VOLUME 4 GEOTECHNICS AND DRAINAGE
SECTION 2 DRAINAGE

PART 8

HA 118/06

DESIGN OF SOAKAWAYS

SUMMARY

This advice note gives design guidance on how soakaways may be incorporated into systems used to treat and store road runoff prior to discharging to ground. It describes the steps needed to protect receiving groundwater and the constraints these may place on soakaway design and construction. This document provides general design advice, however there are a number of design procedures described herein which must be adopted as mandatory practice, for which reference is made to HD 33 (DMRB 4.2) as appropriate.

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2. Insert new Contents pages for Volume 4 dated May 2006.

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Design of Soakaways

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DESIGN OF SOAKAWAYS

Contents

1. INTRODUCTION

1.1 General

1.1.1 This Advice Note gives guidance on how soakaways may be incorporated into systems used to treat and store road runoff prior to discharging to ground. This Advice Note has been compiled to summarise and review the current available design guidance in use within the UK on the selection and construction of soakaways. The design guidance provided in this document focuses on 'point' discharges to the ground from 'single' soakaways (or combinations of these). These are defined as drainage structures (pits, chambers and trenches) that allow infiltration to the ground through their base and sides and that incorporate below ground storage.

1.1.2 The Advice Note originates from a review of available information on the fate and transport of road contaminants and the design of existing road soakaway systems. The review focussed primarily on an understanding of the processes operating in the unsaturated zone (i.e. above the water table) and how these may influence soakaway design and prevent groundwater pollution.

1.1.3 In most of the UK the term 'highways' is equivalent to Scottish 'roads'. In this document, as with the guidance provided in HA 216: Road Drainage and the Water Environment (DMRB 11.3.10), the term 'roads' will be used as standard terminology.

1.1.4 This document provides general design advice, however there are a number of design procedures described herein which must be adopted as mandatory practice, for which reference is made to HD 33: Surface and Sub-Surface Drainage Systems for Highways (DMRB 4.2) as appropriate.

1.2 Background

1.2.1 There is growing awareness by the Environmental Protection Agencies (EPAs) that road runoff may, under certain circumstances, have an adverse effect on receiving waters, including groundwater. This has arisen both because of improving knowledge of the polluting content of road runoff and because of improved treatment of other sources of pollution. Contact details for the various EPAs can be found on their respective web-sites:

www.environment-agency.gov.uk

www.sepa.org.uk

www.ehsni.gov.uk

1.2.2 Overseeing Organisations have a duty under pollution protection legislation to ensure that road runoff does not pollute receiving waters. This can arise both from the effects of routine runoff and from spillages on the road. For discharges to ground, The Groundwater Regulations 1998 (SI 1998 No 2746) in England, Scotland and Wales or The Groundwater Regulations (Northern Ireland) 1998 (Statutory Rule NI 1998 No 401) include lists of substances whose entry to groundwater must be prevented or controlled. These substances are commonly referred to as List I and List II substances. Details of these substances are set out in HA 216 (DMRB 11.3.10). Because consents are not required for the discharge of road runoff, the responsibility is with the Overseeing Organisations to discharge their duty not to pollute receiving waters by ensuring that systems for the treatment of road runoff are installed when necessary. EPAs should, however, be consulted about proposals for discharging road runoff, as they have the power to serve prohibition notices in respect of discharges that are in breach of pollution legislation. Implementation into UK law of the Water Framework Directive (2000/60/EC) (e.g. The Water Environment (Water Framework Directive) (England and Wales) Regulations 2003 (SI 2003 No 3245); (similar regulations pertain to Scotland and Northern Ireland) has given added weight to the need to protect existing water bodies.

1.2.3 The disposal of road runoff through soakaway systems is reasonably well established within the UK. However, the attenuation mechanisms operating on road runoff to reduce pollutant loadings at the discharge point below the soakaway, and within the unsaturated zone above the water table, are currently poorly understood. Changes in design practice, as well as legislation controlling the discharge of pollutants to controlled waters and the results of future research into the fate of pollutants in soakaways and the unsaturated zone may cause current guidance to be superseded.

1.2.4 Design of other drainage structures such as linear drains is discussed in HD 33 (DMRB 4.2). The use of vegetated systems to treat road runoff is discussed in HA 103: Vegetated Drainage Systems for Highway

Runoff (DMRB 4.2). HA 216 (DMRB 11.3.10) provides guidance on assessing the risks to groundwater from road runoff.

1.3 Design Concepts

1.3.1 There are three major objectives in the drainage of roads:

- the speedy removal of surface water to provide safety and minimum nuisance for the road user;
- provision of effective sub-surface drainage to maximise longevity of the pavement and its associated earthworks;
- minimisation of the impact of road runoff on the receiving environment.

1.3.2 These design objectives require that to operate successfully, soakaways should be sited in porous and permeable ground of sufficient depth and lateral extent to be able to accommodate potential maximum discharges under storm conditions. Furthermore, what is good for the physical disposal of road drainage (i.e. rapid dispersal of flow) is the exact opposite of what is required with respect to the in-ground attenuation of pollutants. Where slow infiltration rates are utilised to optimise these in-ground processes, the use of balancing ponds or other flow attenuation mechanisms may be required to accept the quantity of runoff generated under peak flow conditions by the road drainage.

1.3.3 This design guidance allows the designer to consider those processes that may occur in the passage of road runoff through the soakaway system and through the unsaturated zone, prior to its ultimate discharge into groundwater. However, application of the risk assessment methodology described in HA 216 (DMRB11.3.10) may demonstrate the requirement for pollution prevention measures to be incorporated in the design of the drainage system. These should be incorporated upstream of the soakaway discharge. Such measures could include structures for the control and containment of accidental spillages, or introduce methods for the treatment of pollution derived from routine road runoff. Guidance for these measures may be found in HD 33 (DMRB 4.2) and HA 103 (DMRB 4.2).

1.3.4 Recently much attention has been paid to the design of drainage systems with more emphasis on controlled transmittal of runoff to discharge points (notably to surface waters). Such systems place a greater reliance on retaining water in storage ponds and allowing slow recharge to groundwater and have in particular been applied to the reduction of the flashy nature of runoff from urban drainage. Guidance on the use of these systems for roads is provided in HA 103 and there is also published guidance available from the Environment Agency (A Guidance Manual for Constructed Wetlands), and additional information on their website.

1.3.5 The design of soakaways, of any description, should also take into account constraints arising from the possible impact on landscape and ecology. Discharges to groundwater may potentially affect biodiversity (e.g. through impacts on wetland habitats) and any such effects should be considered both in the location and the function of the soakaways.

