Conceptual SuDS strategy report

For the proposed development at

Lake Barn, Maypole Lane, Yapton, BN18 0DR

Prepared by

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1 Executive Summary

A The design team have detailed a Sedum roof as the primary "green" SuDS strategy for the site.

B All residual surface water from the roof areas will be taken to the Northern boundary ditch via attenuation and hydraulic control.

C The project team have detailed "off line" rainwater butt(s) to harvest water for external use.

D All areas of hard standing on the site will be constructed using a pervious medium.

E All SuDS on site will be installed with full consideration to long term maintenance.

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2 Introduction

2.1 Site location

The development is on land at Lake Barn, Maypole Lane, Yapton, BN18 0DR (see Figure 1).

Figure 1: Site location plan, in red (source: As provided by Client)

2.2 Proposed development description

The Approved development is for a new dwelling. (Approved plans at Appendix A).

2.3 Planning Conditions to APP/C3810/W/18/3196233

Conditions 4 & 5

See Figure 2.

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4) Development shall not commence until full details of the proposed surface water drainage scheme have been submitted to and approved in writing by the Local Planning Authority. The design should follow the hierarchy of preference for different types of surface water drainage disposal systems as set out in Approved Document H of the Building Regulations, the recommendations of the SUDS Manual produced by CIRIA. Winter groundwater monitoring to establish highest annual ground water levels and Percolation testing to BRE 365, or similar approved, will be required to support the design of any Infiltration drainage. No building shall be occupied until the complete surface water drainage system serving the property has been implemented in accordance with the agreed details and the details so agreed shall be maintained in good working order in perpetuity.

5) The development shall not proceed until formal consent has been approved in writing from the Lead Local Flood Authority (WSCC) or its agent (ADC) for the discharge of any flows to watercourses, or the culverting, diversion, infilling or obstruction of any watercourse on the site. Any discharge to a watercourse must be at a rate no greater than the pre-development run off values.

Figure 2: Conditions 4 and 5

2.4 Geology

Trial hole data at Appendix D.

2.4.1 Water table

Trial hole data at Appendix D.

2.4.2 Infiltration rates

Trial hole data at Appendix D. Infiltration was only found viable for soakaways in one location. This location is however within 5m of the proposed building.

3 Existing surface water disposal strategy

The existing site is Greenfield and, based on the site levels (ref. Appendix A.1), the site naturally drains to the ditch running along the site's Northern boundary.

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3.1 Greenfield estimation of peak rate of run-off

3.1.1 Methodology

For the lower limit, consider this is a greenfield site and is less than 50 ha therefore run-off rate calculations have been carried out in accordance with the IH Report 124 'Flood estimation for small catchments'[1]. The pro rata method on the size of catchment has been used.

3.1.2 Formula

For catchments less than 50ha:

$$Q_{BAR50ha} = 1.08\,(50/100)^{0.89} * SAAR^{1.17} * SPR^{2.17} \tag{1}$$

$$Q_{BAR} = Q_{BAR50ha} * \frac{A}{50} \tag{2}$$

$$Q_{1yr} = Q_{BAR} * 0.85 \tag{3}$$

$$Q_{100yr} = Q_{BAR} * GC_{100} \tag{4}$$

3.1.3 Variables

Qbar/Qmed =0.85

SAAR = 756mm

Hydrological Region 7

Growth curve factors: 30 yr = 2.3; 100 yr = 3.19

SPR = 0.3

3.1.4 Calculations

$$\begin{aligned} Q_{BAR50ha} =& 1.08 * 0.5^{0.89} * 756^{1.17} * 0.3^{2.17} \\ =& 0.58 * 2332.76 * 0.07 \\ =& 99.71 \end{aligned}$$

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Using Equation 2:

$$Q_{BAR} = \frac{99.71 * 0.10}{50}$$
$$= 0.21 ls^{-1}$$

Using Equation 3:

$$Q_1 = 0.21 * 0.85$$
$$= 0.17 ls^{-1}$$

Using Equation 4:

$$Q_{100} = 0.21 * 3.19$$
$$= 0.66 ls^{-1}$$

3.1.5 Peak run-off rates

For the 1 year Return Period event the peak runoff calculates to 0.17 ls^{-1}
For the 30 year Return Period event the peak runoff calculates to 0.47 ls^{-1}
For the 100 year Return Period event the peak runoff calculates to 0.66 ls^{-1}

3.2 Practicable discharge rates

> "A practicable minimum limit on the discharge rate from a flow attenuation device is often a compromise between attenuating to a satisfactorily low flow rate while keeping the risk of blockage to an acceptable level. This limit is set at 5 litres per second, using an appropriate vortex or other flow control device. Where sedimentation could be an issue, the minimum size of orifice for controlling flow from an attenuation device should normally be 150mm laid at a gradient not flatter than 1 in 150, which meets the requirements of Sewers for Adoption 7th Edition" [4].

Note: This is considered now to be dated guidance and far lower rates can be achieved for smaller developments. for this site the limiting discharge rate will be as close to greenfield rates as practicable.

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3.3 Limiting discharge rate

By considering out fall rates as derived in Sections 3.1 a 1 in 1yr limiting discharge rate for the site is 0.3 ls^{-1}as being the lowest practicable value achievable.

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4 SuDS Principles

4.1 SuDS design philosophy

The CIRIA SuDS[2] manual provides the design philosophy:

> "SuDS design should, as much as possible, be based around the following:
>
> - using surface water run-off as a resource
> - managing rainwater close to where it falls
> - managing run-off at the surface
> - allowing rainwater to soak into the ground
> - promoting evapotranspiration
> - slowing and storing run-off to mimic natural run-off characteristics
> - reducing contamination of run-off through pollution prevention and controlling the run-off at source
> - treating run-off to reduce the risk of urban contaminants causing environmental pollution."

4.2 Source control

The following are widely recognised as source control SuDS.

- Sedum roofing.
- Infiltration devices. Typically soakaways.
- Rainwater harvesting.
- Bio-retention planting, rain gardens.
- Permeable paving, porous asphalt. These provide both infiltration and short term storage volumes thus reducing overall un-mitigated run-off volumes.

4.3 "End of pipe" solutions

To be considered only after implementation of the above options.

- Retention tanks with outfall controlled by hydraulic means to limiting discharge rates and volumes to discharge to existing SW flow pathways.

Sections 5.2.1 to 5.2.4 consider the viability of a range of these SuDS devices.

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4.4 Design Criteria

In line with the SuDS management train, the following hierarchy have been considered in applying the use of SuDS into the proposed development scheme.

- Source control
- Site control
- Outfall control

4.4.1 Storm period

All SW drainage shall be designed to a 1 in 100 year storm event allowing for climate change of + 40%.

4.4.2 Building Regulations

All drainage on site, both foul and SW will be subject to compliance with Part H of the Building Regulations. Hence all SW runs, pipe diameters etc. will comply in full with the requirements of Part H, be designed following the guidance of Approved Document H, and be inspected and approved by the Building Control body at the time of construction.

4.4.3 Consent to discharge

Bylaw and or land drainage consents will be required.

4.4.4 Design standards

All SuDS on site will be designed and installed in accordance with CIRIA 753 & CIRIA 768.

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5 Appraisal of SuDS options

The primary aim is to meet the requirements of the Local Plan core policies.

5.1 Site constraints impacting on SuDS

- Small site.
- No viable infiltration at soakaway depth in areas outside a 5m distance of the building footprint.
- Low pro-rata greenfield run-off rates given the size of the site.

5.2 Source control devices

5.2.1 Sedum roofs

With reference to Section 4.1, sedum roofs promote the following SuDS design criteria:

- manages rainwater close to where it falls
- manages run-off at the surface
- promotes evapotranspiration
- slows and stores run-off to mimic natural run-off characteristics
- treats run-off to reduce the risk of urban contaminants causing environmental pollution.

The use of Sedum roofs can significantly reduce run-off volumes from roofs [3]. These are found suitable for this development.

5.2.2 Infiltration devices

Due to site constraints, Section 5.1, soakaways are not viable for this site.

5.2.3 Rainwater harvesting

With reference to Section 4.1, Rainwater harvesting promotes the following SuDS design criteria:

- uses surface water run-off as a resource
- manages rainwater close to where it falls

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For external use

Rain water harvesting / water butts: These provide additional, "off line[1]" SuDS, and are deemed a suitable SuDS component for small plots[2], extract at Figure 3. The image shows a water butt in "off-line" configuration using a standard diverter.

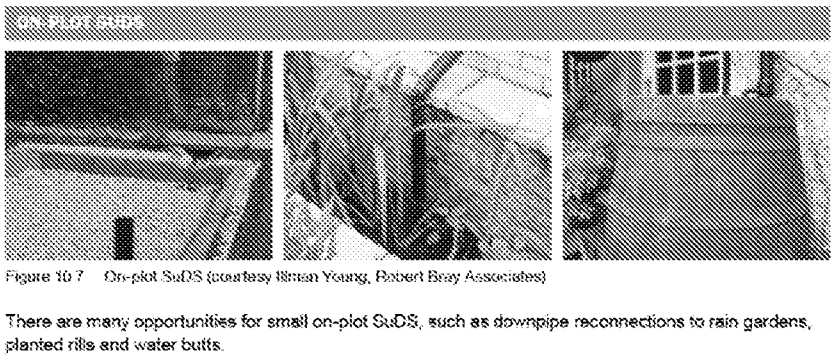

Figure 3: Use of water butts as provided in the SuDS manual

The collection and re-use of water can reduce run off volumes arising from roofs. The collected water, via readily available diverters (e.g. Web link: Standard diverter example, as per Figure 4), being used for external uses.

Figure 4: Standard rainwater diverter

Rainwater butts can, in part, accommodate the 5mm event dependent on manual drawdown and evaporation.

[1]The term "off-line" refers to the fact that a water butt is a harvesting device that is not "in-line" in the same manner that a pipe is in-line. Water is collected (harvested) until the water butt is full. When full, the rainwater continues down the rainwater pipe. Outflow from the tank is not "automatic" since this would negate the reason to harvest rainwater. Instead, manual drawdown occurs with the harvested water being used for external uses. Since a water butt may be full, the useful volume is not accounted for in storage and run-off calculations.

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5.2.4 Rain gardens/Raised planters

Due to site constraints, Section 5.1, such planters are not suited for this site.

5.2.5 Pervious paving

With reference to Section 4.1, pervious paving promotes the following SuDS design criteria:

- manages rainwater close to where it falls
- manages run-off at the surface
- allows rainwater to soak into the ground
- slows and stores run-off to mimic natural run-off characteristics
- treats run-off to reduce the risk of urban contaminants causing environmental pollution.

A 30% void ratio is assumed through a 350mm sub-base. This is appropriate for a DOT Type 3 Sub-base hence the storage capacity equates to circa 105mm per $1m^2$ therefore based on a M6 100hr + cc storm of 87mm rainfall the paving offers, without any allowance for infiltration, a circa 1:1.2 drained volume:storage volume capacity (= 20% space capacity). Hence there is no anticipated exceedence flow from the areas of permeable paving.

The areas of permeable paving are primarily disconnected from the proposed SW network, i.e. they are not primarily designed to drain to the network. Surface water retained in the sub-base matrix is lost through evaporation and infiltration, at shallow depths, into the surrounding naturally fissured sub-soils (due to action of freeze-thaw, roots, earthworms and the proposed local re-grading following any site clearance). In doing so it mimics as close as possible the natural hydrological process of water falling onto the ground and finding natural flow paths for dispersion.

Treatment potential: TSS 0.7, Metals 0.6, Hydrocarbons 0.7 = suitable for trafficked areas

All permeable paving offers sufficient storage volume to accommodate the 5mm event.

5.2.6 "End of pipe" solutions

To be considered only after implementation of the above options.

