1.0 INTRODUCTION

This summary guidance document has been prepared by Hydrock Consultants Limited (Hydrock) on behalf of the Somerset Drainage Boards Consortium (SDBC). A full document (Ref. R/09191/001/2) has been prepared for SDBC, however this document has been produced for issue to those developers proposing infiltration devices within the Somerset Levels and Moors area and provides a simple summary of the points in the overall guidance document.

Current best practice guidance promotes the use of SUDS methods of surface water disposal. However the geological and hydrological conditions prevalent in the Somerset Levels and Moors region means that to design SUDS strategies to modern standards, specifically infiltration solutions, can prove problematic in some situations / locations. The inappropriate use of infiltration drainage solutions may inadvertently increase flood risk within an area.

2.0 INFILTRATION DESIGN CRITERIA

The design and construction procedures for infiltration devices, specifically soakaways, is prescribed in document BRE Digest 365, and is the recommended method that should be adopted for all proposed soakaway designs within the study area.

There are effectively two steps in the design process, the determination of whether infiltration would be feasible on the site and, if so, the design of the proposed soakaway structure.

The evidence and results to support such a proposal should be undertaken by a technically competent Civil Engineer and would require the approval of SDBC.

A list of the minimum evidence that should be submitted to SDBC in light of a proposed soakaway structure is included in Appendix A. Examples of calculations and various scenarios are detailed in Section 3.0.

<u>Ground Investigation</u>

A Ground Investigation should assess the soil infiltration rate, depth to groundwater and, if necessary, note any geotechnical implications.

Soil Infiltration Rate

The infiltration rate of the ground at a subject site should be determined within a site specific trial pit(s), ideally in the approximate location of the proposed soakaway. For potentially large area soakaways, a trial pit should be dug at intervals of approximately every 10m. Trial pits should be dug to the same depth as that anticipated for the proposed soakaway (around 1.0m – 1.5m below the anticipated invert level of the pipe discharging to the proposed soakaway); be between 0.3m – 1.0m wide; and, approximately 1m – 3m long, with trimmed vertical sides.

The trial pit(s) should be rapidly filled three times to its ‘effective depth’ (i.e. the anticipated soffit level of the soakaway structure) within the same, or on consecutive, day(s). The depth of water should be recorded at regular intervals on each occasion, until the trial pit(s) is near empty.

The soil infiltration rate should be calculated as follows:

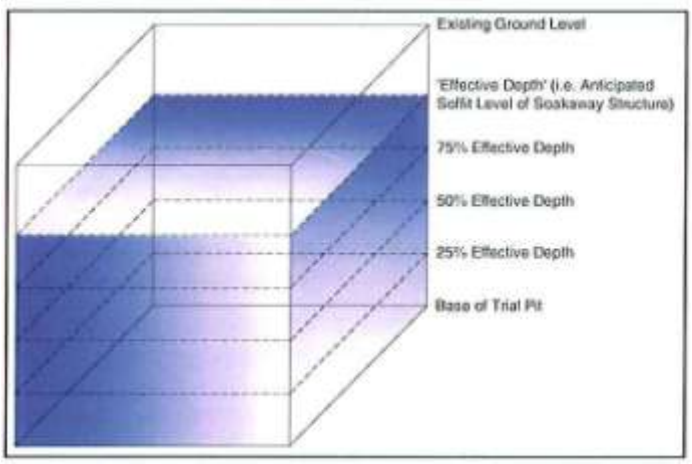
$$\mathbf{f} = \mathbf{V}_{p75\text{-}25} \div \mathbf{a}_{p50} \times \mathbf{t}_{p75\text{-}25}$$

f: soil infiltration rate (m/s)

$\mathbf{V}_{p75\text{-}25}$: volume of water in the trial pit between 75% - 25% effective depth (m³)

$\mathbf{a}_{p50}$: internal surface area of trial pit up to 50% effective depth, including the base area (m²)

$\mathbf{t}_{p75\text{-}25}$: time for water to fall from 75% - 25% effective depth (secs)



The average calculated infiltration rate should be used for design purposes.