1.3.6 In spite of the promotion and introduction of measures that allow for the slow infiltration of road drainage into the ground, there is little data available that provides a sufficient basis to be able to quantify these effects, either in the short or longer term. As discussed above, further research, particularly on the fate of contaminants on the unsaturated zone, is needed to determine what these effects may be.

1.4 Purpose

1.4.1 The purpose of this note is to provide advice on the design and construction of soakaways comprising an excavated pit or trench rather than systems such as attenuation ponds for which there is design advice available elsewhere (HA 103 (DMRB 4.2)). This Advice Note also discusses the measures that can be made to complement the pollutant attenuation capacity of the soakaway system, including taking into account the underlying unsaturated zone, in order to prevent the risk of groundwater pollution. The note should therefore be read in conjunction with HA 216 (DMRB 11.3.10) which provides an overview of the current knowledge of road runoff in the UK, the ground conditions that are believed to affect its nature and a guide to assessing the risk of pollution arising from routine road runoff and accidental spillages.

1.4.2 The design of soakaways cannot be prescribed. Each situation should be considered individually as there are many factors that should be taken into consideration, for example, depth of unsaturated zone, geology, traffic flows.

1.5 Scope

1.5.1 The principles outlined in this Advice Note apply to all schemes of Overseeing Organisations for Trunk Roads including Motorways. They may also be applied generally to other new highway schemes and by other highway authorities for use during the preparation, design and construction of their own comparable schemes. Soakaways may be installed during major maintenance works or as a retro-fit. Designers and Specifiers of DBFO schemes should note that it is not considered currently feasible to specify performance standards for these systems.

1.6 Implementation

1.6.1 The Advice Note should be used forthwith for all schemes currently being prepared provided that, in the opinion of the Overseeing Organisation, this would not result in significant additional expense or delay progress. In making such an assessment, it should be borne in mind that the Overseeing Organisations have a duty not to pollute groundwater. Design Organisations should confirm its application to particular schemes with the Overseeing Organisation.

2. DESCRIPTION OF SOAKAWAY SYSTEMS

2.1 General

2.1.1 There are a range of drainage systems which may act as soakaways, where the primary discharge from the system is to groundwater. Fundamentally, these aim to encourage efficient hydraulic contact between the drainage system and the underlying ground in order to provide effective drainage. Such options include for example:

- combined surface and groundwater filter drains;
- fin drains;
- filter drains;
- informal drains or 'over the edge drainage.'

In addition there may be systems wherein discharge to groundwater occurs but is incidental to the function of the drainage (e.g. unlined ditches).

2.1.2 Further details of both these types of system are provided in HD 33 (DMRB 4.2).

2.1.3 Additionally a number of surface water drainage features also incorporate discharges to the unsaturated zone for example:

- retention ponds;
- sedimentation ponds;
- infiltration basins;
- wetlands;
- swales/grassed channels.

2.1.4 Further details of these are provided in HA 103 (DMRB 4.2).

2.1.5 These options all provide varying degrees of protection to groundwater resources, primarily through maximising the depth of unsaturated zone beneath the drain. Guidance on the design of these types of drainage is provided in HD 33 (DMRB 4.2) and HA 103 (DMRB 4.2). In order to produce a suitable design and to minimise the impact of road drainage on groundwater quality, whilst accounting for the attenuation properties of the unsaturated zone, soakaway drainage incorporating any of these options should also embrace the design principles described in Chapter 3.

2.1.6 As described in Section 1.1.1, this guidance focuses on soakaway structures that essentially provide discharge to the ground at a single point, either through chambers or trenches or into open pit type structures.

2.1.7 There are a wide range of these soakaway types that have been put into use including, for example:

- segmental concrete chambers within excavated pits (with the chamber used as storage);
- pre-cast concrete perforated ring units;
- brickwork within previously created excavations;
- trenches;
- open pits;
- rubble/aggregate filled pits;
- pits/trenches with proprietary 'geo-cellular' units.

2.1.8 Sections 2.2 and 2.3 provide typical design considerations for pre-cast and trench type soakaways, although the designer should consider those designs most suitable to ground conditions, space, discharge requirements and other site specific criteria.

2.1.9 Soakaways for draining roads will commonly service relatively large areas requiring significant storage volumes. Such soakaways may not, in themselves provide such storage capacity, although there are examples where large storage volumes comprise part of the soakaway.

2.2 Pre-cast Perforated Concrete Ring Type Soakaway

2.2.1 This system (see Figure 1) is commonly used for its simplicity of construction and ease with which compatible components can be supplied from various sources. An excavation to the required depth is made, a concrete footing formed and then segments lowered one on top of the other until the hole is filled. The area between the outside of the rings and the excavation can be backfilled with aggregate.

2.3 Trench Type Soakaway

2.3.1 Trench type soakaways should be constructed with inspection tubes at regular intervals. These inspection tubes (observation wells) should be connected by a horizontal perforated or porous distributor pipe laid in the top of the granular fill along the trench as shown on Figure 2 (BRE Digest 365). The extreme ends of the trenches should be identified by inspection tube covers or other access covers.

2.3.2 Trenches are generally constructed with a horizontal base (CIRIA Report 156) and the volume between the structure and the excavation backfilled with granular material. Typically a minimum width of 300mm will be considered (CIRIA, Report 156).

2.3.3 Trenches tend to require a lower volume of excavation and granular fill material for a given discharge capacity than a soakaway with a square profile. The narrower and longer the trench, the more efficient it is in terms of outflow performance and construction cost compared to wider and shorter trenches (CIRIA C522). A narrower trench, of for example, 0.3m width, requires a reduced storage volume relative to wider trenches, of 0.6m or 1.0m, because it has an enhanced outflow performance.

2.4 Contaminant Attenuation Processes

2.4.1 Once they enter the unsaturated zone around a soakaway, pollutants within road runoff are dependant upon ground conditions, subject to transport through various pathways prior to entering groundwater in the saturated zone. Such pathways are illustrated in Figure 3. Within these pathways, and with the unsaturated zone acting as a substrate, a number of contaminant attenuation processes occur which may act to reduce the concentration of pollutants arriving at the saturated zone.

2.4.2 Natural attenuation results from the combined impacts of physical processes (e.g. filtration), chemical reactions (e.g. oxidation of sulphides) and biochemical transformations (e.g. the degradation of compounds under aerobic or anaerobic conditions). The action of these various attenuation mechanisms may influence the design of a soakaway system for instance by maximising the contact with strata that may provide enhanced attenuation potential or preventing direct discharge into a strata that does not offer any potential.

2.5 Physical Attenuation Processes

2.5.1 The physical attenuation of contaminants may be by processes associated with adsorption onto the solid matrix through which flow takes place, or by filtration.