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- Retention tanks with outfall controlled by hydraulic means (e.g. hydrobrakes, pipe sizing, orifice plate etc.) to limiting rates and volumes to discharge to existing flow pathways.

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6 Proposed surface water disposal strategy

6.1 Roof area

The design team have detailed part of the roof area as a Sedum roof as the primary "green" SuDS strategy for the site, with exceedence flows taken to the boundary ditch under attenuation and hydraulic control via a rainwater butt in offline configuration.

6.1.1 Design parameters

"In summer green roofs can retain 70–80% of rainfall and in winter they retain 10–35%"[3] hence, it follows, will reduce run-off by these amounts.

The green roof will be designed to prevent run-off from all rainfall events up to the 5mm event which is equivalent to a 1 in 1 peak run-off summer storm for the site - generally the standard target reduction for sedum roofs. A suitable option with a max 20mm (20kg.m^{-2}) of retention capacity can be found in Appendix B.

Cv taken as 0.95 for the non-sedum part of the roof.

1 in 1yr

Maximum intensity storm for the site for a 1 in 1yr return period is a 6 minute summer profile storm giving a total of 5mm of rainfall.

Proposed total roof area = 200m^2

Sedum roof area = 80m^2

With the accepted 100% retention of a 5mm event by the area of sedum roof, max 1:1 out fall rate from the sedum roof area is therefore 0 ls^{-1}

Remainder of roof = 120m^2

Run-off rate from remainder of the roof area =

$$\frac{0.95 * 5 * 120}{(60 * 6)} = 1.6ls^{-1}$$

Total proposed peak 1 in 1yr run off rate = 1.6ls^{-1}

1 in 100yr

Maximum intensity storm for the site for a 1 in 100yr return period is a 8 minute summer profile storm giving a total of 18.1mm of rainfall.

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Proposed total roof area = 200m^2

Sedum roof area = 80m^2

Assuming a conservative 50% retention of a summer storm (refer to 6.1.1 above) by the sedum roof, max 1:100 out fall rate from the sedum roof area, in ls^{-1}, is therefore circa:

$$\frac{0.5 * 18.1 * 80}{(60 * 8)} = 1.51ls^{-1}$$

(reducing to circa 0.75ls^{-1} when established).

Remainder of roof = 120m^2

Run-off rate from remainder of the roof area =

$$\frac{0.95 * 18.1 * 120}{(60 * 8)} = 4.3ls^{-1}$$

Total proposed peak 1 in 100yr run off rate = 5.81ls^{-1}

6.1.2 Rainwater harvesting

The project team have detailed a 250l "off line" rainwater butt to harvest water for external use. Since these are in off-line configuration any exceedence flows are automatically directed back to the downpipes.

This will help reduce potable water demand and serve as an additional SuDS component.

6.1.3 Residual

All residual surface water from the roof areas will be taken to the Northern boundary ditch via attenuation and hydraulic control. The outfall will require a headwall such as that provided at Appendix A.4. Commercial "off the shelf" headwalls are also suitable for which there are too many to list.

This can be achieved using a commercially available orifice control device - see Appendix E. This unit incorporates a higher level 100mm diameter overflow pipe to route exceedence flows under system failure events.

The following calculations also allow for the area of permeable surface directly over, and hence also draining via, the attenuation cells. The attenuation volume required is then:

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Designed to accomodate all surface water arising from a design drained area of 280.5m^2 requires a minimum attenuation volume of 18 m^3. This can be achieved using an overall cell volume of 23 m^3 formed with 0.4m deep units. See Table 1.

Drained area	255m^2	
Urban Creep	1.1	
Designed drained area	280.5m^2	
Return periods considered	1yr, 30yr, 100yr	
Storm profiles used	50% Summer	75% Winter
Storm coeffs	a = 0.1, b = 0.815	a = 0.06, b = 1.026
Storm range, storm increments	From 5 minutes duration in further 2 min. intervals until critical storm reached	
M5-60	20mm	
r	0.4	
Rainfall model	FSR	
Critical design storm	337 mins, Winter	
Climate change	1.4	
Storm mean intensity	10.2mm.hr^{-1}	
Design mean intensity	14.3mm.hr^{-1}	
Storm peak intensity	28.9mm.hr^{-1}	
Design peak intensity	40.5mm.hr^{-1}	
Design maximum head	0.3m	
Calculated maximum head	0.30m	
Minimum attenuation volume required	18.19m^3	
Void ratio	95%	
Design attenuation volume	18.3m^3	(0.3m x 61m^2)
Provided attenuation volume	24.4m^3	(0.95 x 64m^2 x 0.4m)
1 in 1yr maximum outfall rate	0.3ls^{-1}	(See Figure 8.)
1 in 30yr maximum outfall rate	0.4ls^{-1}	(See Figure 9.)
1 in 100yr maximum outfall rate	0.5ls^{-1}	(See Figure 10.)
1 in 100yr Time to peak	292 mins	
Outfall control method	20mm Orifice	CD = 0.62

Table 1: Storage volume design summary

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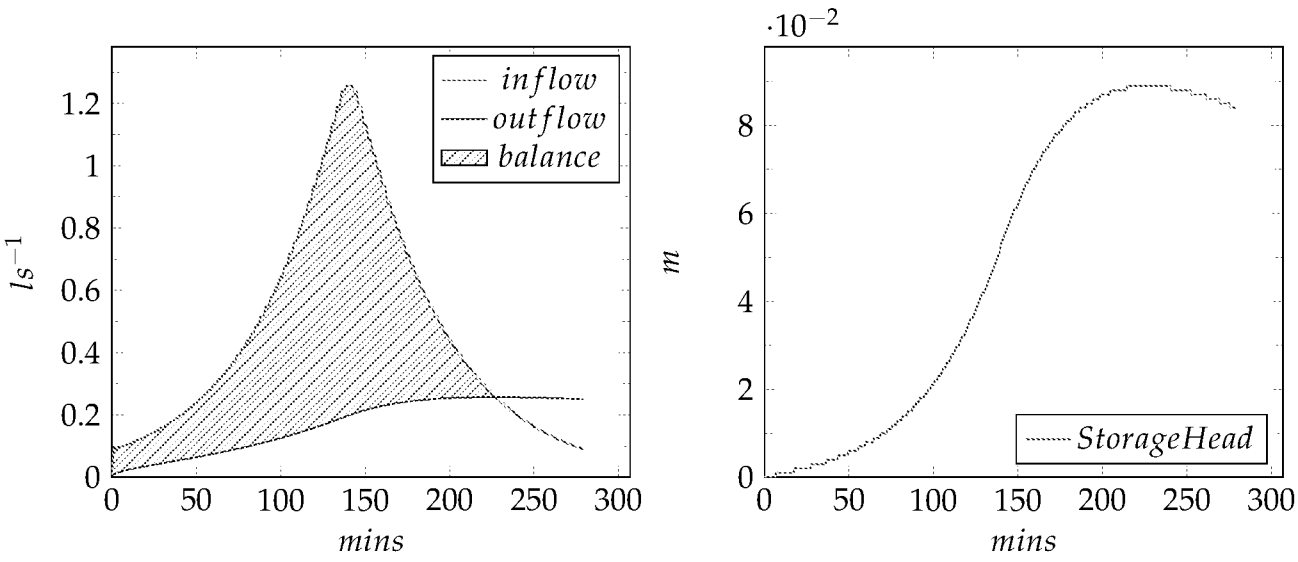

Figure 5: 1 in 1 year critical storm event

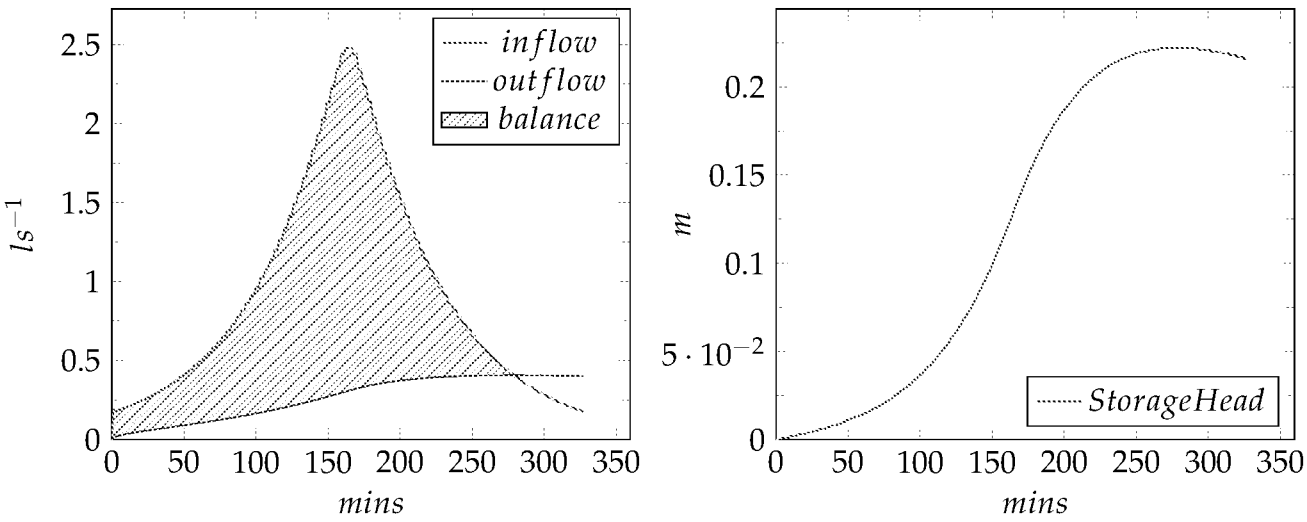

Figure 6: 1 in 30 year critical storm event

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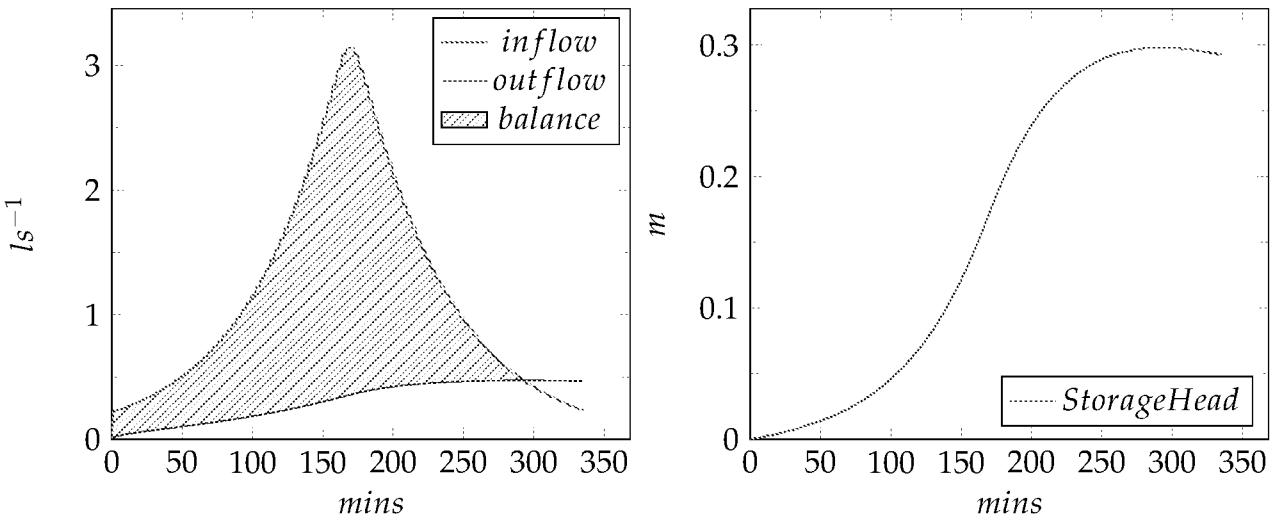

Figure 7: 1 in 100 year critical storm event

Note: Bylaw and or Land drainage consents will be required.