Depth to Groundwater

To ensure the adequate performance of a proposed soakaway structure and in accordance with the requirements of the Environment Agency, a minimum 1.0m 'buffer' should be ensured between the bottom of a proposed soakaway structure and the groundwater table.

As such the groundwater level at a subject site should be determined via a site specific trial pit(s) / borehole(s), ideally in the approximate location of the proposed soakaway. The groundwater level should be monitored daily over a minimum one week period between mid-April – mid-November (to coincide with the period where water levels are maintained at a relatively high level), and the highest level recorded.

Geotechnical Implications

To ensure that the introduction of potentially large volumes of rainwater into the ground does not adversely affect existing sub-surface drainage patterns and/or surrounding ground stability it may be necessary, at the discretion of SDBC, and certainly for infiltration drainage proposals within areas of Blown Sand geology, to undertake a Geotechnical Assessment by a suitably qualified professional. Such an assessment should identify whether the site or surrounding area could become susceptible to inundation settlement, the effect of any ground slopes on downhill waterlogging, and, any other adverse impacts that could likely result from a proposed infiltration means of surface water disposal.

Construction

Storage Volume Calculations

The soakaway storage volume should be calculated either as detailed below or via a computer modelling package such as WinDes, or similar.

$$S = I - O$$

S: soakaway storage volume (m^3)
I: inflow from the impermeable area drained to the soakaway (m^3)
O: outflow infiltrating into the soil (m^3)

Inflow

$$I = A \times R$$

A: impermeable area to be drained to the proposed soakaway (m^2)
R: total rainfall in design storm (m)
In line with Document H, Drainage and Waste Disposal, of the Building Regulations 2000, soakaways should be designed to accommodate a minimum of a 1 in 10 year return period event for the critical storm duration (i.e. that storm which would require the largest storage volume). It is advised that the following 1 in 10 year return period rainfall values be used for infiltration proposals within the study area:

Table 2.0: 1 in 10 year Rainfall Values for Study Area

Storm Duration (mins)	**5**	**10**	**15**	**30**	**60**	**120**	**240**	**360**	**600**
M10-D (mm/m)	8.64	12.44	15.25	19.59	24.80	30.26	36.60	40.90	46.41

Outflow

$$O = a_{s50} \times f \times D$$

a_{s50}: Internal surface area of proposed soakaway up to 50% effective depth, excluding the base area (m^2)
f: soil infiltration rate [see Section 5.2.1] (m/s)
D: storm duration (sec)

Review of Suitability

It is generally considered that rainwater discharge direct from roof areas to soakaways would not require additional pollution control measures. However, any discharge from paved areas should pass through a suitable form of oil interception device prior to discharging to a soakaway.

In line with Document H, Drainage and Waste Disposal, of the Building Regulations 2000 proposed infiltration structures should not be sited within 5.0m of building and / or highway foundations; nor in areas of unstable land; and, be sufficiently far away from any existing watercourses / ditches. For the purposes of this area, ‘sufficiently far away’ is considered a minimum of 5.0m.

It should also be ensured that any proposed soakaway discharge from full to half-volume within the required maximum 24 hour duration, to allow for subsequent storm inflow.

The half drain time (ts50) should be calculated as follows:

$$t_{s50} = S \times 0.5 \div a_{s50} \times f$$

3.0 EXAMPLES

<u>Example 1</u>

A proposal involves the development of two new dwellings. Rainwater run-off would occur from the combined 100m² proposed roof area and 150m² proposed paved area.

Soil Infiltration Rate

The Ground Investigation undertook a trial pit of dimensions 2.00m deep, 1.00m wide and 3.00m long and was filled three times to a depth of 1.50m (effective depth). The three tests drained from 75% -25% effective depth in 417mins, 500mins and 625mins respectively.