2.5.2 Adsorption retains contaminants within the matrix of the unsaturated zone. In general terms, materials of mixed mineralogy, especially those containing a proportion of clay minerals, provide greater opportunity for retention or retardation of particles by adsorption than formations composed principally of silica (e.g. clean sands and sandstones) or calcium carbonate (clean limestones, particularly the Upper Chalk).

2.5.3 Filtration removes suspended particles, trapping them within the pore spaces of the drainage medium. In general, shallow groundwater, protected by a thin unsaturated zone and composed generally of coarse grained or heavily fissured materials is likely to be more vulnerable to contamination by particulates (due to lesser potential filtration) than is groundwater in finer grained, more massive materials and with a significant depth of unsaturated zone.

2.5.4 Volatilisation will allow partial attenuation of volatile organic compounds through venting to atmosphere from a porous matrix. The effectiveness of this process depends on the relative temperature of the ground with respect to ambient air and the depth of unsaturated zone.

2.6 Chemical and Biochemical Attenuation Processes

2.6.1 Chemical and biochemical processes of attenuation act mainly on organic contaminants such as hydrocarbons, although metals may be transformed through processes such as oxidation.

2.6.2 Biodegradation is typically the most important process acting to reduce contaminant mass. The process acts to reduce contamination levels by oxidation-reduction reactions and is dependent on groundwater geochemistry, microbial population, and contaminant properties. Biodegradation can occur under aerobic and or anaerobic conditions and may ultimately result in complete degradation of many organic contaminants.

2.6.3 Abiotic degradation can result in partial or complete degradation of contaminants through chemical transformations. These reactions are dependent on the contaminant properties and groundwater geochemistry. Rates of degradation are typically much slower than those associated with biodegradation.

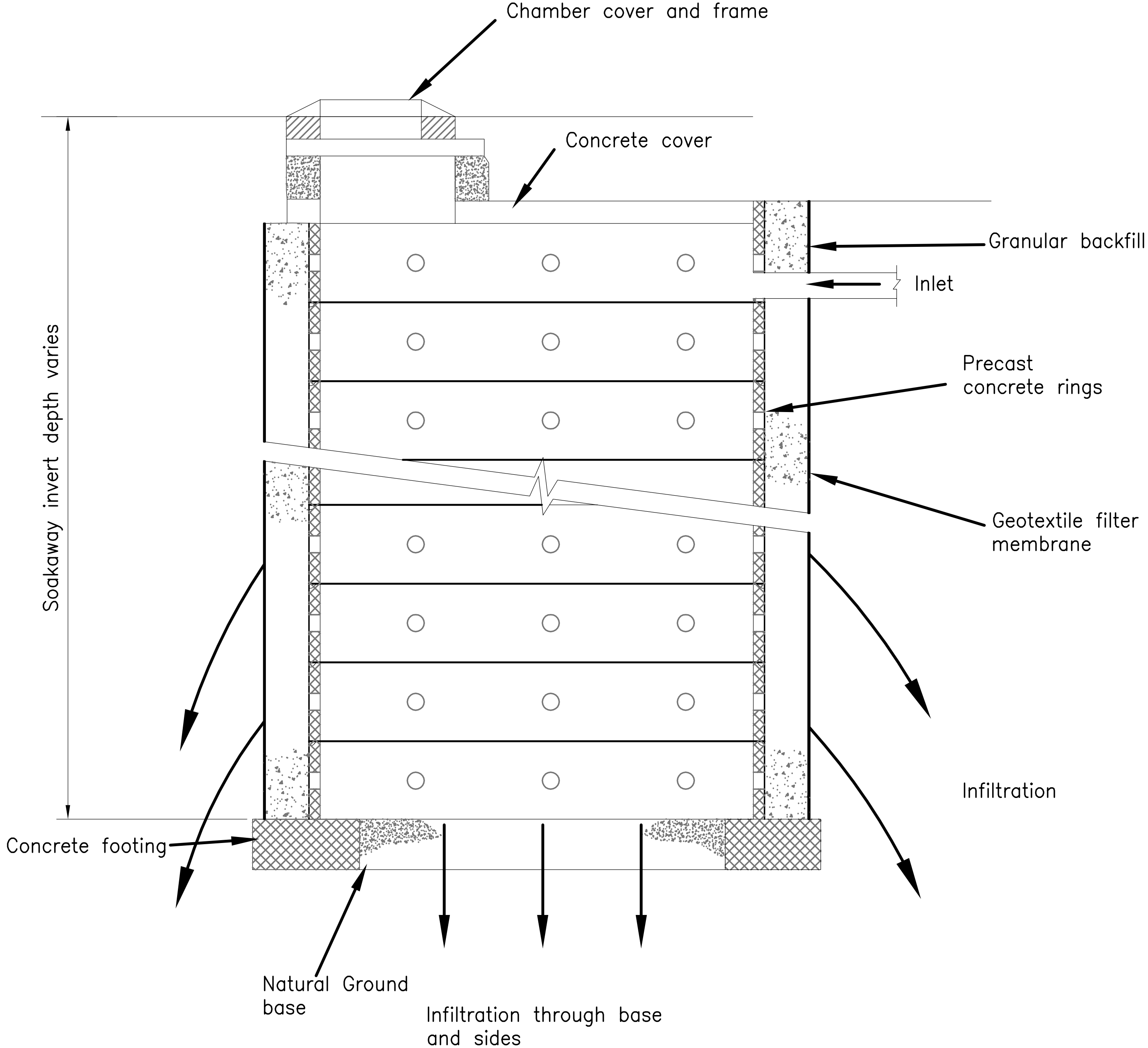


Figure 1: Pre-cast Perforated Concrete Rings Type Soakaway (After CIRIA C522)

