6	4.6	18.2	O K
60 min Winter	3.290	0.300	0.0	4.8	4.8	21.4	O K
120 min Winter	3.325	0.335	0.0	4.9	4.9	23.2	O K
180 min Winter	3.328	0.338	0.0	4.9	4.9	23.2	O K
240 min Winter	3.325	0.335	0.0	4.9	4.9	23.2	O K
360 min Winter	3.306	0.316	0.0	4.9	4.9	22.4	O K
480 min Winter	3.284	0.294	0.0	4.8	4.8	21.0	O K
600 min Winter	3.258	0.268	0.0	4.7	4.7	19.2	O K
720 min Winter	3.230	0.240	0.0	4.5	4.5	17.1	O K
960 min Winter	3.169	0.179	0.0	4.2	4.2	12.8	O K
1440 min Winter	3.064	0.074	0.0	3.7	3.7	5.3	O K
2160 min Winter	2.990	0.000	0.0	3.1	3.1	0.0	O K
2880 min Winter	2.990	0.000	0.0	2.5	2.5	0.0	O K
4320 min Winter	2.990	0.000	0.0	1.8	1.8	0.0	O K
5760 min Winter	2.990	0.000	0.0	1.4	1.4	0.0	O K
7200 min Winter	2.990	0.000	0.0	1.1	1.1	0.0	O K
8640 min Winter	2.990	0.000	0.0	1.0	1.0	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
7200 min Summer	1.565	0.0	172.5	0
8640 min Summer	1.338	0.0	176.6	0
10080 min Summer	1.172	0.0	179.9	0
15 min Winter	119.734	0.0	30.4	25
30 min Winter	78.587	0.0	40.3	39
60 min Winter	49.133	0.0	50.5	68
120 min Winter	30.027	0.0	62.1	120
180 min Winter	22.733	0.0	70.6	158
240 min Winter	18.777	0.0	77.7	192
360 min Winter	14.518	0.0	90.6	266
480 min Winter	12.171	0.0	101.0	336
600 min Winter	10.603	0.0	110.2	404
720 min Winter	9.453	0.0	118.0	472
960 min Winter	7.821	0.0	130.0	598
1440 min Winter	5.867	0.0	146.3	836
2160 min Winter	4.294	0.0	160.6	0
2880 min Winter	3.404	0.0	169.6	0
4320 min Winter	2.422	0.0	180.6	0
5760 min Winter	1.895	0.0	187.9	0
7200 min Winter	1.565	0.0	193.6	0
8640 min Winter	1.338	0.0	198.2	0

Cascade Summary of Results for Catchment B4 Attenuation Crates 100+20.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
10080 min Winter	2.990	0.000	0.0	0.9	0.9	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
10080 min Winter	1.172	0.0	202.1	0

Cascade Rainfall Details for Catchment B4 Attenuation Crates 100+20.SRCX

Rainfall Model	FEH	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
FEH Rainfall Version	2013	Cv (Winter)	0.840
Site Location	GB 617561 168162	Shortest Storm (mins)	15
Data Type	Point	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+20

Time Area Diagram

Total Area (ha) 0.066

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.012	4	8	0.027	8	12	0.027

Cascade Model Details for Catchment B4 Attenuation Crates 100+20.SRCX

Storage is Online Cover Level (m) 3.570

Cellular Storage Structure

Invert Level (m) 2.990 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	75.2	74.3	0.400	0.0	87.5
0.300	75.2	87.5			

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-CHE-0108-5000-0600-5000
Design Head (m)	0.600
Design Flow (l/s)	5.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	No
Diameter (mm)	108
Invert Level (m)	2.740
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.600	5.0
Flush-Flo™	0.194	5.0
Kick-Flo®	0.264	3.4
Mean Flow over Head Range	-	3.7

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	3.0	1.200	7.0	3.000	11.0	7.000	16.6
0.200	5.0	1.400	7.6	3.500	11.9	7.500	17.2
0.300	3.6	1.600	8.1	4.000	12.7	8.000	17.8
0.400	4.1	1.800	8.6	4.500	13.4	8.500	18.3
0.500	4.6	2.000	9.0	5.000	14.1	9.000	18.9
0.600	5.0	2.200	9.4	5.500	14.8	9.500	19.4
0.800	5.8	2.400	9.9	6.000	15.5		
1.000	6.4	2.600	10.3	6.500	16.0		