Using equation $\mathbf{f} = \mathbf{V}_{p75\text{-}25} \div \mathbf{a}_{p50} \times \mathbf{t}_{p75\text{-}25}$

$\mathbf{V}_{p75\text{-}25}$: 3.00 x 1.00 x (1.125 – 0.375) = 2.25m³

$\mathbf{a}_{p50}$: (3.00 x 0.75 x 2) + (1.00 x 0.75 x 2) + (1.00 x 3.00) = 9.00m²

$\mathbf{t}_{p75\text{-}25}$: 417, 500 & 625 respectively (mins)

Therefore,

= 2.25 ÷ (9.00 x 417) = 0.00060 = 6.0 x 10-4

= 2.25 ÷ (9.00 x 500) = 0.00050 = 5.0 x 10-4 = average infiltration rate to be used for design

= 2.25 ÷ (9.00 x 625) = 0.00040 = 4.0 x 10-4

Depth to Groundwater

Periodic monitoring of the groundwater level over a one week period in July recorded a maximum groundwater level of 5.50m below ground level.

Geotechnical Implications

The underlying geology was identified as Blown Sand, and as such a Geotechnical Assessment was commissioned and subsequently undertaken by a suitably qualified professional. The report concluded that the nature of the underlying geology in that particular location and distance to existing adjacent structures would mean that the proposed use of soakaway drainage would not result in demonstrable harm to existing adjacent areas or the proposal site.

Storage Volume Calculations

For the purposes of this example a soakaway with dimensions 1.50m effective depth and 3.00m long was proposed due to site constraints, with the width (W) to be determined to suit the critical storm event. The soakaway would be constructed of a granular fill material and have an approximate 30% void space.

Inflow (I = A x R)

A: 100m² + 150m² = 250m²
R: M10-5 = 8.64mm = 0.00864m

Therefore,

= 250 x 0.00864 = 2.16m³

Outflow (**O** = $\mathbf{a_{s50}}$ **x f x D**)

$\mathbf{a_{s50}}$: 2 x (3.00+ W) x (1.50 ÷ 2)
4.50 + 1.50 Wm^2

f: 5.0 x 10^{-4}m/s

D: 5min = 300sec

Therefore,

= (4.50 + 1.50 W) x (5.0 x 10^{-4}) x 300

Storage Volume

Effective volume of soakaway with 30% void space: 1.50 x 3.00 x W x 0.3 = 1.35 Wm^3

Satisfactory storage of M10-5, using S = I – O:

Therefore,

= 2.16 -(4.50 + 1.50 W) x (5.0 x 10^{-4}) x 300

= 2.16 – 0.9 W

= 1.26 W

= 1.26 ÷ 1.35

= required soakaway width for M10-5 storm = 0.93m

Calculations were then repeated for a range of critical storm durations.

Table 3.0: Required Soakaway Widths for range of Storm Durations

Storm Duration (mins)	Required Soakaway Width (m)
5	0.93 (as above)
10	0.97
15	0.82
30	-0.37
60	-3.41
120	-10.39
240	-25.22
360	-40.42
600	-71.41

The calculations have indicated the critical storm duration to be 10 minutes in this situation, i.e. greatest soakaway width. A soakaway of dimensions 1.50m effective depth, 3.00m long and 0.97m wide was shown to be suitable for the M10-10 critical storm in this situation.

Review of Suitability

The proposed soakaway design must also ensure that: a suitable form of oil interception device would be fitted to the inflow pipe from the proposed paved areas; would be >5.0m from any proposed or existing building, highway or watercourse / ditch foundations; would not be within an area of unstable land; and, the invert level of the structure would be >1.0m above the maximum recorded groundwater level (in this instance a 3.50m ‘buffer’ is provided, taking the soffit level of the proposed structure as 0.50m below ground level combined with a 1.50m effective depth, and a depth to groundwater of 5.50m).