6.2 Driveways and hard standing

All areas of hard standing on the site will be constructed using a pervious medium on a DOT/MOT 3 sub-base of 350mm depth (refer to Section 5.2.5).

The perimeter of these areas will be considered for expansive planting to accommodate any exceedence flows.

While infiltration is not viable at soakaway depth inspection of the soakaway tests show that at shallow depths a limited infiltration potential exists. Hence a notional 10mm.hr^{-1}m^{-2} outfall rate is assumed in the following. The following is based on a nominal area of 100m^2 which can be reduced or increased pro rata.

Designed to accomodate all surface water arising from a design drained area of 100m^2 requires a minimum attenuation volume of 5 m^3. This can be achieved using an overall storage volume of 35.0 m^3 formed within a 100m^2 x 0.35m deep 30% void ratio sub-base. See Table 2.

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Drained area	$100m^2$	
Urban Creep	1	
Designed drained area	$100m^2$	
Return periods considered	1yr, 30yr, 100yr	
Storm profiles used	50% Summer	75% Winter
Storm coeffs	a = 0.1, b = 0.815	a = 0.06, b = 1.026
Storm range, storm increments	From 5 minutes duration in further 2 min. intervals until critical storm reached	
M5-60	20mm	
r	0.4	
Rainfall model	FSR	
Critical design storm	121 mins, Winter	
Climate change	1.4	
Storm mean intensity	$23.4mm.hr^{-1}$	
Design mean intensity	$32.8mm.hr^{-1}$	
Storm peak intensity	$63.8mm.hr^{-1}$	
Design peak intensity	$89.3mm.hr^{-1}$	
Design maximum head	0.25m	
Calculated maximum head	0.16m	
Minimum attenuation volume required	$4.81m^3$	
Void ratio	30%	
Design attenuation volume	$8m^3$	(0.3 x $100m^2$ x 0.25m)
Provided attenuation volume	$11m^3$	(0.3 x $100m^2$ x 0.35m)
1 in 1yr maximum outfall rate	$0.3ls^{-1}$	(See Figure 8.)
1 in 30yr maximum outfall rate	$0.3ls^{-1}$	(See Figure 9.)
1 in 100yr maximum outfall rate	$0.3ls^{-1}$	(See Figure 10.)
1 in 100yr Time to peak	111 mins	
Design head: Time to drop to 50%	2.48 hrs	
Time to 50% total capacity	2.31 hrs	
Outfall control method	Nominal GF outflow	

Table 2: Storage volume design summary

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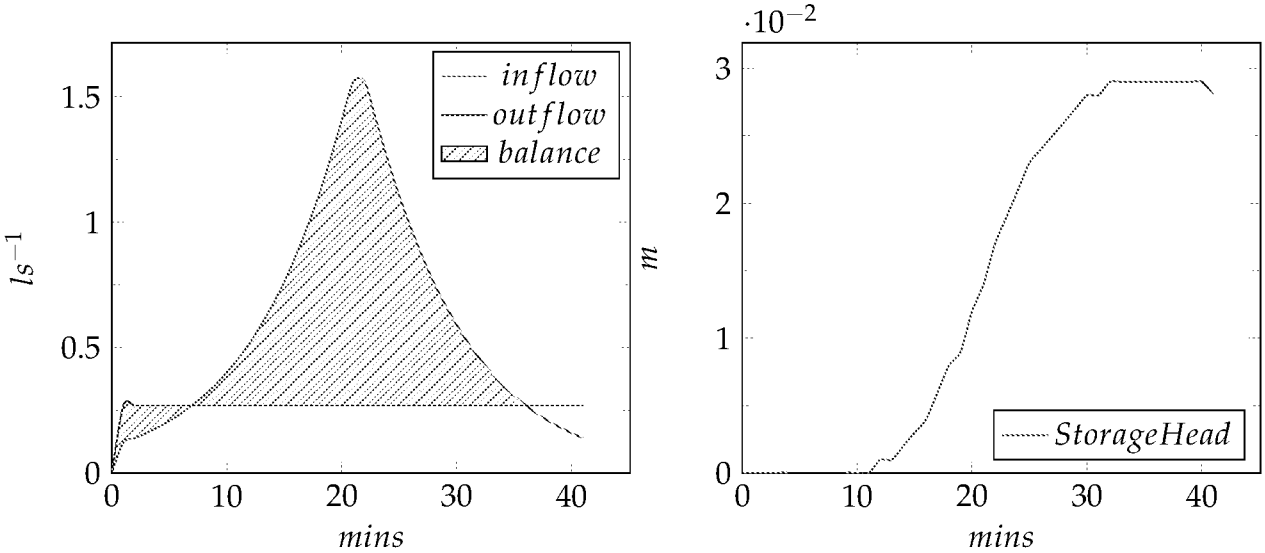

Figure 8: 1 in 1 year critical storm event

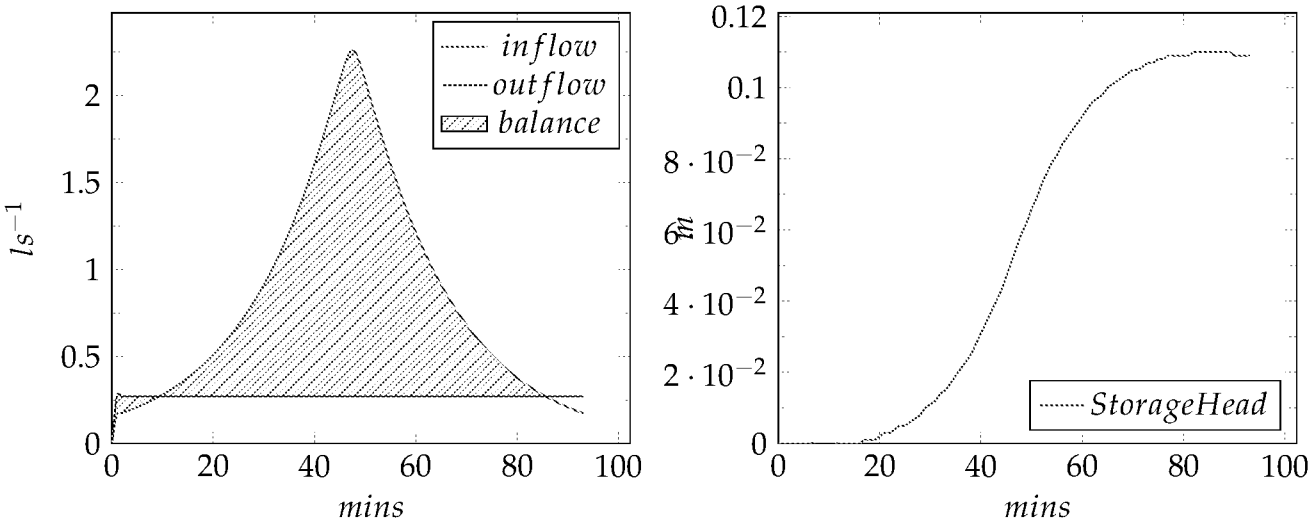

Figure 9: 1 in 30 year critical storm event

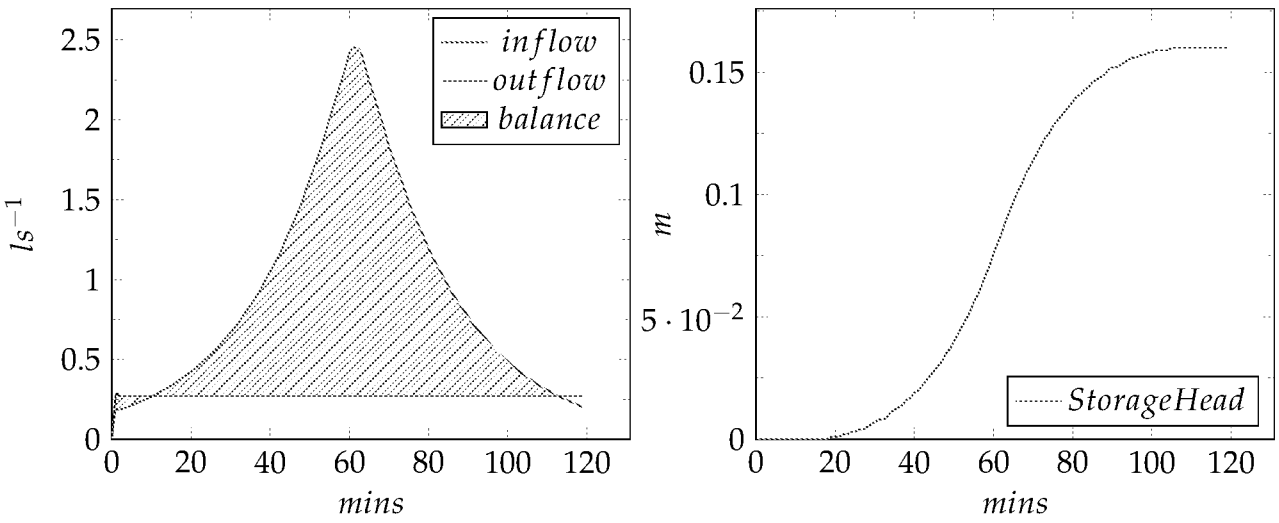

Figure 10: 1 in 100 year critical storm event

6.3 Landscaped areas

There is no anticipated exceedence flows from areas of domestic planting and similar landscaping.

6.4 Indicative scheme

See proposal plans in Appendix A.2

6.5 Exceedence flows

Sedum roof- exceedence flows taken to the existing SW drainage on site via a water butt.

Water butt - when full, the water is diverted to the existing surface water drainage on site.

Garden landscaping - No anticipated exceedence flows from these areas.

Attenuation cells - via a high level 100mm diameter pipe in the orifice chamber taken direct to the headwall.

There are no design overland exceedence flow paths other than as noted above.

Natural gradients indicate that any exceedence flows, beyond those designed, will be towards the boundary ditch.

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6.6 Maintenance of SuDS

Ultimate responsibility for the long term maintenance with SuDS in this environment lay with the land owner/management company.

All SuDS on site will be installed with full consideration to long term maintenance. The following guidance is provided and applies:

6.6.1 Sedum roofs

See details in Appendix C.

6.6.2 Water butts

A maintenance plan for water butts should include:

- Regular inspection of silt traps and filters.
- Removal of sediments and debris as required.

6.6.3 Geocellular systems

The maintenance plan for areas of geocellular systems will include:

- Regular inspection of silt traps, IC's, pipework and pre-treatment devices (safe access provision required)
- Removal of sediments and debris as required.

Access points are required so as to be able to use a suction tanker on an annual basis.

6.7 Summary

The use of SuDS techniques on site, as detailed above and when installed in line with best practice (I.e. CIRIA 753 & CIRIA 768), will reduce and treat the run-off volumes in line with the core policies.

Signed:

Dr Robin Saunders C. Build E, MCABE, BEng(Hons), PhD

Date: 6th March, 2019

ARUN DISTRICT COUNCIL Y/32/19/RES

References

[1] DCW Marshall & AC Bayliss. Flood estimation for small catchments. Technical Report No. 124, Institute of Hydrology, June 1994.

[2] CIRIA. The SUDS manual. Technical report, CIRIA, 2015.

[3] C Hassell and B Coombes. Green roofs. Technical report, CIBSE, 2007.

[4] R Kellagher. Rainfall runoff management for developments. Technical report, Department for Environment Food and Rural Affairs, 2013.