Appendix C - Catchment C

Summary of Results for 100 year Return Period (+20%)

Half Drain Time : 22 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	3.116	0.216	0.0	2.3	2.3	4.0	O K
30 min Summer	3.156	0.256	0.0	2.4	2.4	4.7	O K
60 min Summer	3.151	0.251	0.0	2.4	2.4	4.6	O K
120 min Summer	3.118	0.218	0.0	2.3	2.3	4.0	O K
180 min Summer	3.089	0.189	0.0	2.2	2.2	3.5	O K
240 min Summer	3.063	0.163	0.0	2.1	2.1	3.0	O K
360 min Summer	3.021	0.121	0.0	2.0	2.0	2.2	O K
480 min Summer	2.988	0.088	0.0	1.9	1.9	1.6	O K
600 min Summer	2.961	0.061	0.0	1.8	1.8	1.1	O K
720 min Summer	2.939	0.039	0.0	1.7	1.7	0.7	O K
960 min Summer	2.906	0.006	0.0	1.7	1.7	0.1	O K
1440 min Summer	2.900	0.000	0.0	1.3	1.3	0.0	O K
2160 min Summer	2.900	0.000	0.0	1.0	1.0	0.0	O K
2880 min Summer	2.900	0.000	0.0	0.8	0.8	0.0	O K
4320 min Summer	2.900	0.000	0.0	0.6	0.6	0.0	O K
5760 min Summer	2.900	0.000	0.0	0.4	0.4	0.0	O K
7200 min Summer	2.900	0.000	0.0	0.4	0.4	0.0	O K
8640 min Summer	2.900	0.000	0.0	0.3	0.3	0.0	O K
10080 min Summer	2.900	0.000	0.0	0.3	0.3	0.0	O K
15 min Winter	3.150	0.250	0.0	2.4	2.4	4.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	119.734	0.0	6.2	21
30 min Summer	78.587	0.0	8.3	31
60 min Summer	49.133	0.0	10.3	48
120 min Summer	30.027	0.0	12.6	82
180 min Summer	22.733	0.0	14.2	114
240 min Summer	18.777	0.0	15.7	146
360 min Summer	14.518	0.0	18.3	208
480 min Summer	12.171	0.0	20.4	268
600 min Summer	10.603	0.0	22.2	328
720 min Summer	9.453	0.0	23.8	388
960 min Summer	7.821	0.0	26.3	498
1440 min Summer	5.867	0.0	29.6	0
2160 min Summer	4.294	0.0	32.5	0
2880 min Summer	3.404	0.0	34.3	0
4320 min Summer	2.422	0.0	36.6	0
5760 min Summer	1.895	0.0	38.2	0
7200 min Summer	1.565	0.0	39.4	0
8640 min Summer	1.338	0.0	40.5	0
10080 min Summer	1.172	0.0	41.4	0
15 min Winter	119.734	0.0	7.0	21