The proposed soakaway is also shown to discharge from full to half-volume within the required maximum 24 hour duration, using, $\mathbf{t}_{s50}$ = **S x 0.5** ÷ $\mathbf{a}_{s50}$ **x f**

Therefore,

= (((1.50 x 3.00 x 0.97) x 0.3) x 0.5) ÷ (((3.00 + 0.97) x 2) x 0.75) x (5.0 x 10^{-4})

= 219.90sec

= 3min 40sec

Example 2

A proposal involves the development of one new dwelling. Rainwater run-off would occur from the 50m² proposed roof area.

Soil Infiltration Rate

The Ground Investigation undertook a trial pit of dimensions 2.00m deep, 1.00m wide and 3.00m long and was filled to a depth of 1.50m (effective depth). Water from the first test did not appreciably drain despite being monitored for several days. No further tests or calculations were considered necessary.

Depth to Groundwater

Periodic monitoring of the groundwater level over a one month period in August recorded a maximum groundwater level of 1.00m below ground level.

Based on the conclusions of the infiltration testing and groundwater level monitoring it was acknowledged that a soakaway means of surface water disposal from the site would not be feasible. Discussions between the developer and SDBC concluded that a discharge to an adjacent rhyne would be possible, provided certain conditions were met.

Example 3

A proposal involves the development of four new dwellings. Rainwater run-off would occur from the combined 200m² proposed roof area and 250m² proposed paved area.

Soil Infiltration Rate

The Ground Investigation undertook a trial pit of dimensions 2.00m deep, 1.00m wide and 3.00m long and was filled three times to a depth of 1.50m (effective depth). The three tests drained from 75% -25% effective depth in 417mins, 500mins and 625mins respectively.

Using equation **f =** $\mathbf{V}_{p75\text{-}25}$ ÷ $\mathbf{a}_{p50}$ x $\mathbf{t}_{p75\text{-}25}$

$\mathbf{V}_{p75\text{-}25}$: 3.00 x 1.00 x (1.125 – 0.375) = 2.25m³

$\mathbf{a}_{p50}$: (3.00 x 0.75 x 2) + (1.00 x 0.75 x 2) + (1.00 x 3.00) = 9.00m²

$\mathbf{t}_{p75\text{-}25}$: 417, 500 & 625 respectively (mins)

Therefore,

= 2.25 ÷ (9.00 x 417) = 0.00060 = 6.0×10^{-4}

= 2.25 ÷ (9.00 x 500) = 0.00050 = 5.0×10^{-4} = average infiltration rate to be used for design