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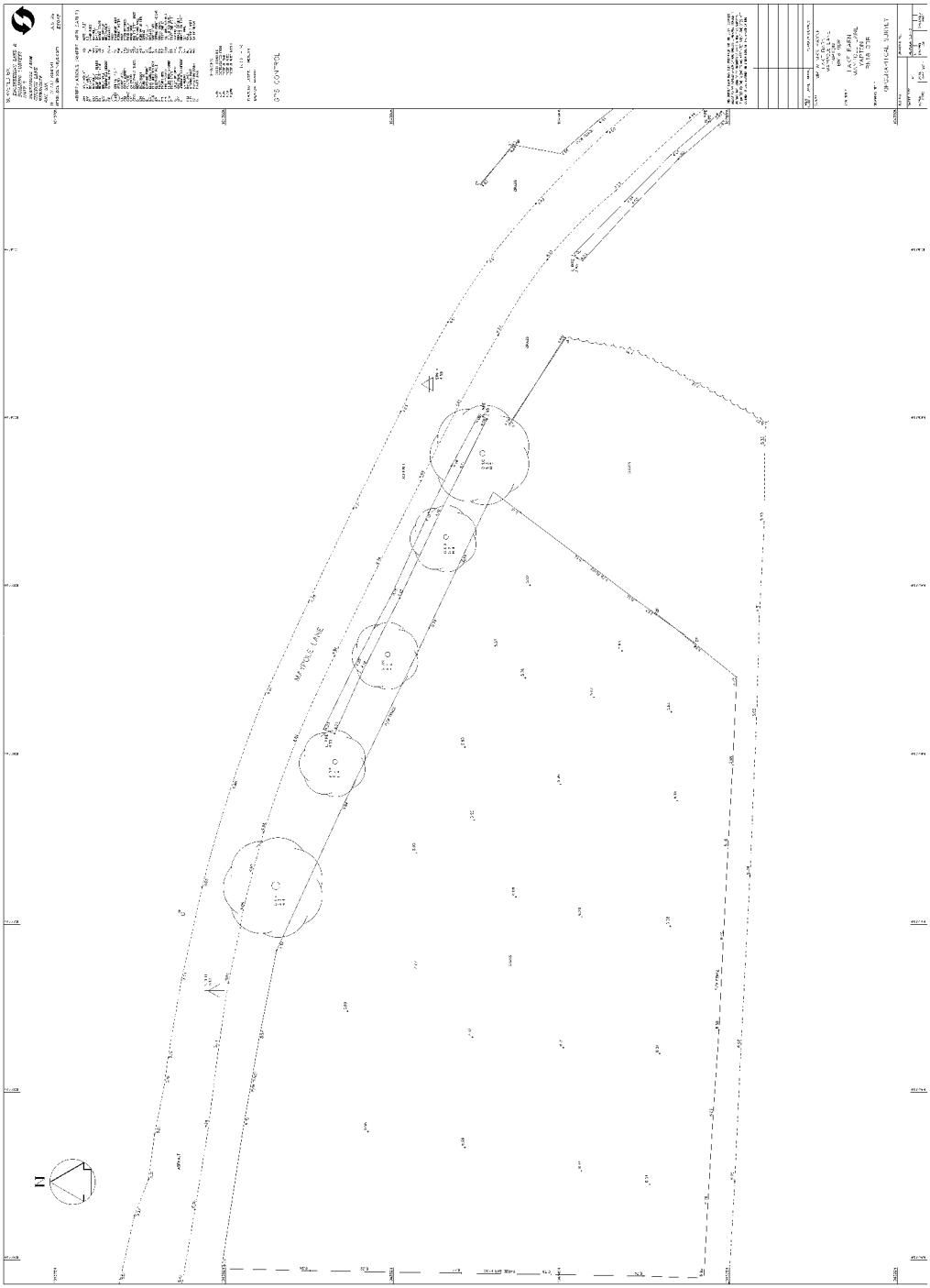
A Proposal plans

A.1 Existing site plan



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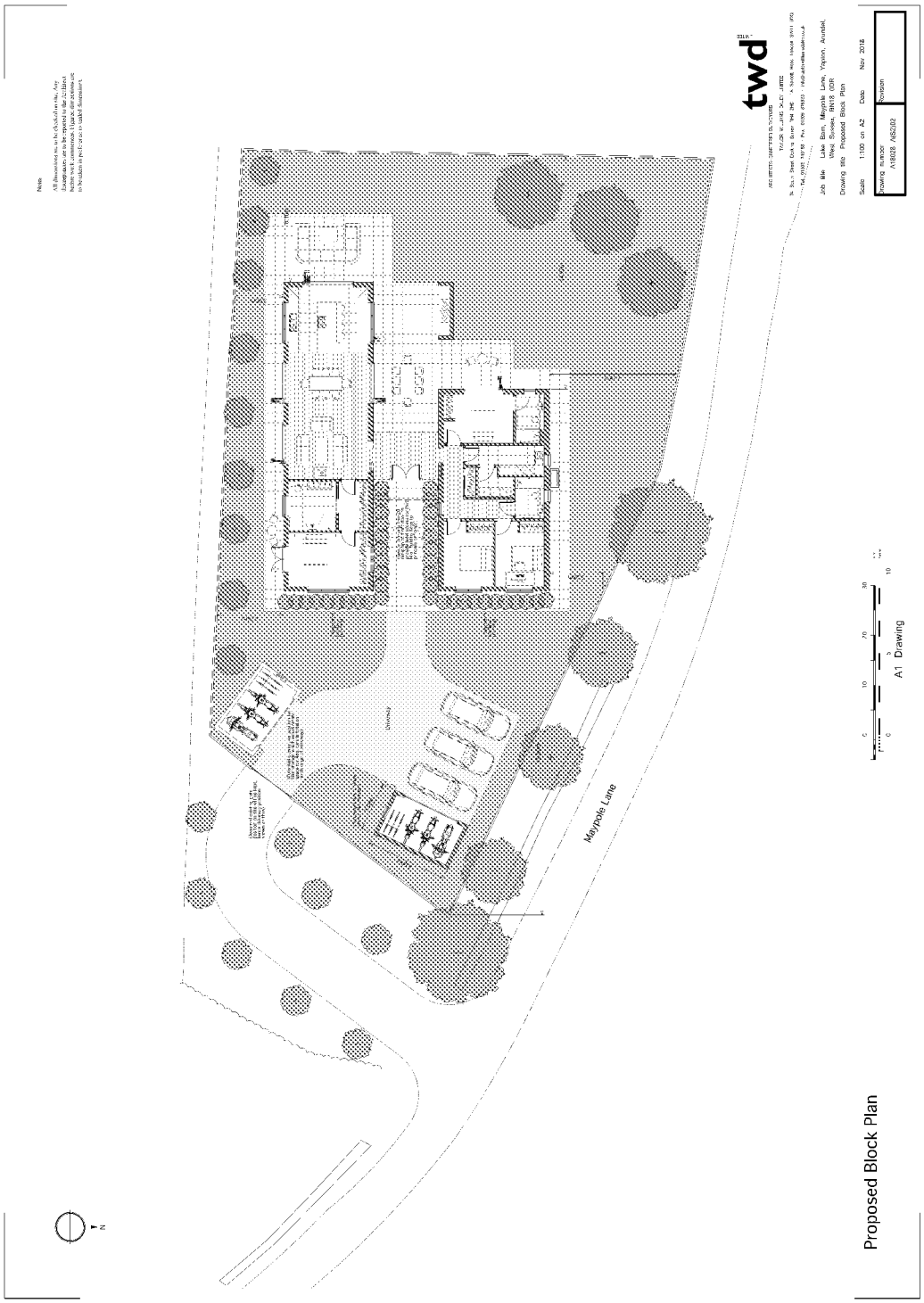
A.2 Approved plans



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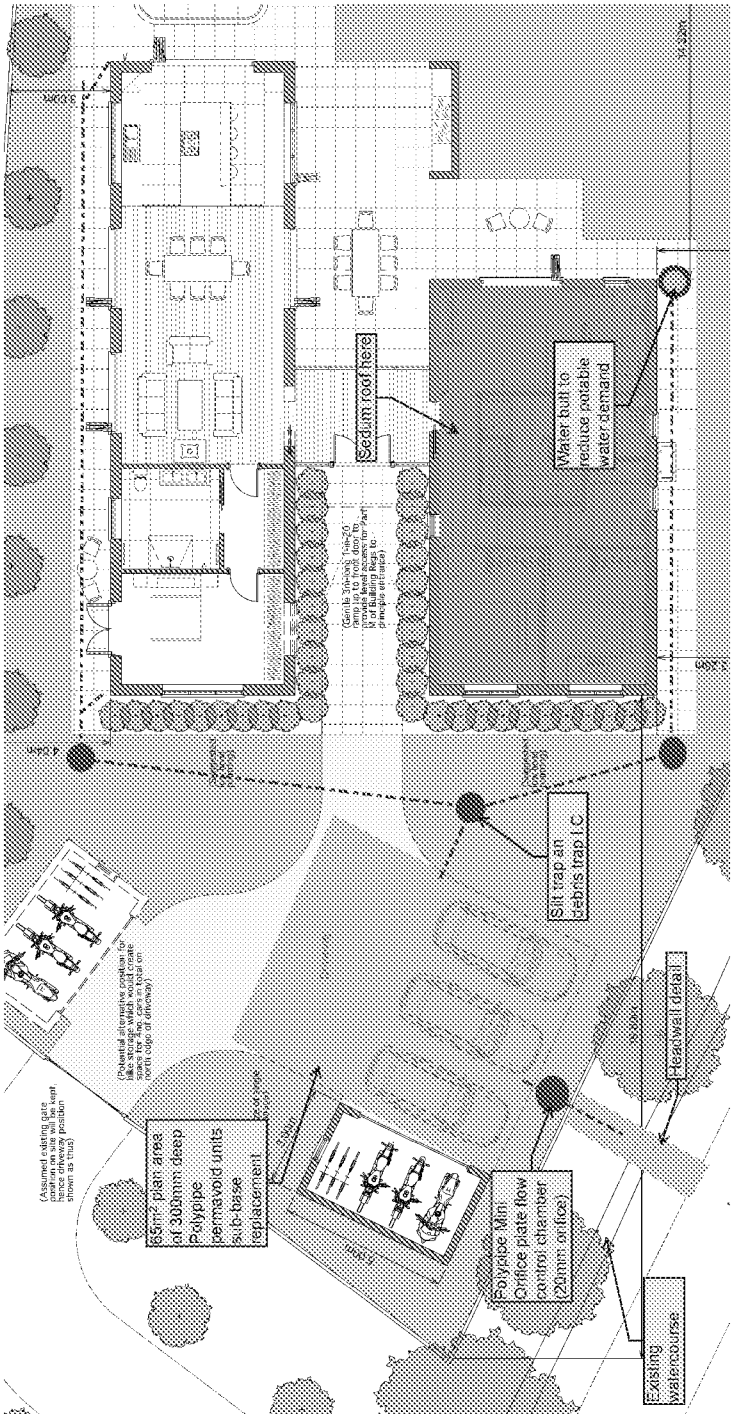
A.3 SuDS layout