Summary of Results for 100 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control Σ (l/s)	Max Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	3.198	0.298	0.0	2.5	2.5	5.5	O K
60 min Winter	3.189	0.289	0.0	2.5	2.5	5.3	O K
120 min Winter	3.135	0.235	0.0	2.3	2.3	4.3	O K
180 min Winter	3.086	0.186	0.0	2.2	2.2	3.4	O K
240 min Winter	3.045	0.145	0.0	2.1	2.1	2.7	O K
360 min Winter	2.984	0.084	0.0	1.9	1.9	1.5	O K
480 min Winter	2.940	0.040	0.0	1.7	1.7	0.7	O K
600 min Winter	2.905	0.005	0.0	1.7	1.7	0.1	O K
720 min Winter	2.900	0.000	0.0	1.6	1.6	0.0	O K
960 min Winter	2.900	0.000	0.0	1.3	1.3	0.0	O K
1440 min Winter	2.900	0.000	0.0	1.0	1.0	0.0	O K
2160 min Winter	2.900	0.000	0.0	0.7	0.7	0.0	O K
2880 min Winter	2.900	0.000	0.0	0.6	0.6	0.0	O K
4320 min Winter	2.900	0.000	0.0	0.4	0.4	0.0	O K
5760 min Winter	2.900	0.000	0.0	0.3	0.3	0.0	O K
7200 min Winter	2.900	0.000	0.0	0.3	0.3	0.0	O K
8640 min Winter	2.900	0.000	0.0	0.2	0.2	0.0	O K
10080 min Winter	2.900	0.000	0.0	0.2	0.2	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	78.587	0.0	9.2	32
60 min Winter	49.133	0.0	11.5	50
120 min Winter	30.027	0.0	14.1	86
180 min Winter	22.733	0.0	16.1	120
240 min Winter	18.777	0.0	17.7	154
360 min Winter	14.518	0.0	20.5	216
480 min Winter	12.171	0.0	22.9	276
600 min Winter	10.603	0.0	24.9	324
720 min Winter	9.453	0.0	26.7	0
960 min Winter	7.821	0.0	29.4	0
1440 min Winter	5.867	0.0	33.1	0
2160 min Winter	4.294	0.0	36.4	0
2880 min Winter	3.404	0.0	38.4	0
4320 min Winter	2.422	0.0	41.0	0
5760 min Winter	1.895	0.0	42.8	0
7200 min Winter	1.565	0.0	44.2	0
8640 min Winter	1.338	0.0	45.3	0
10080 min Winter	1.172	0.0	46.3	0

Rainfall Details

Rainfall Model	FEH	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
FEH Rainfall Version	2013	Cv (Winter)	0.840
Site Location	GB 617561 168162	Shortest Storm (mins)	15
Data Type	Point	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+20

Time Area Diagram

Total Area (ha) 0.028

Time From:	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**
0	4	0.009	4	8	0.009	8	12	0.010

Model Details

Storage is Online Cover Level (m) 3.500

Cellular Storage Structure

Invert Level (m) 2.900 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	**Area (m²)**	**Inf. Area (m²)**	**Depth (m)**	**Area (m²)**	**Inf. Area (m²)**
0.000	19.3	25.0	0.400	0.0	31.1
0.300	19.3	31.1			

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-CHE-0081-2500-0500-2500
Design Head (m)	0.500
Design Flow (l/s)	2.5
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	No
Diameter (mm)	81
Invert Level (m)	2.700
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

Control Points	**Head (m)**	**Flow (l/s)**
Design Point (Calculated)	0.500	2.5
Flush-Flo™	0.153	2.5
Kick-Flo®	0.210	1.7
Mean Flow over Head Range	-	1.9

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	1.9	1.200	3.8	3.000	6.0	7.000	9.1
0.200	1.7	1.400	4.1	3.500	6.5	7.500	9.4
0.300	1.9	1.600	4.4	4.000	6.9	8.000	9.7
0.400	2.2	1.800	4.7	4.500	7.3	8.500	10.0
0.500	2.5	2.000	4.9	5.000	7.7	9.000	10.3
0.600	2.7	2.200	5.2	5.500	8.1	9.500	10.6
0.800	3.1	2.400	5.4	6.000	8.4		
1.000	3.5	2.600	5.6	6.500	8.8		

Appendix D - Sustainable Urban Drainage Systems Management and Maintenance Plan

Former Bus Depot, High Street, Herne Bay, CT6 5LE
Sustainable Urban Drainage Systems Management and Maintenance Plan

1. Introduction

This Sustainable Urban Drainage Systems (SuDS) Management and Maintenance Plan has been produced for SuDS elements at the Former Bus Depot, High Street, Herne Bay, CT6 5LE.

The following SuDS elements are proposed within the development.

- Permeable paving
- Attenuation crates
- Control structures

2. Management

The attenuation crates and associated structures will be maintained by a management company set up to maintain communal areas.

3. Maintenance

The following maintenance plans will be put in place for each of the SuDS elements present within the development.

Permeable Paving

SUDS Element	**Permeable Paving**	
Maintenance Issues	Pervious surfaces are susceptible to silt blockage.	
Maintenance Period	**Maintenance Task**	**Frequency**
Regular	Surface brushing to reduce silt accumulation.	Monthly.
	Brushing and jet wash in autumn after leaf fall.	Annually.
	Mow grass edges to paving at 35-50mm and remove weeds and leaves.	As required.
Occasional tasks	Jetting where silt has accumulated in joints or voids. Replace grit and vibrate surface to lock.	As required.
Remedial Work	Where shrinkage or surface damage occurs, uplift paving, remove grit bedding layer and geotextile if present and reinstate to design profile.	As required.