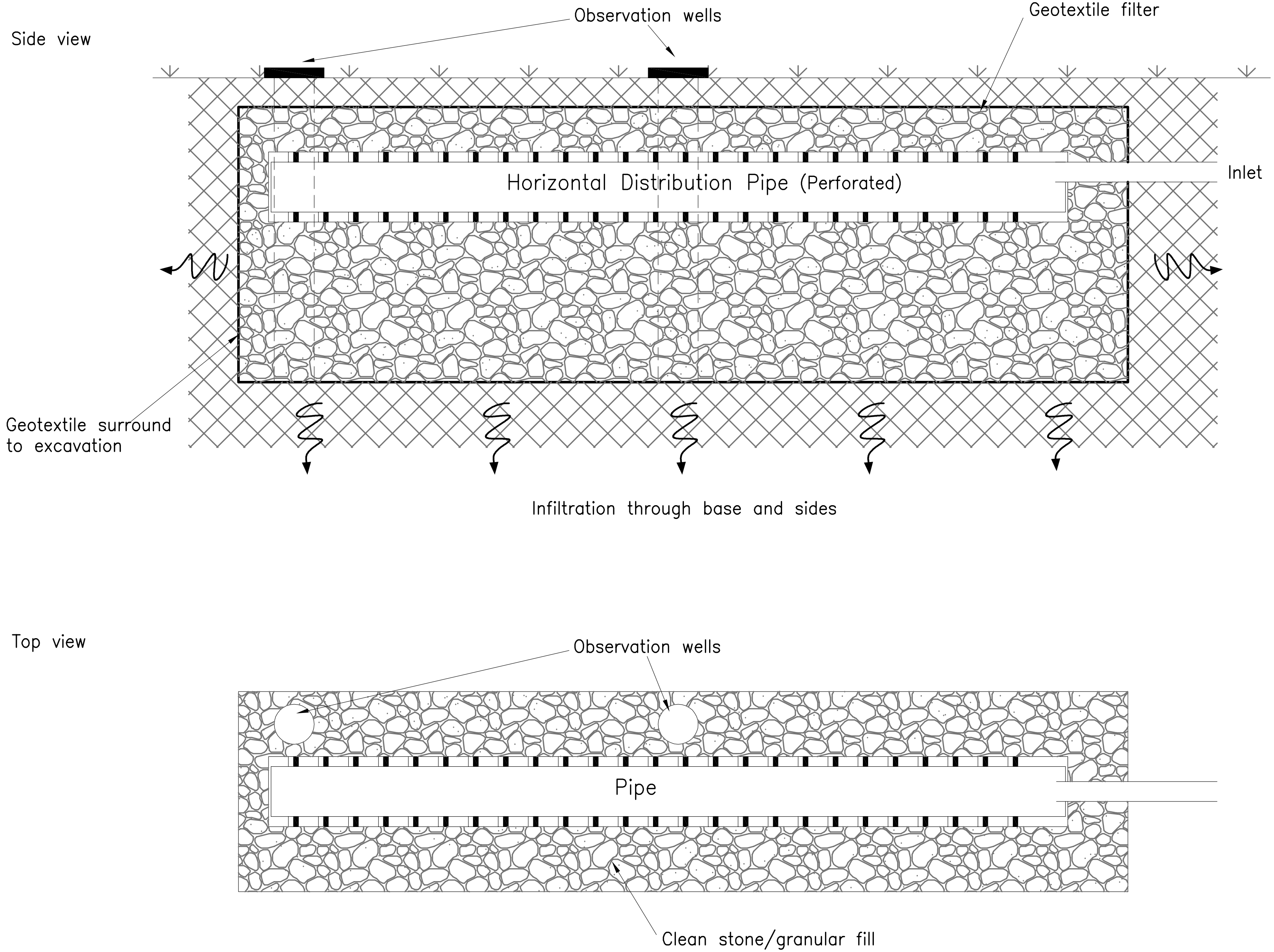


Figure 2: Trench Type Soakaway with Horizontal Distributor Pipe (After BRE Digest 365)