= 2.25 ÷ (9.00 x 625) = 0.00040 = 4.0×10^{-4}

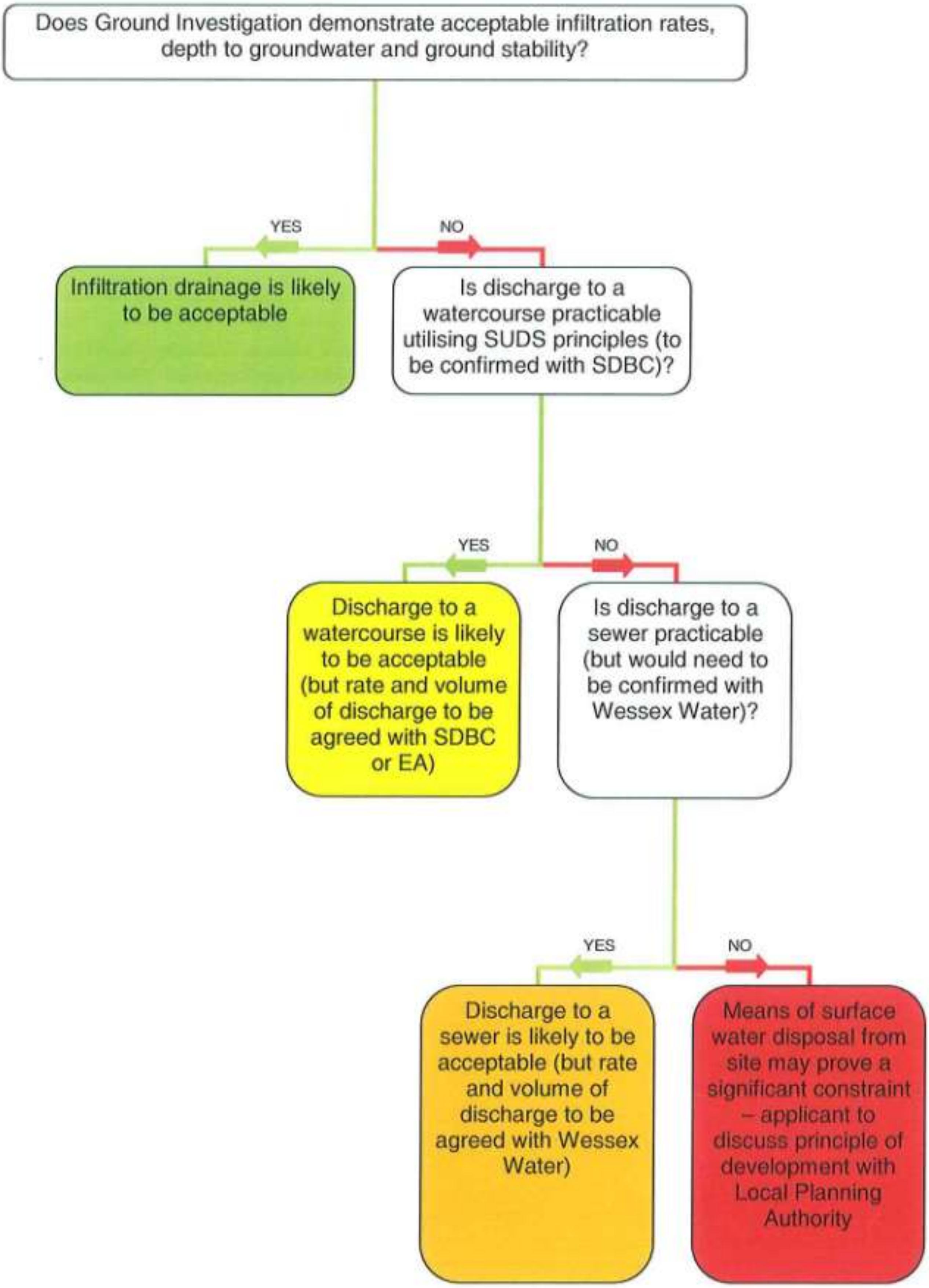
Depth to Groundwater

Periodic monitoring of the groundwater level over a one week period in July recorded a maximum groundwater level of 5.50m below ground level.

Geotechnical Implications

The underlying geology was identified as Blown Sand, and as such a Geotechnical Assessment was commissioned and subsequently undertaken by a suitably qualified professional. The report concluded that the nature of the underlying geology in conjunction with the topography of the site in relation to adjacent existing buildings, could potentially result in waterlogging of several adjacent downhill properties and could affect the stability of the land both beneath the proposal site and under adjacent land. As such it was acknowledged that a soakaway means of surface water disposal from the site would not be feasible, even though the infiltration rate indicated this to be potentially acceptable. Discussions between the developer and SDBC concluded that no rhynes were within a practicable connection distance of the site. Subsequent discussions with Wessex Water concluded that a discharge to an adjacent surface water sewer would be possible, provided certain conditions were met.

Surface Water Drainage Decision Flow Chart



Minimum Evidence ‘Check List’

Site	
Site location plan	
Site plan showing impermeable area to be drained to soakaway	
Ground Investigation	
Plan showing location of trial pit(s) and dimensions	
Infiltration rate calculations from all trial pit tests	
Written results of groundwater level assessment and nature of geology	
Geotechnical Assessment Report, if necessary	
Construction	
Drawing showing plan layout of proposed soakaway(s)	
Drawing showing cross-section of proposed soakaway(s) (including maximum recorded groundwater level)	
Storage volume calculations	
Emptying time calculations	

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