Attenuation Crates

SUDS Element	Attenuation Crates	
Maintenance Issues	Debris entering storage causing blockage.	
Maintenance Period	**Maintenance Task**	**Frequency**
Regular	Inspect storage and inlets to identify any elements not working correctly.	Monthly for 3 months, then six monthly.
	Debris removal from gutters.	Annually in autumn after leaf fall.
	Remove sediment from silt traps.	Annually or as required.
Remedial Work	Repair inlets and silt traps	As required.
	Clear out storage if it becomes blocked	As required.

Control Structures

SUDS Element	Control Structure	
Maintenance Issues	Debris blocking control structure.	
Maintenance Period	**Maintenance Task**	**Frequency**
Regular	Inspect chamber and remove any debris from control device.	Quarterly and following heavy rainfall.
Remedial Work	Repair or replace control device if it is damaged.	As required.

Appendix E - Kent County Council Drainage Summary

Drainage Strategy Summary

1. Site details	
Site/development name	Former Bus Depot
Address including post code	High Street Herne Bay CT6 5LE
Grid reference	E 617561 N 168162
LPA reference	n/a
Type of application	Outline ☐ Full ☐ Discharge of Conditions ☒ Other ☐
Site condition	Greenfield ☐ Brownfield ☒

2. Existing drainage				Document/Plan where information is stated:
Total site area (ha)	0.535			Surface Water Drainage Design Report
Impermeable area (ha)	0.535			
Final discharge location	Infiltration ☐ Watercourse ☐ Sewer ☒ Tidal reach/sea ☐			
Greenfield discharge rate (l/s) for existing site area	QBAR (l/s)	2.1		Surface Water Drainage Design Report
	1 in 1 year (l/s)	1.8		
	1 in 30 year (l/s)	4.8		
	1 in 100 year (l/s)	6.6		

3. Proposed drainage areas			Document/Plan where information is stated:
Impermeable area (ha)	Roof	0.210	Surface Water Drainage Design Report
	Highway/road	0.000	
	Other paved areas	0.325	
	Total	0.535	
Permeable area (ha)	Open space	0.000	
	Other permeable areas		
	Total	0.000	
Final discharge location	Infiltration ☐ Infiltration rate ____________m/s Watercourse ☐ Sewer ☒ Tidal reach/sea ☐		Surface Water Drainage Design Report
Climate change allowance included in design	20% ☒ 30% ☐ 40% ☐		

4. Post-Development Discharge rates, without mitigation			**Document/Plan where information is stated:**
Developed discharge rates (l/s)	1 in 2 year	39	Surface Water Drainage Design Report
	1 in 30 year	90	
	1 in 100 year	115	
	1 in 100 year + CC	139	

5. Post-Development Discharge rates, with mitigation			**Document/Plan where information is stated:**
Describe development drainage strategy in general terms: Permeable paving plus subbase replacement attenuation storage provide storage with a controlled discharge from the site to the existing surface water sewer.			Surface Water Drainage Design Report
(a) No control required, all flows infiltrating		☐	
(b) Controlled developed discharge rates (l/s)	1 in 2 year	9.4	Surface Water Drainage Design Report
	1 in 30 year	10.7	
	1 in 100 year	11.6	
	1 in 100 year + CC	12.3	

6. Discharge Volumes			**Document/Plan where information is stated:**
	Existing volume (m^3)	Proposed volume (m^3)	Surface Water Drainage Design Report
1 in 2 year	121	96	
1 in 30 year	240	188	
1 in 100 year	326	256	
1 in 100 year + CC	392	308	

All information presented above should be contained within the attached Flood Risk Assessment, Drainage Strategy or Statement and be substantiated through plans and appropriate calculations.

Form completed by	Robert Beck
Qualifications	Chartered Civil Engineer
Company	RMB Consultants (Civil Engineering) Ltd
Telephone	01227 472128
Email	robert.beck@rmbconsultants.co.uk
On behalf of (client's details)	Coastal Developments Ltd
Date	12/12/18