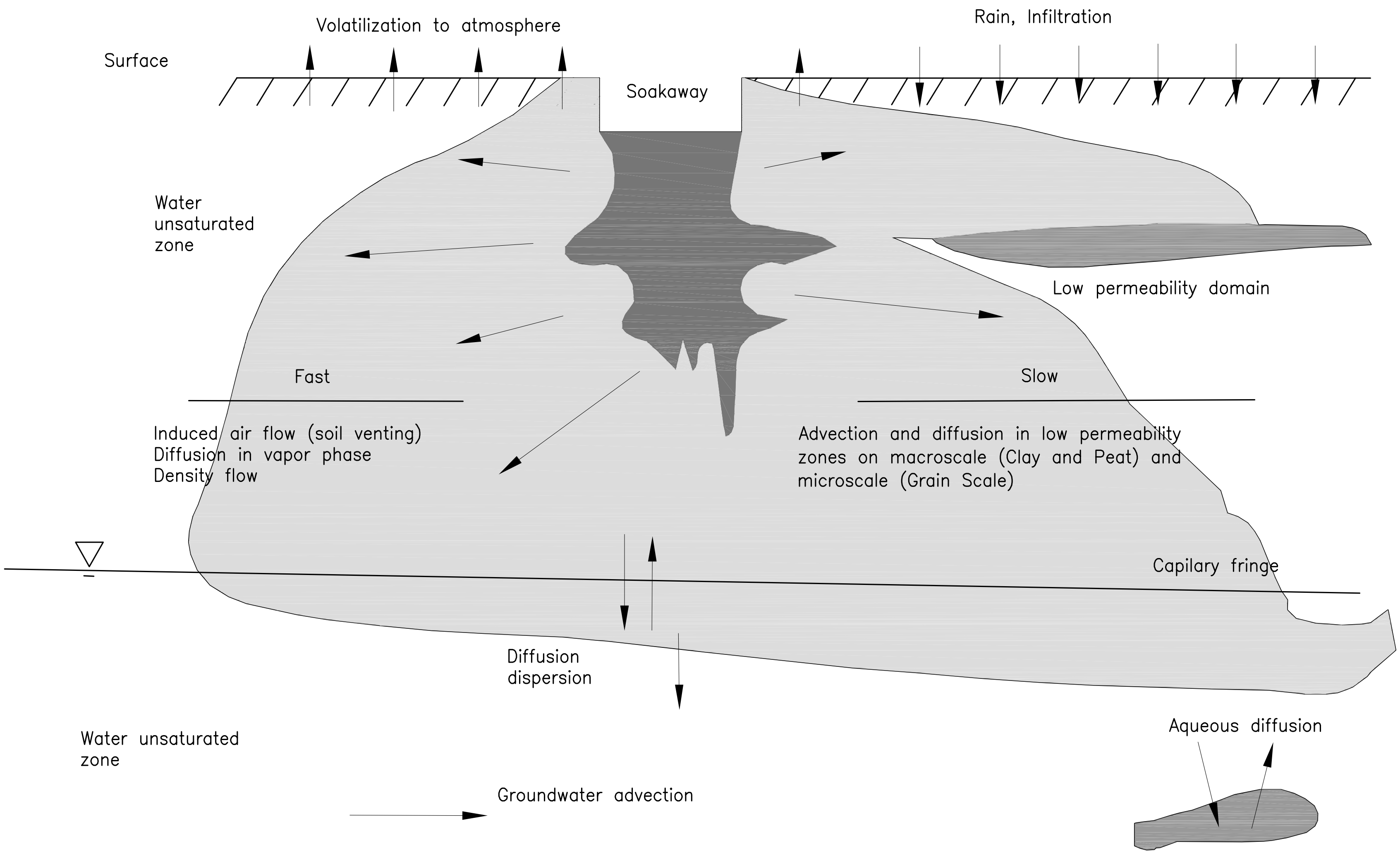


Figure 3: Schematic Showing Attenuation Processes Active in the Subsurface

3. DESIGN AND CONSTRUCTION OF SOAKAWAY SYSTEMS

3.1 General

3.1.1 In the past soakaways have been designed primarily on hydraulic grounds; i.e. simply to transmit runoff efficiently and facilitate drainage into the underlying unsaturated zone using 1 in 10 year return periods for volume requirements. Previous designs of soakaway chambers have even incorporated boreholes to by-pass the unsaturated zone once the storage capacity of the chambers has been reached, ensuring that the roadway remains clear of water but potentially allowing contaminants to enter the saturated zone with little impedance. Under the current legislative regime and with the introduction of tighter controls within the Water Framework Directive, allowing direct discharge to groundwater through structures such as boreholes is considered inappropriate and should not be used within a soakaway system design. HD 33 (DMRB 4.2) provides mandatory requirements with respect to such direct discharges.

3.1.2 Traditionally little regard has been made to the effects the soakaway may have in particular hydrogeological situations, although more recently designs have been influenced by the need to meet requirements set by the regulators.

3.2 Overall Requirements

3.2.1 There are three fundamental principles that should be applied to soakaway discharge system design, which are to:

- ensure that the hydraulic performance of the soakaway 'outfall' allows sufficient storage and infiltration capacity such that the system will have the capacity to drain the 'design storm' (and hence prevent flooding of the carriageway);
- ensure protection of receiving groundwater; and
- provide measures to prevent the possibility of an accidental spillage passing through the discharge system. The level of control provided should be commensurate with the risk identified at a soakaway. Guidance on the risk of pollution from accidental spillages is provided in HA 216 (DMRB 11.3.10).

3.2.2 The most fundamental hydraulic design principle for soakaway discharge systems for roads applications is to provide sufficient storage capacity to allow the removal of storm runoff from the carriageway, quickly and effectively. The principal hydraulic design criterion is therefore to provide sufficient capacity within the system to cover peak runoff. This is generally achieved by constructing large detention ponds, to temporarily store the water discharging from the road, upstream of the soakaways or by constructing underground chambers with porous sides or bases that also have sufficient internal capacity to store the runoff. The size and number of retention ponds or chambers should be determined to provide the required capacity of the drainage system within the design constraints of the location.

3.2.3 The requirement to provide effective drainage cannot, however, override the need to protect groundwater, which is an explicit legal requirement. This applies to both pollutants carried by routine drainage (the focus of this Advice Note) and pollutants that may enter the system through accidental spillage.

3.2.4 As described in Section 1.3.3, the risk assessment methodology in HA 216 (DMRB 11.3.10) provides a means to determine the level of risk to groundwater from chronic pollution derived from routine road runoff. This should be carried out by a specialist and the potential risks discussed with the EPA prior to selection of the soakaway site. The assessment may demonstrate the requirement for pollution prevention measures to be incorporated in the design of the drainage system. These should be incorporated upstream of the soakaway discharge.

3.2.5 The soakaway design should take into consideration potential impacts on ecology, habitats and biodiversity. These could arise from, for example, potential effects of soakaway drainage on the quality of receiving groundwaters which subsequently emerge at the surface (e.g. providing flow to wetlands).

3.2.6 Certain soakaway designs (e.g. open pits) could encourage the development of new habitats. The implications of any such developments should be evaluated both with respect to the potential for providing new habitats for protected species (such as Water Voles and Great Crested Newts) and with respect to the potential for encouraging invasive species.

3.2.7 Whilst the soakaway itself may have little manifestation at the surface, fencing, maintenance, access routes and signage may all have landscape impacts. Sympathetic design should be adopted, particularly in sensitive locations, with advice sought from the Overseeing Organisation as necessary.

3.3 Site Specific Factors

3.3.1 There are a number of potential limiting factors in the design of a soakaway in order to minimise the pollution potential and also to maximise the scope for attenuation within the unsaturated zone, these include:

- The hydrogeological potential of the site. Is the substrate an aquifer?
- The location of the site. Is the site located within the bounds of a source protection zone (SPZ)? The discharge of List II (see 1.2.2) substances to groundwater is permitted with adequate risk assessment, and the presence of an SPZ will affect the level of permissible risk.
- The depth to groundwater at the site (thickness of the unsaturated zone).
- The soil or rock type and thickness encountered at the site.
- The microclimate of the region. Climatic factors including precipitation and surface evaporation rates are important considerations when assessing the amount of road runoff, particularly peak storm flows.
- Would a soakaway lead to mobilisation of pollutants in existing contaminated land?

3.3.2 Note – the Water Framework Directive is such that it essentially treats all groundwater with equal weight – i.e. a certain 'minimum level' of protection is required. Where source protection zones may be impacted, additional protection may be warranted with respect to the protection of human health. These concepts are explained in more depth in DMRB 11.3.10.

3.4 Site-Specific Design

3.4.1 Once the general area where a soakaway is to be situated is identified, the detailed specific design is required. In the past designs have tended to be general for a whole scheme with no variations to take into account differences in ground conditions along the route. As a road generally traverses a wide range of ground conditions the design of the discharge system should also change to reflect this. In low lying areas near rivers there may be little unsaturated zone available and a soakaway should perhaps be broad and flat in configuration whereas on high ground, the depth of unsaturated zone is large enough for smaller deeper structures, reducing the amount of land take.

3.4.2 The pre-treatment of drainage water should also be considered as a means of reducing or removing some potential contaminants, as well as possibly providing some short-term storage capacity within the drainage system. Treatment systems may require periodic maintenance to remove accumulated pollutants before the capacity is exceeded. As an example, the use of vegetative treatment systems in road drainage is discussed in HA 103.

3.4.3 There are a number of factors to be considered when selecting a soakaway for a specific location. The key factors are the topography and the shape of the area available adjacent to the road. The design should ensure that the:

- soakaway selected suits the site dimensions;
- soakaway is not within 3-6m of a building, to meet practices nationally (see note below);
- road sub-base remains unsaturated when the soakaway is at its maximum design capacity;
- vertical distance between the soakaway and the ground water is maximised;
- soakaway does not lead to (harmful) groundwater emergence downgradient;
- soakaway does not surcharge groundwater leading to (harmful) waterlogging or exacerbate groundwater flooding;
- soakaway does not lead to the washing out of fines (causing instability) or lead to (harmful) dissolution of the subsurface.