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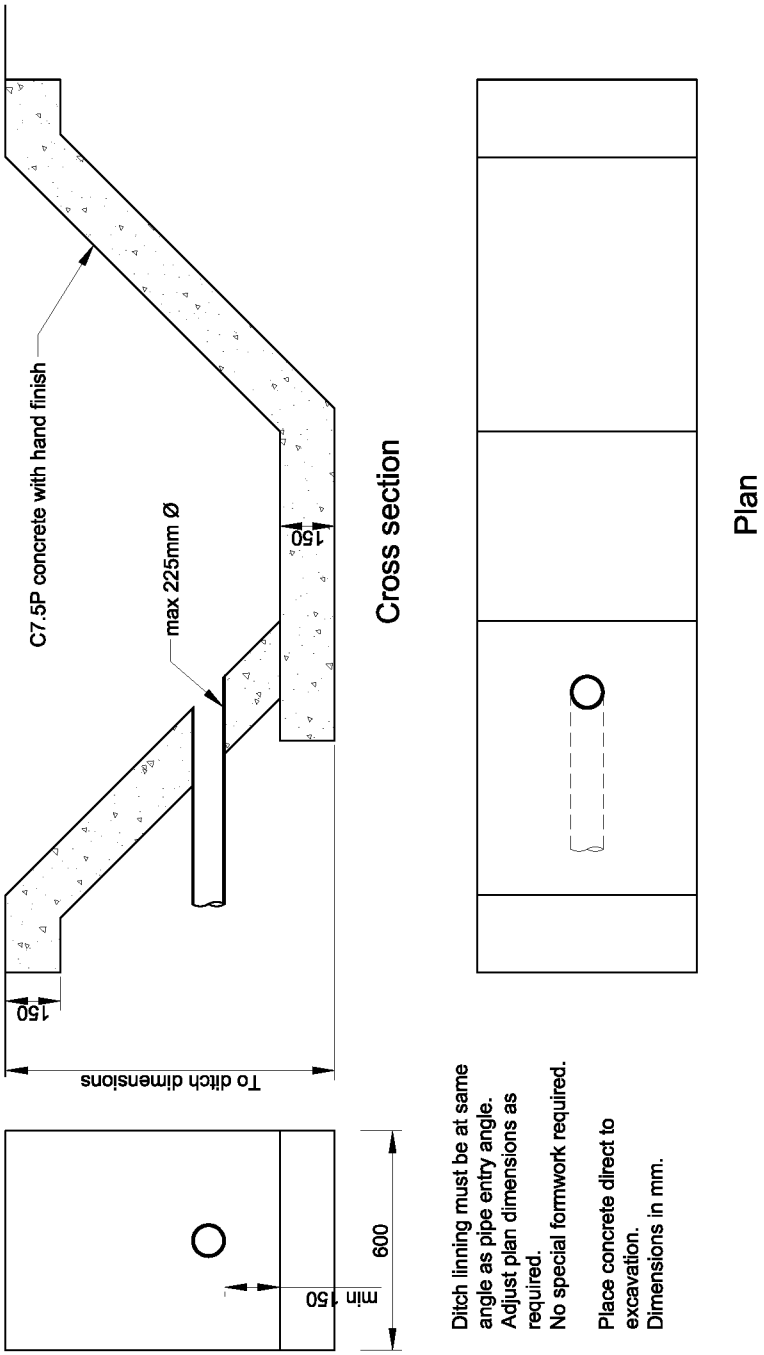
A.4 Headwall detail



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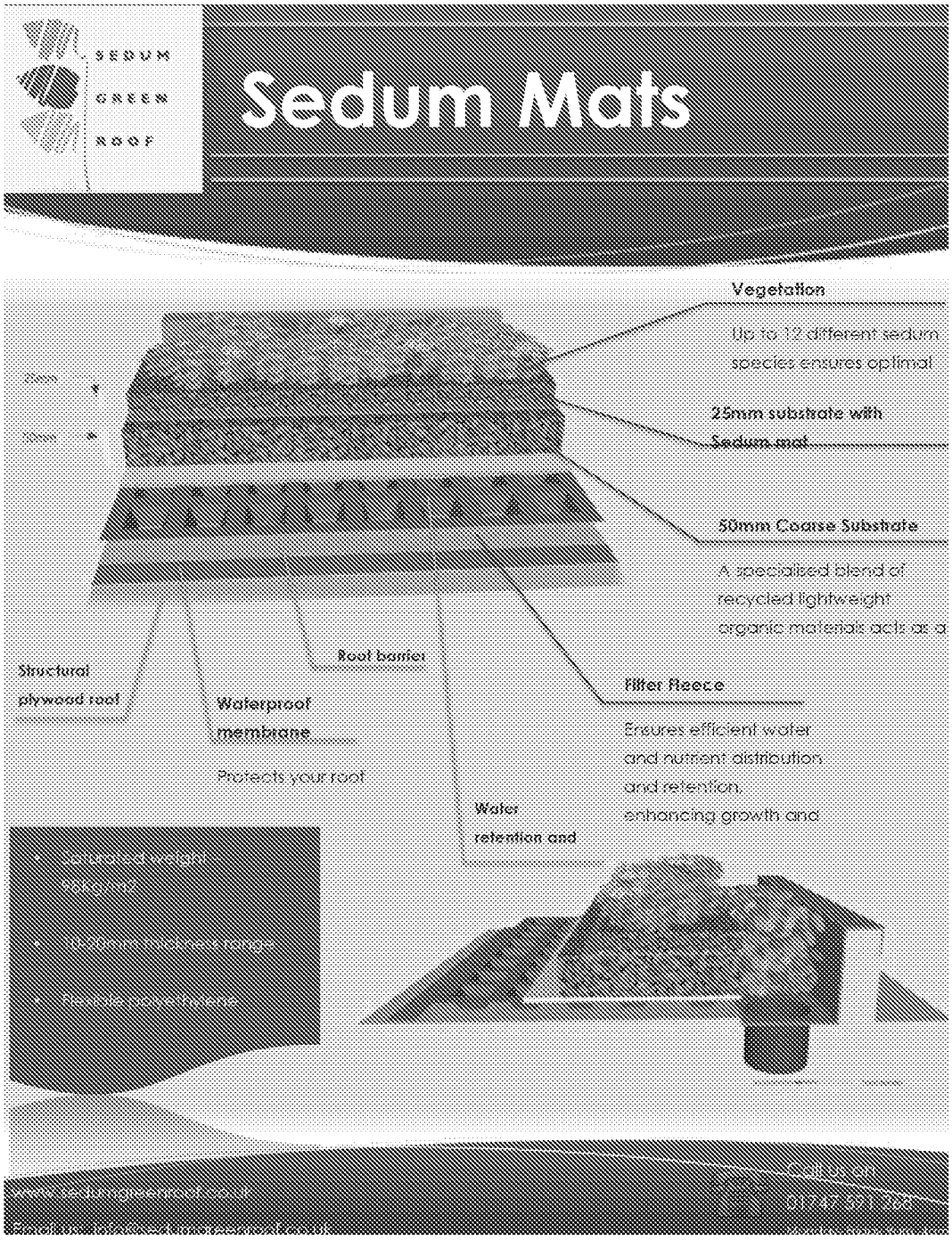
B Sedum



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C Installation and maintenance guide for the sedum roof

Guide to installing your Sedum Roof.

Firstly inspect your roof for any damage to the roof water membrane. Report any problems to the installer. After inspection install the aluminium trim, if required, around the perimeter. This holds the sedum layers in place around the edge. If this needs to be stuck down ask the waterproof membrane manufacture what adhesives to use.

The first layer to go down is the drainage layer. Cut to lengths off the roof to avoid damage to the waterproof membrane. Lay this down with the thick fabric, the protection fleece, on the bottom. The filter fleece, thin fleece, will be facing upwards. Make sure you open out the white flap of the top layer, (the filter fleece). If your roof has no root barrier as part of the waterproof membrane a root barrier must be laid first.

The second layer to go down is the substrate. Take all the bags of substrate to the roof and work from one end. Lay a minimum of 2 bags per m2 of substrate growing medium onto the roof. Make sure that the entire roof has been evenly laid. Simply empty out the contents and rake over evenly. Finish depth should be 50mm

The final layer to go on is the Sedum Matting. Unroll the sedum mats on the **day of arrival** if not being installed on the day of delivery. Unroll the Sedum mats and work from one end of the roof. As you go, make sure the edges are butted up neatly to avoid any bare substrate showing. Fill any gaps with left over mats to get an even coverage. Check to see what the weather is doing. If rain is due over the next 3 days then leave off watering. If installing in the summer give it a good watering in after completion. With the S-Pods the same applies, they must be **un-stacked on day of arrival.**

How to maintain your Sedum Roof.

Frequency of maintenance visits should be a minimum of 2 a year. Once in spring, this visit is to carry out weeding and a fertilizer application, (6 month slow release fertilizer is best). The second visit will just be weeding and inspecting the rainwater outlets to make sure they are clear prior to winter weather!!

Maintenance consists of: Removal of any unwanted plant material ie grasses and weeds etc. Correction of any localized plant system problems that may have occurred post installation. Application of nutrients in the Spring Maintenance visit - 6 month slow release fertiliser. Removal of dead flower heads, (if required). Inspection of rainwater outlet chambers and surrounding vegetation breaks. Replenishment of any areas, of settled substrates.

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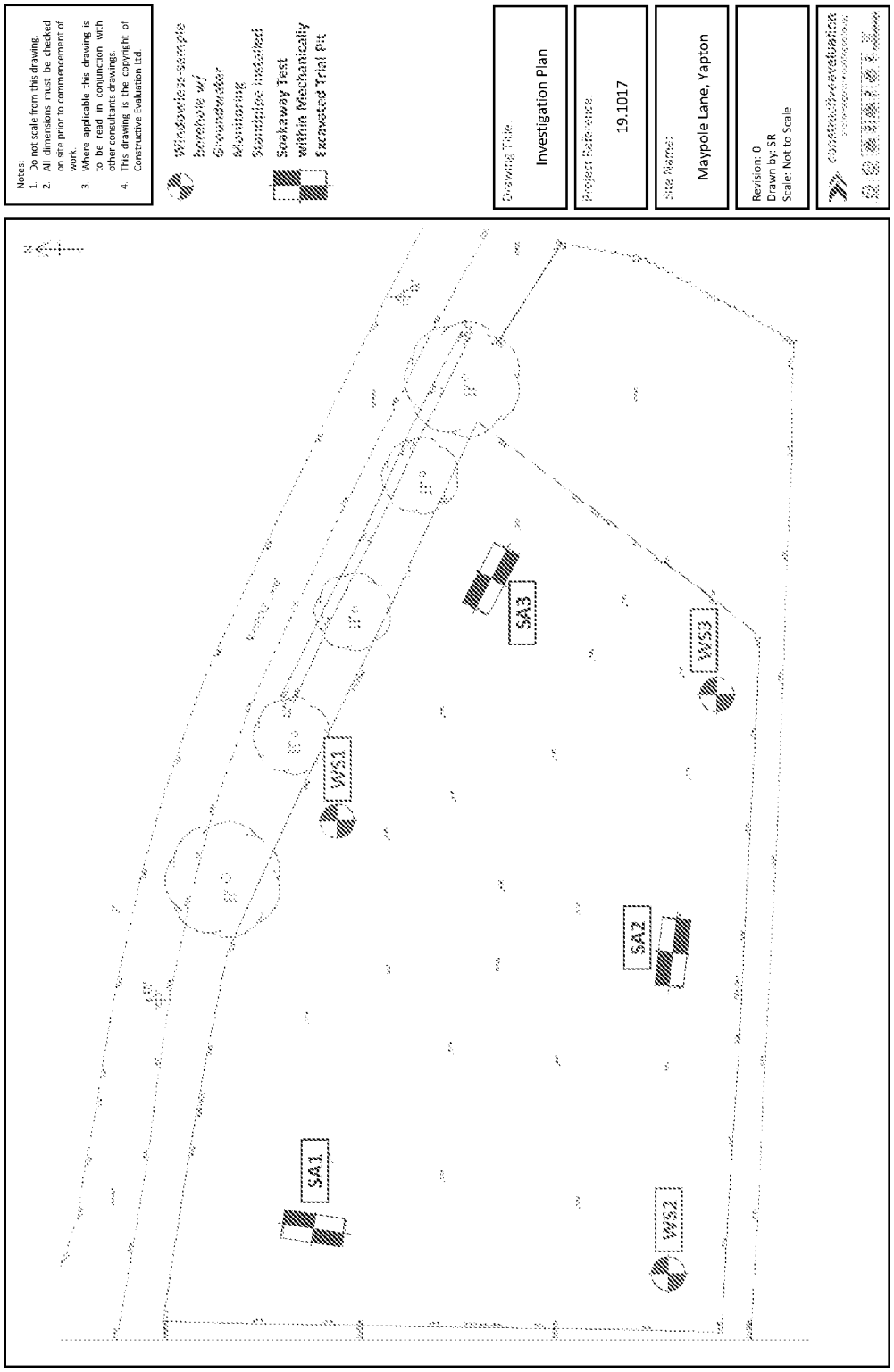
D Site investigation data

D.1 Site plan



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D.2 Trial pit logs

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Borehole Log

Borehole No. **WS1**
Sheet 1 of 1

Project Name: Maypole Lane, Yapton	Project No. 19.1017	Co-ords:	Hole Type WLS
Location: Maypole Lane, Yapton		Level:	Scale 1:35
Client: Taylor Williams Daley / Jim Payne		Dates: 11/02/2019	Logged By SR

Well	Water Strikes	Sample and In Situ Testing: Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description	
					0.05			Grass over TOPSOIL Firm to stiff becoming soft to firm brown locally greyish brown sandy gravelly becoming very sandy very gravelly CLAY/SILT. Sand is fine to coarse. Gravel is fine to coarse, subrounded to angular flint. (BRICKEARTH - RIVER TERRACE DEPOSIT)	
		0.50	D						
		1.00 - 1.50	D					*Occasional peat lenses.*	1
		1.10	SPT	N=11 (2,2/2,2,3,4)					
		1.70 - 1.80	D		1.70			Pale brown clayey SAND AND GRAVEL. Sand is fine to medium. Gravel is fine to medium, subangular to angular flint. (BRICKEARTH - RIVER TERRACE DEPOSIT)	
		1.80 - 2.20	D		1.80				
		2.00	SPT	N=7 (2,1/2,1,2,2)					2
		2.20 - 2.60	D		2.20			Firm to stiff brown and black mottled slightly gravelly sandy CLAY/SILT. Sand is fine to coarse. Gravel is fine, subrounded to subangular flint. Black mottling comprises lignitic material. (Reworked LAMBETH GROUP?)	
		2.60 - 3.10	D		2.60			Loose beige slightly gravelly clayey SAND. Sand is fine to medium. Gravel is fine to medium, subrounded to subangular flint. (RAISED BEACH DEPOSIT)	
		3.00	SPT	N=2 (2,0/1,0,0,1)				Loose orangish brown and beige slightly gravelly SAND. Sand is fine to medium. Gravel is fine to medium, subrounded to subangular flint. (RAISED BEACH DEPOSIT)	3
		3.10 - 4.00	D		3.10			Soft becoming firm very sandy becoming slightly sandy gravelly CLAY. Sand is fine to medium. Gravel is fine to coarse, rounded to subrounded flint and rare chalk. (LAMBETH GROUP)	
		4.00 - 4.80	D		4.00			Soft brown and cream sandy CLAY/SILT. Sand is fine. (Thought to be representative of a transitionary zone between soil descriptions above and below)	4
		4.00	SPT	N=1 (0,0/0,1,0,0)					
					4.80			Structureless CHALK composed of silty sandy subrounded to subangular GRAVEL. Clasts are very weak to weak low to medium density white and cream. Grade Dc. (LEWES NODULAR CHALK FORMATION)	5
		5.00 - 6.00	D						
		5.00	SPT	N=5 (1,0/0,3,2,0)					
					6.00			End of Borehole at 6.000m	6
									7

Remarks
CAT-scanned before breaking ground. 1.10m service clearance pit completed prior to drilling. Groundwater strike at 4.50mbgl. Installed with 6.00m standpipe with washed gravel surround and bentonite seal for groundwater monitoring. Finished to the surface with 100mm concrete around a raised cover.

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Borehole Log

Borehole No. **WS2**

Sheet 1 of 1

Project Name: Maypole Lane, Yapton	Project No. 19.1017	Co-ords:	Hole Type WLS
Location: Maypole Lane, Yapton		Level:	Scale 1:35
Client: Taylor Williams Daley / Jim Payne		Dates: 11/02/2019	Logged By SR

Well	Water Strikes	Sample and In Situ Testing: Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description	
					0.05			Grass over TOPSOIL Firm brown slightly sandy slightly gravelly becoming very sandy very gravelly CLAY/SILT. Sand is fine to coarse. Gravel is fine to coarse, rounded to angular flint. (BRICKEARTH - RIVER TERRACE DEPOSITS)	
		1.00 - 1.50	D		1.00			Beige to orangish beige fine to medium SAND. (RAISED BEACH DEPOSITS)	1
		1.20	SPT	N=24 (3,5/6,6,5,7)					
		1.50 - 2.00	D						
		2.00 - 2.60	D		2.00			Orangish beige gravelly SAND. Sand is fine to medium. Gravel is fine to coarse, subrounded to angular flint. Rare flint cobbles. (RAISED BEACH DEPOSITS)	2
		2.00	SPT	N=28 (2,3/5,6,8,9)					
		2.60 - 3.00	D		2.60			Structureless CHALK composed of sandy very silty subrounded to angular GRAVEL. Clasts are weak medium density white and cream with occasional black specs. Matrix is white locally beige. Frequent medium to coarse rounded to angular black and white flints. Grade Dc. (LEWES NODULAR CHALK FORMATION)	
		3.00 - 4.00	D						3
		3.00	SPT	N=22 (5,4/4,5,6,7)					
		4.00 - 4.80	D					*Becomes SL Chalk of gravelly SILT.*	4
		4.00	SPT	N=21 (3,4/6,6,5,4)					
					4.80			Structureless CHALK of white and beige slightly sandy gravelly SILT. Gravel is weak medium density white fine to coarse subrounded to angular. Grade Dm. (LEWES NODULAR CHALK FORMATION)	
		5.00 - 5.80	D						5
		5.00	SPT	N=8 (3,2/1,2,3,2)					
								Band of black silty clay.	
					5.80			Structureless CHALK composed of sandy silty subrounded to angular GRAVEL. Clasts are weak medium density white and cream with occasional black specs. Matrix is white cream and pale orange. Occasional fine to medium angular black and white flints. Grade Dc. (LEWES NODULAR CHALK FORMATION)	
		6.00 - 7.00	D						6
					7.00			End of Borehole at 7.000m	7

Remarks

CAT-scanned before breaking ground. 1.20m service clearance pit completed prior to drilling. Groundwater strike at 5.20mbgl, rising to 4.55mbgl after 30 minutes. Installed with 7.00m standpipe with washed gravel surround and bentonite seal for groundwater monitoring. Finished to the surface with 100mm concrete around a raised cover.

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Borehole Log

Borehole No. **WS3**

Sheet 1 of 1

Project Name: Maypole Lane, Yapton	Project No. 19.1017	Co-ords:	Hole Type WLS
Location: Maypole Lane, Yapton		Level:	Scale 1:35
Client: Taylor Williams Daley / Jim Payne		Dates: 11/02/2019	Logged By SR

Sample and In Situ Testing: Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Stratum Description
			0.05		Grass over TOPSOIL Soft to firm brown orangish brown slightly sandy gravelly CLAY/SILT. Sand is fine to medium. Gravel is fine to medium, subrounded to subangular flint.
			0.50		Orangish brown and blackish brown very clayey very sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse, subangular to angular flint. Occasional to rare flint cobbles. Blackish brown speckling is lignitic. (Possible reworked LAMBETH GROUP?)
			0.90		Soft brown gravelly very sandy CLAY. Sand is fine to coarse. Gravel is fine to coarse, rounded to subangular flint.
1.10 - 1.30 1.10 1.30 - 2.00	D SPT D	N=2 (2,0/1,0,1,0)	1.25		Structureless CHALK composed of sandy silty subrounded to angular GRAVEL. Clasts are weak medium density cream with rare black specks and fine to coarse. Matrix is cream locally orangish. Frequent fine to coarse, rounded to angular flints. Occasional 50-80mm lenses of infill comprised over overburden material. Grade Dc. (LEWES NODULAR CHALK FORMATION)
2.00 - 3.00 2.00	D SPT	N=10 (2,2/2,2,3,3)	2.10		Structureless CHALK composed of very silty subrounded to angular GRAVEL. Clasts are weak medium density white and cream with frequent black and grey specks and fine to coarse. Matrix is white and pale orange mottled. Occasional medium to coarse rounded to angular flints. Grade Dc. (LEWES NODULAR CHALK FORMATION)
3.00 - 4.00 3.00	D SPT	N=13 (3,3/3,3,3,4)			
					Matrix becomes greyish and off-white.
4.00 - 4.50 4.00	D SPT	N=14 (4,2/3,3,4,4)			
4.50 - 5.00	D		4.50 4.55		Grey fine to medium angular GRAVEL of flint. Structureless CHALK composed of cream locally orangish cream slightly gravelly sandy SILT. Gravel is weak medium density white and cream and subrounded to subangular. Occasional fine to medium angular black flints. Grade Dm. (LEWES NODULAR CHALK FORMATION)
5.00 - 5.60 5.00	D SPT	N=18 (2,2/6,6,3,3)			
5.60 - 6.00	D		5.60		Structureless CHALK composed of very silty subrounded to angular GRAVEL. Clasts are weak medium density white and cream with frequent black and grey specks and fine to coarse. Matrix is white and pale orange mottled. Occasional medium to coarse rounded to angular flints. Grade Dc. (LEWES NODULAR CHALK FORMATION)
			6.00		End of Borehole at 6.000m

Remarks

CAT-scanned before breaking ground. 1.10m service clearance pit completed prior to drilling. Groundwater strike at 4.00mbgl, rising to 3.75mbgl after 30 minutes. Installed with 6.00m standpipe with washed gravel surround and bentonite seal for groundwater monitoring. Finished to the surface with 100mm concrete around a raised cover.

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D.3 Infiltration test pit logs

Trial Pit Log

Trialpit No **SA1**

Sheet 1 of 1

Project Name: Maypole Lane, Yapton	Project No. 19.1017	Co-ords: - Level:	Date 13/02/2019
Location: Maypole Lane, Yapton		Dimensions (m): 1.7 × 0.55	Scale 1:35
Client: Taylor Williams Daley / Jim Payne		Depth 1.50	Logged SR

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
				0.05			Grass over TOPSOIL
							Firm to stiff becoming soft to firm brown sandy gravelly becoming very sandy very gravelly CLAY/SILT. Sand is fine to coarse. Gravel is fine to coarse, subrounded to angular flint. (BRICKEARTH - RIVER TERRACE DEPOSIT)
				1.30			Pale brown clayey SAND AND GRAVEL. Sand is fine to medium. Gravel is fine to medium, subangular to angular flint. (BRICKEARTH - RIVER TERRACE DEPOSIT)
				1.50			End of pit at 1.50 m

Remarks: CAT-scanned before breaking ground. Pit dimensions (m) (LxWxD) 1.70 x 0.55 x 1.50. BRE365 Soakage Testing carried out within. Backfilled with arisings and reinstated approximately to conditions as found.

Stability: Good to moderate stability.