Some of these aspects of soakaway design are critical to minimise impacts on nearby structures and the water environment. HD 33 (DMRB 4.2) provides mandatory guidance with respect to a number of these design elements.

Note:

According to BS EN 752-4:1998: "If drainage is to be a soakaway, the subsoil and the general level of the groundwater should be investigated. It is not desirable to locate a soakaway cloaser than 3m to 6m from a building's foundations, nor in any other position such that the ground below foundations is likely to be adversely affected."

BRE Digest 365 recommends that: "Soakaways should not normally be constructed closer than 5m to building foundations."

Scottish Building Standards for domestic dwellings refer to both the above standards but also recommend that, for single dwellings: "the finished soakaways should be a minimum of 5m from the dwelling and the boundary. However, this dimension may br reduced slightly on small sites where ground conidtions allow, such as very well draining soil."

Given the potentially high discharge volumes and rates that may be generated by road run-off, designers must consider the proximity of buildings on a site specific basis, particularly with respect to ground conditions.

3.4.4 CIRIA Report 156 includes a number of flowcharts to aid the design process, including the selection of a suitable system.

3.5 Soakaway Design

3.5.1 The risk assessment process described in HA 216 (DMRB 11.3.10) includes evaluation of the geological setting of the site, which should be a fundamental consideration in the development of the design.

3.5.2 Based on the criteria detailed in the following sections, and subject to the risk assessment, the key elements in the design and construction of an effective soakaway are:

- where identified as necessary, the introduction of containment and control measures for potential pollution from accidental spillage;
- where identified as necessary, pre-treatment to remove non-soluble and particulate contaminants;
- sufficient capacity to accommodate the quantity of design runoff;
- sufficient drainage paths/ports to allow water to infiltrate into surrounding ground;
- filter or settlement mechanisms to prevent the blockage of drains or siltation of the drainage paths plus the surrounding ground;
- maximising depth of unsaturated zone;
- allowance for the controlled overflow of extreme storm events;
- the provision of observation wells/pipes (inspection tubes/chambers) to allow inspection and maintenance.

3.6 Infiltration Capacity

3.6.1 The performance of a soakaway system will depend to a large extent on the ability of water to infiltrate through the unsaturated zone, which is in turn dependant on the physical properties of the ground and the surface area in contact with the soakaway. The ability of a soakaway to transmit water will be influenced by a number of factors, such as the number and size of drainage ports, the amount of sediment allowed to settle and remain in the chambers and the degree of choking that occurs immediately outside the chamber in the surrounding ground. For example, special soakaway manhole rings are available from pre-cast concrete suppliers. These have sufficient outlets to allow the water to infiltrate into the ground. If non-standard pre-cast concrete units are used, or a site specific design for the soakaway chamber is undertaken, then the capacity to discharge into the ground should be considered.

3.7 Vertical and Horizontal Drainage

3.7.1 The permeability of a rock formation may vary between the horizontal and vertical, dependant upon the precise lithology and structure. In sedimentary formations consisting of interbedded layers, the horizontal (along bedding) component may be significantly higher than the vertical. The effectiveness of soakaways in layered systems will be heavily influenced by the degree of interconnection between layers of high transmissivity, through fractures and fissures.

3.7.2 In areas of significant fracturing, for example in some sandstones or granite, in an otherwise homogenous lithology, the soakaway performance will be determined largely through interception of one or more fracture systems.

3.7.3 Natural geological systems may be complex, with a variety of flow components contributing to drainage capacity around the soakaway. Figure 4 shows some possible permutations in drainage characteristics around a soakaway. Site specific information will be required to optimise soakaway design to local flow conditions.

3.8 Aspect Ratio

3.8.1 It is considered good practice to maximise the depth of unsaturated zone below a soakaway device to allow the maximum attenuation of pollutants to occur. This may mean that the depth and size of chambers needs to be varied so that in areas with less unsaturated depth, the soakaway system comprises a number of shallow interconnected chambers to provide sufficient short-term storage, whilst maximising the depth of unsaturated zone. In areas with a deeper unsaturated zone the soakaway may comprise fewer deeper chambers, so requiring less land, whilst still maintaining sufficient attenuation capacity. This is illustrated schematically in Figure 5. It should be noted, however, that further land may be necessary for access and maintenance.

3.8.2 Surface infiltration systems (e.g. lagoons, infiltration ponds etc) also depend on surface area to provide sufficient drainage capacity, so that a large shallow infiltration pond will allow rapid dispersal of water through the semi-permeable base whereas a deep narrow pond will retain water for much longer.

3.9 Storage

3.9.1 The drainage system must provide a balance between sufficient infiltration rate and storage capacity to allow the fast and efficient removal of water from the surface of the road. The storage capacity must be designed to cope with peak runoff from the maximum design storm events defined, for no flooding of the road surface without the drainage network backing up. Storage is thus essential where the discharge rate from the road exceeds the infiltration capacity of the soakaway. The rate of runoff from the road surface should be calculated using an appropriate design methodology/drainage modelling programme using the actual design rainfall values. The calculated outflows from the drainage system should be utilised in the design of the soakaway instead of following the methods given in the published design guidance (BRE 365 and CIRIA Report 156). This will ensure that the soakaways are designed to suit the actual road or section thereof under consideration.

3.10 Spillages

3.10.1 Measures to control and contain spillage should be installed where the combination of the probability of the occurrence of a major spillage and risk to the receiving waters is sufficient to justify them. Such measures will enable polluting material to be intercepted before it reaches the soakaway or infiltration zone, providing sufficient time for emergency spill responses to be implemented. Guidance on the necessity for the provision of spillage control and containment is provided in HA 216 (DMRB 11.3.10).

3.11 Design Procedures

3.11.1 Soakaways store storm water runoff and provide for its infiltration into the surrounding soil. The infiltration must occur sufficiently quickly to provide the necessary capacity within the drainage system to cope with the expected runoff, based on expected rainfall intensity and frequency or the outflow calculations from the use of modelling as described in 3.9.1. Providing adequate storage volume and subsequent discharge are the two design parameters that govern the calculations for soakaway design. Design of soakaways and infiltration trenches should be undertaken in accordance with:

- BRE Digest 365 Soakaway Design;
- CIRIA, Report 156 Infiltration Drainage – Manual of Good Practice.

3.11.2 It is also possible to determine information relating to the capacity for a given lithology to transmit water through a falling or rising head test using a groundwater monitoring standpipe or borehole. This test is generally carried out by surcharging a piezometer with water and monitoring the fall in head as the column of water equilibrates with the watertable over time. A procedure for undertaking this test is provided in BS 5930: Code of Practice for Site Investigation. This test may potentially be useful at initial design stages as many road schemes will have borehole coverage along the length of the proposed route and calculations of the aquifer permeability can be made at each location.