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Trial Pit Log

Trialpit No **SA2**

Sheet 1 of 1

Project Name: Maypole Lane, Yapton	Project No. 19.1017	Co-ords: - Level:	Date 13/02/2019
Location: Maypole Lane, Yapton		Dimensions (m): 1.5 × 0.65 × Depth 1.60	Scale 1:35
Client: Taylor Williams Daley / Jim Payne			Logged SR

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
				0.05			Grass over TOPSOIL
							Firm brown locally dark brown locally orangish brown slightly gravelly sandy becoming very sandy very gravelly CLAY/SILT. Sand is fine to coarse. Gravel is fine to coarse, rounded to angular flint. (BRICKEARTH - RIVER TERRACE DEPOSITS)
				1.20			Orangish brown and blackish brown very clayey very sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse, subangular to angular flint. Occasional to rare flint cobbles. Blackish brown speckling is lignitic. (Possible reworked LAMBETH GROUP?)
				1.50			Beige to orangish beige fine to medium SAND. (RAISED BEACH DEPOSITS)
				1.60			End of pit at 1.60 m

Remarks: CAT-scanned before breaking ground. Pit dimensions (m) (LxWxD) 1.50 x 0.65 x 1.60. BRE365 Soakage Testing carried out within. Backfilled with arisings and reinstated approximately to conditions as found.

Stability: Good stability.

Trial Pit Log

Trialpit No **SA3**

Sheet 1 of 1

Project Name:	Maypole Lane, Yapton	Project No. 19.1017	Co-ords: - Level:
Date	13/02/2019		
Location:	Maypole Lane, Yapton	Dimensions (m):	1.5 × 0.5
Scale	1:35		
Client:	Taylor Williams Daley / Jim Payne	Depth	1.50
Logged	SR		

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
				0.05			Grass over TOPSOIL
				0.35			Firm to stiff becoming soft to firm brown becoming orangish brown sandy gravelly becoming very sandy very gravelly CLAY/SILT. Sand is fine to coarse. Gravel is fine to coarse, subrounded to angular flint. (BRICKEARTH - RIVER TERRACE DEPOSIT)
				0.65			Firm orangish brown slightly gravelly silty very sandy CLAY. Sand is fine to medium. Gravel is fine to medium, rounded to angular flint.
							Yellowish brown to beige locally orangish brown gravelly cobbly locally clayey/silty SAND. Sand is fine to coarse. Gravel is fine to coarse, rounded to angular, flint. Cobbles are rounded to subrounded flints. (RAISED BEACH DEPOSIT)
				1.50			End of pit at 1.50 m

Remarks: CAT-scanned before breaking ground. Pit dimensions (m) (LxWxD) 1.50 x 0.50 x 1.50. BRE365 Soakage Testing carried out within. Backfilled with arisings and reinstated approximately to conditions as found.

Stability: Good stability.

AGS

D.4 Infiltration test data

Soakaway Test Results & Soil Infiltration Rate

Site: Maypole Lane, Yapton

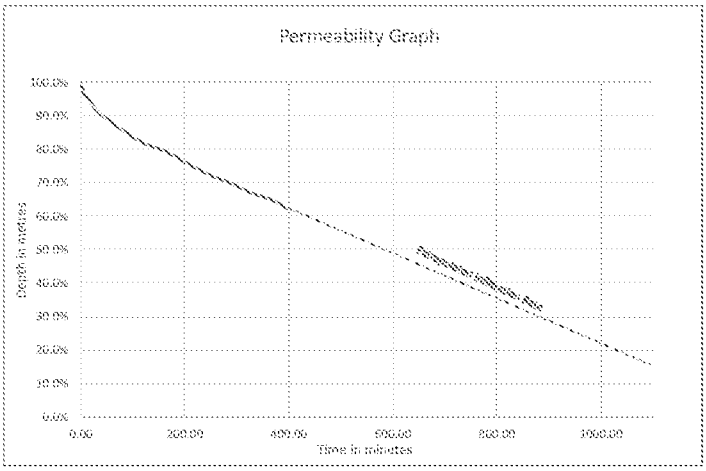
Job No: 19.1017 **Trial Hole: SA1** **Test 1**

Time in minutes	Depth to water in metres	Depth to water in metres	Percentage Volume Remaining
0.00	0.53	0.97	100.0%
1.00	0.54	0.96	99.0%
2.00	0.54	0.96	99.0%
3.00	0.55	0.95	97.9%
4.00	0.55	0.95	97.9%
5.00	0.56	0.94	96.9%
10.00	0.57	0.93	95.9%
15.00	0.58	0.92	94.8%
30.00	0.61	0.89	91.8%
45.00	0.63	0.87	89.7%
113.00	0.70	0.80	82.5%
163.00	0.73	0.77	79.4%
211.00	0.77	0.73	75.3%
250.00	0.80	0.70	72.2%
285.00	0.82	0.68	70.1%
327.00	0.85	0.65	67.0%
366.00	0.87	0.63	64.9%
403.00	0.90	0.60	61.9%
75%	25%	25%	75%

WARNING DOES NOT PASS TO 25% OF START DEPTH Refer to graph sheet for extrapolation

	Dimensions	Time in mins	
Length	1.70	250	75%
Width	0.55	75	25% (extrapolated)
Depth	1.50		

Infiltration Rate from75%-25% Not Valid



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<u>Soakaway Test Results & Soil Infilltration Rate</u>

Site: Maypole Lane, Yapton

Job No: 19.1017 **Trial Hole: SA2** **Test 1**

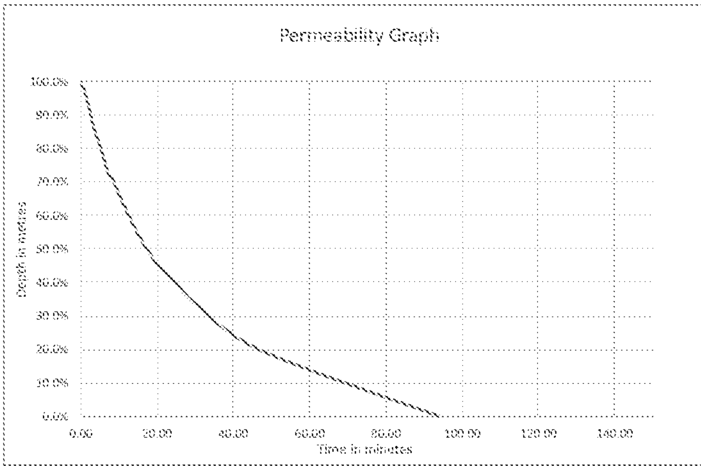
[illegible]	[illegible]	[illegible]	[illegible]
0.00	0.59	1.01	100.0%
1.00	0.62	0.98	97.0%
2.00	0.66	0.94	93.1%
3.00	0.71	0.89	88.1%
4.00	0.75	0.85	84.2%
5.00	0.78	0.82	81.2%
6.00	0.82	0.78	77.2%
7.00	0.86	0.74	73.3%
8.00	0.88	0.72	71.3%
9.00	0.90	0.70	69.3%
10.00	0.93	0.67	66.3%
15.00	1.05	0.55	54.5%
20.00	1.14	0.46	45.5%
25.00	1.20	0.40	39.6%
30.00	1.26	0.34	33.7%
47.00	1.40	0.20	19.8%
94.00	1.60	0.00	0.0%
94.00	1.60	0.00	0.0%

INFILTRATION CALCULATED FROM 75%-25% WATER DEPTH RANGE

[illegible]	
Length	1.50
Width	0.65
Depth	1.60

Time in mins	
6.5	75%
37	25%

<u>Infiltration Rate</u> <u>from75%-25%</u> **8.55101E-05**



Soakaway Test Results & Soil Infilltration Rate

Site: Maypole Lane, Yapton

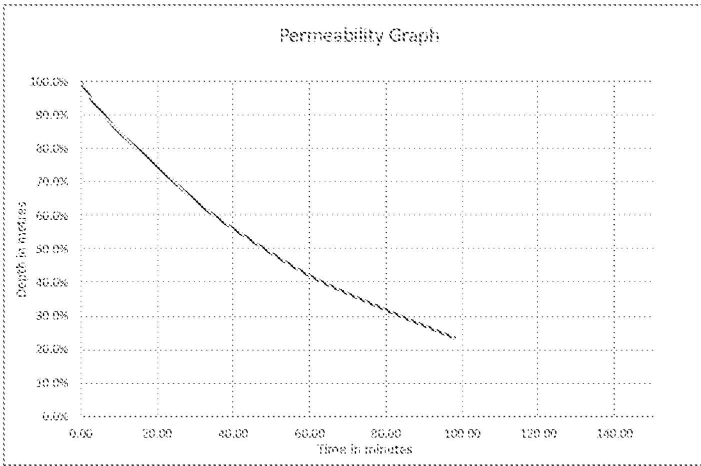
Job No: 19.1017 **Trial Hole: SA2** **Test 2**

[illegible]	[illegible]	[illegible]	[illegible]
0.00	0.53	1.07	100.0%
1.00	0.55	1.05	98.1%
2.00	0.57	1.03	96.3%
3.00	0.59	1.01	94.4%
4.00	0.61	0.99	92.5%
5.00	0.62	0.98	91.6%
10.00	0.69	0.91	85.0%
20.00	0.80	0.80	74.8%
30.00	0.91	0.69	64.5%
40.00	1.00	0.60	56.1%
60.00	1.15	0.45	42.1%
82.00	1.27	0.33	30.8%
92.00	1.32	0.28	26.2%
98.00	1.35	0.25	23.4%
[illegible]	[illegible]	[illegible]	[illegible]

INFILTRATION CALCULATED FROM 75%-25% WATER DEPTH RANGE

[illegible]		Time in mins	
Length	1.50	20	75%
Width	0.65	94	25%
Depth	1.60		

Infiltration Rate from75%-25% **3.58672E-05**



Soakaway Test Results & Soil Infilltration Rate

Site: Maypole Lane, Yapton

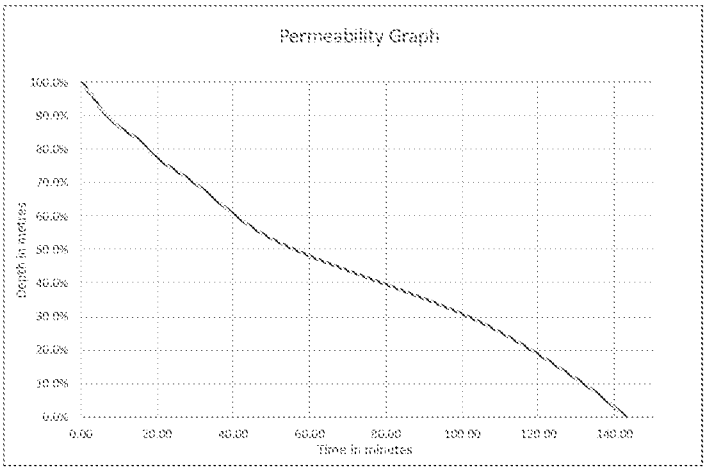
Job No: 19.1017 **Trial Hole: SA2** **Test 3**

Time in minutes	Depth to water in metres	Depth to water in metres	Percentage of water remaining
0.00	0.54	1.06	100.0%
1.00	0.55	1.05	99.1%
2.00	0.57	1.03	97.2%
3.00	0.58	1.02	96.2%
4.00	0.60	1.00	94.3%
5.00	0.62	0.98	92.5%
10.00	0.68	0.92	86.8%
15.00	0.72	0.88	83.0%
20.00	0.78	0.82	77.4%
30.00	0.86	0.74	69.8%
45.00	1.00	0.60	56.6%
60.00	1.09	0.51	48.1%
103.00	1.29	0.31	29.2%
130.00	1.48	0.12	11.3%
143.00	1.60	0.00	0.0%

INFILTRATION CALCULATED FROM 75%-25% WATER DEPTH RANGE

	Dimensions	Time in mins	
Length	1.50	23	75%
Width	0.65	110	25%
Depth	1.60		

Infiltration Rate from75%-25% **3.04223E-05**



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Soakaway Test Results & Soil Infilltration Rate