3.11.3 BRE Digest 365 provides advice on the design of soakaways in urban environments, which, whilst not strictly applicable to roads, does provide methods for determining the size of the soakaway required to deal with anticipated levels of runoff. The methodology uses a 10 year return period for a 15 minute duration storm to determine the required storm flow capacity. This may not be appropriate for roads design.

3.11.4 The BRE's methodology does not allow for attenuation of flow within the drainage system itself. Road drainage systems will very often comprise long drain runs which run to a low point in the road to where the soakaway drainage is provided. A significant amount of water will be attenuated as it flows through the drainage run, effectively reducing the peak flow at the soakaway. The BRE's methodology, therefore, over designs the required soakaway capacity based on inflow volume from the road and in order to accurately calculate the required soakaway size the inflow calculation used in the guidance should be replaced with the design flows calculated for the road based on guidance in HD 33 (DMRB 4.2).

3.11.5 CIRIA Report 156 provides brief guidance on designs of drainage systems to remove pollutants, based on physical and biological systems, such as sediment traps, interceptors, soakaways and vegetative treatment systems for a range of drainage scenarios, including roads. This report provides methods for determining the required size for a drainage system based on the amount of rainfall and infiltration characteristics of the ground. In terms of groundwater protection this report relies upon the Environment Agency's Policy and Practice for the Protection of Groundwater, which provides basic guidance on the suitability of discharges to soakaway in terms of providing protection to water abstraction sources and groundwater resources in general. CIRIA Report 156 concentrates on source protection and does not provide detailed advice on treatment systems. Implementation of the Water Framework Directive requires a different approach whereby all groundwater is protected regardless of use and the Agency will be producing new guidance on groundwater in light of this.

3.11.6 The methodology within CIRIA Report 156 uses the lower portion of the chamber walls plus the base of the soakaway to calculate the infiltration rate into the ground and hence the required storage capacity. It should be noted that over time the base of a soakaway can become silted, unless adequate maintenance or upstream protective measures are implemented. Incorporating the base into the contact area can thus lead to overestimating the rate of infiltration and underestimating the volume of storage. This method can therefore under estimate the size of soakaway required for a given inflow runoff rate.

3.11.7 The design guidelines in BRE 365 and CIRIA Report 156 may not always give similar results for a specific circumstance because the two methods treat the factor of safety in different ways. CIRIA C521 for Scotland and Northern Ireland and C522 for Wales and England, design manuals for sustainable drainage reference both methods as applicable without favouring either one.

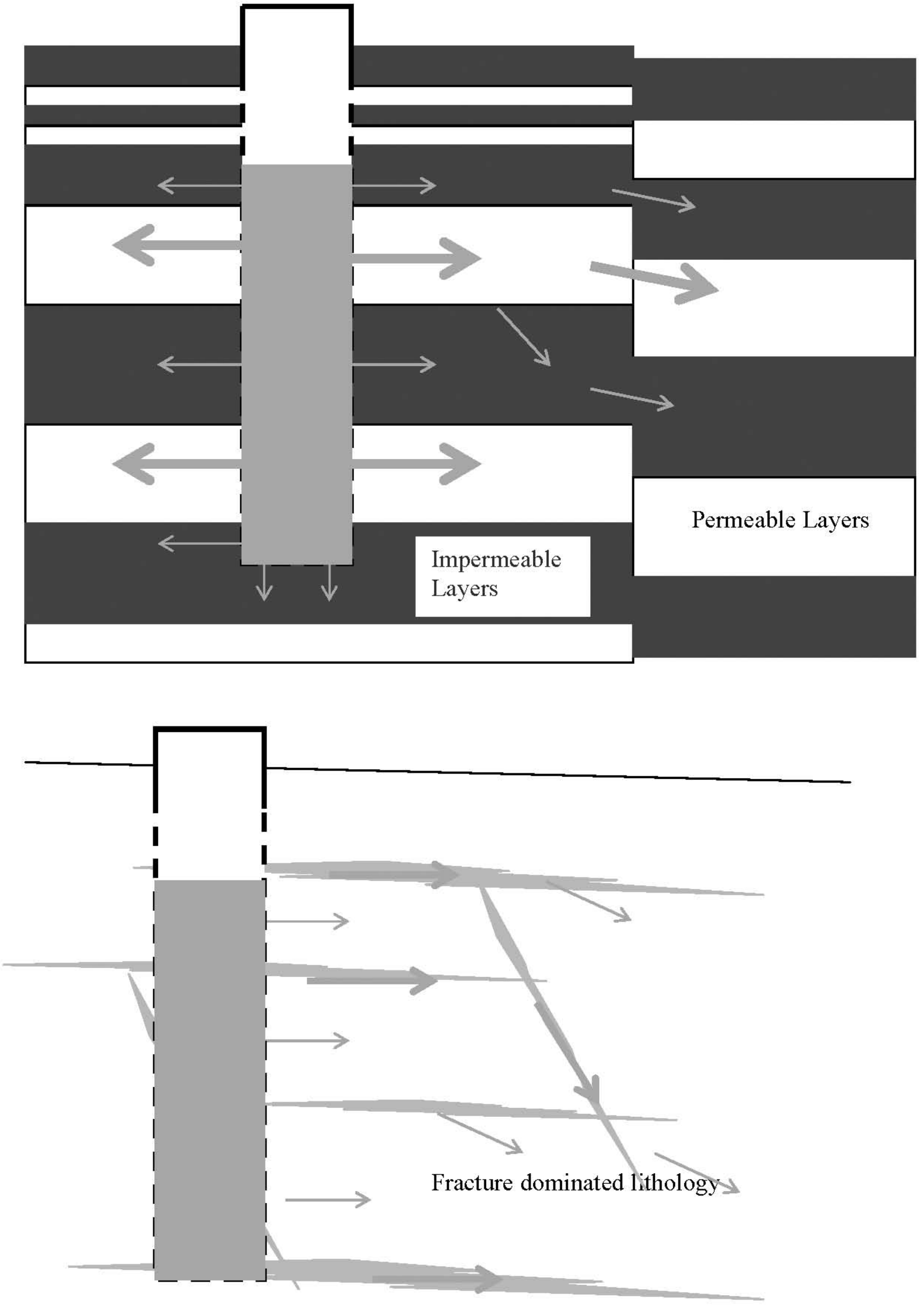
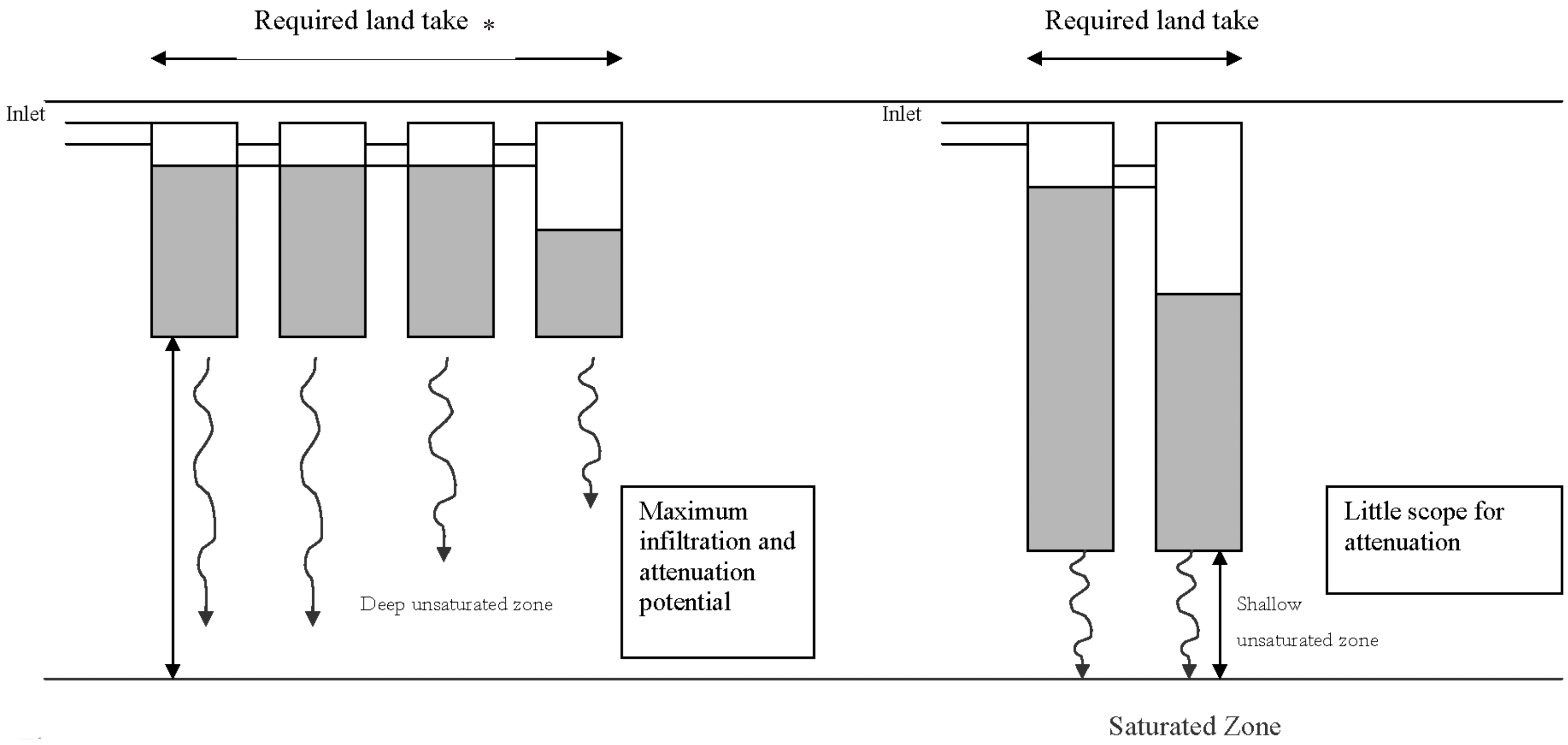