Site: Maypole Lane, Yapton

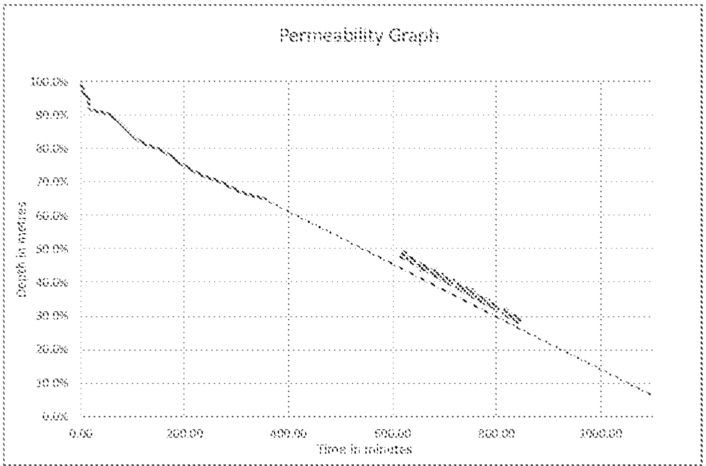
Job No: 19.1017 **Trial Hole: SA3** **Test 1**

[illegible]	[illegible]	[illegible]	[illegible]
0.00	0.530	0.97	100.0%
1.00	0.540	0.96	99.0%
2.00	0.540	0.96	99.0%
3.00	0.550	0.95	97.9%
4.00	0.550	0.95	97.9%
5.00	0.560	0.94	96.9%
10.00	0.570	0.93	95.9%
15.00	0.580	0.92	94.8%
20.00	0.610	0.89	91.8%
61.00	0.630	0.87	89.7%
111.00	0.700	0.80	82.5%
157.00	0.730	0.77	79.4%
196.00	0.770	0.73	75.3%
232.00	0.800	0.70	72.2%
268.00	0.820	0.68	70.1%
309.00	0.850	0.65	67.0%
355.00	0.870	0.63	64.9%
[illegible]	[illegible]	[illegible]	[illegible]

WARNING DOES NOT FALL TO 25% OF START DEPTH Refer to graph sheet for calculation

[illegible]		Time in mins	
Length	1.50	196	75%
Width	0.50	[illegible]	25% (extrapolated)
Depth	1.50		

Infiltration Rate from75%-25% Not Valid



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E Polypipe main components

E.1 Permavoid cells

Permavoid system - components

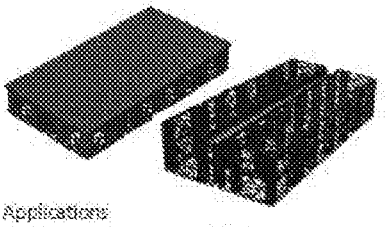
Permavoid 85 and 150

Product code: PVP85 and PVP150

Permavoid is a geocellular interlocking system designed for shallow groundwater storage or infiltration, to be used in place of traditional aggregate sub-base. The system has an exceptionally high compression and tensile strength and bending resistance with a proprietary jointing system to create a horizontal structural 'raft' within the pavement that is ideal for the shallow attenuation of surface water. The system can also be combined in layers using interlocking shear connection to increase depth in 85mm and 150mm increments. This is particularly useful in designing infiltration systems, allowing flexibility in balancing the soil permeability/infiltration area of the Permavoid storage units and residual temporary attenuation.

Element	85mm	150mm
Physical Properties		
Weight per unit	2.25kg	3kg
Weight per square metre	8kg	12kg
Length	2400mm	2400mm
Width	954mm	954mm
Depth	85mm	150mm
Short Term Compressive Strength		
Vertical	21.6kN/m²	21.6kN/m²
Lateral	15.6kN/m²	15.6kN/m²
Short Term Deflection		
Vertical	1mm per 17.5kN/m²	1mm per 15.6kN/m²
Lateral	1mm per 11.6kN/m²	1mm per 10kN/m²
Tensile Strength		
Of a single joint	62.4kN/m²	62.4kN/m²
Of a single joint at the seam (welded)	48.8kN/m²	48.8kN/m²
Bending resistance of unit	0.7kNm	0.7kNm
Bending resistance of single joint	0.14kNm	0.14kNm
Volumetric void ratio	95%	95%
Average effective perforated surface area	32%	32%
Other Properties		
Nominal permeability (k)	2.0 x 10⁻³	2.0 x 10⁻³
Geotextile	Perforated Permeable Permavoid Base Geotextile	Perforated Permeable Permavoid Base Geotextile
Material	Polypropylene (PP)	Polypropylene (PP)

85mm Permavoid Dimensions	150mm Permavoid Dimensions
2.4metre wide, 1 unit deep	2.4metre wide, 1 unit deep
(0.2metre x 0.1metre)	(0.2metre x 0.1metre)
Free Discharge	**Free Discharge**
Gradient (%) 0 1 2	Gradient (%) 0 1 2 3 4 5
Flow Rate (l/min) 6 8 9	Flow Rate (l/min) 8 13 15 17 19 21



Applications

The Permavoid units are suitable for use as a stormwater attenuation and/or infiltration system. The system comprises of single, interconnected cells which can be installed in the ground as part of sub base formation. Permavoid is suitable for use in a range of applications including residential, industrial estates, car parks, sports pitches, roofs, basements, pedestrian areas and rainwater harvesting.

Performance

The structural load bearing capacity of the Permavoid units have been tested in accordance with the following European Standard, BS 7533-13:2009. The system's structural design life expectancy, based upon creep test data (tested in accordance with CIRIA guidelines) is as follows: For lightly loaded areas such as car parks, a design life of 50 years is achievable. For areas with prolonged HGV loading a typical design life may only be 25 years, depending on the design of the pavement surfacing and structural layers over the tank.

Installation standard

All calculations for Permavoid units are based upon site-specific load cases, pavement construction types and thicknesses, soil cover and ground conditions and the suitability must therefore be approved for each project.

Permavoid Technical Manual

Available to download on the website toolbox.

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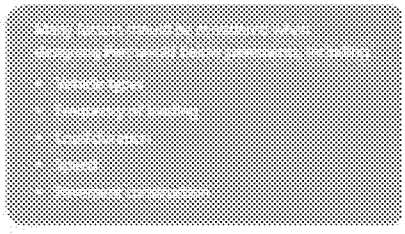
Structural design

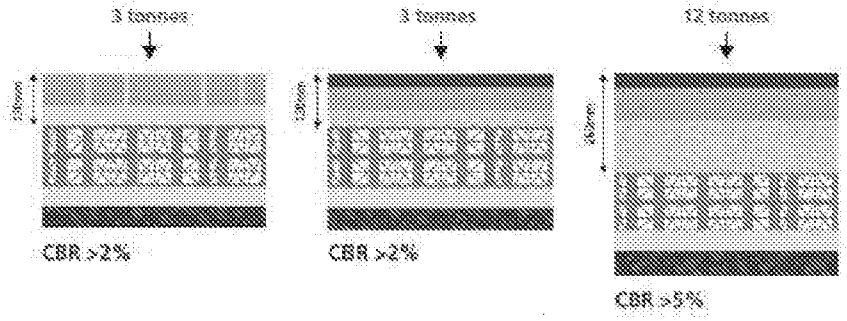
Pavement applications

The Permeweb system has undergone numerous laboratory tests and instrumented site trials to validate use as pavement constructions. Permeweb exceeds the minimum cell performance recommended in industry guidance for geocellular cells installed within a pavement structure.



Pavement construction examples

Typical minimum recommended pavement construction details, for a number of loading situations, are reproduced below, amended to illustrate how Permeweb would typically be installed within these pavement structures.



50mm base
- 150mm sand bed
- 150mm

Applications:
- Private drives
- Car parks with height restrictions

100mm asphalt surface
- 60mm asphalt base
- 60mm Type 1 sub-base
- 150mm

Applications:
- Private drives
- Car parks with height restrictions
- Includes for occasional accidental HGV overrun

100mm asphalt surface
- 60mm asphalt base
- 100mm Type 1 sub-base
- 150mm

Applications:
- Car parks without height restrictions
- Includes for occasional accidental HGV overrun
- Suitable for access roads

Permeweb Technical Manual

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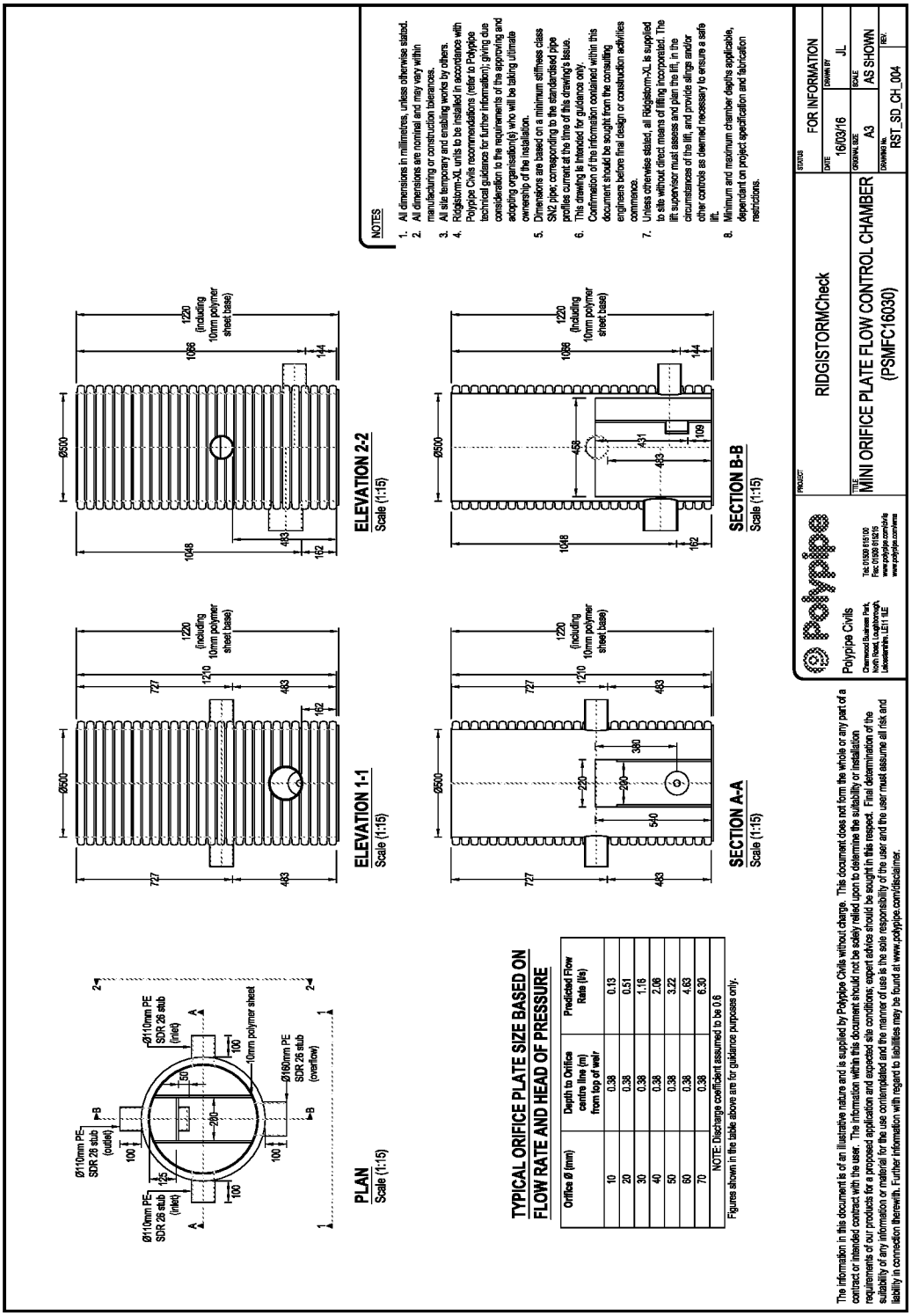
E.2 Orifice chamber



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