Figure 4: Variation in Drainage Characteristics in Multi-Layered and Fracture Lithologies



* Further land may be required acess and maintenance requirements

Figure 5: Maximising the Depth of Unsaturated Zone

4. CONSTRUCTION PRACTICES

4.1 General Construction Guidelines

4.1.1 Soakaways should be constructed sufficiently far away from buildings or other structures such as bridges in order to prevent the risk of undermining foundations. Building practices recommend that a minimum distance of 3m-6m between a subsurface drainage system and a building should be adopted, depending on ground conditions (see Section 3.4.3).

4.1.2 Soakaways should not normally be deeper than 3 to 4m in order to maximise the length of the flowpath to the watertable through the unsaturated zone. The greater the thickness of unsaturated zone available, the greater the potential for pollutant attenuation. The issue of fate and transport of pollutants from road drainage is discussed fully in HA 216 (DMRB 11.3.10).

4.1.3 The long term performance of the soakaway depends on maintaining the initial storage volume by keeping the pores clear within the granular fill. Any material that is likely to clog the pores of the drainage material or seal the interface between the storage and the adjacent soil should be intercepted before discharge to the soakaway (CIRIA, C522) in order to maximise the effective life of the soakaway between cleaning. An assessment of the risk of pollution and need for pre treatment is discussed in HA 216 (DMRB 11.3.10). Consideration of the need for sediment traps and, where appropriate, oil interceptors to treat the surface water prior to discharge to soakaways may be required (CIRIA, Report 156) based on an assessment of the risks. Vegetative systems are discussed in HA 103 (DMRB 4.2) and treatment efficiencies for various drainage systems are provided in HD 33 (DMRB 4.2) for a range of common pollutants.

4.1.4 Whilst the interception of sediments prior to entry into the soakaway is an essential pre-requisite to good design, some soakaway designs may incorporate the use of geotextiles to prevent the migration of fine materials. Geotextiles may be used to:

- separate granular backfill materials from ground material in the walls of excavated pits;
- prevent fines within the soakaway from migrating outward into granular surround materials hence reducing clogging of those materials;
- lay over the top surface of a granular fill to prevent downward ingress of backfill material during and after surface reinstatement.

The requirements for the use of geotextiles will be specific to the type of soakaway design adopted.

4.2 Health and Safety Considerations

4.2.1 As required by The Construction (Design and Management) Regulations 1994 (SI 1994 No 3140), The Construction (Design and Management) Regulations (Northern Ireland) 1995 (SI 1995 No. 209), Designers and Specifiers should be aware of the risks to the public, road maintainers and those implementing the design. A risk assessment should be undertaken at the time the systems are designed or specified.

4.2.2 Ease of access for maintenance is important, not only to encourage regular maintenance, but also for the safety of the maintenance operatives. It will also aid emergency personnel in carrying out any measures to mitigate the effects of a spillage. Appropriate access to systems remote from the main carriageway is essential in all locations, and in many locations a gated access could be provided. Designers should ensure that there is adequate, safe access for both workers and plant and that provision is made for all maintenance operations to be carried out without disruption to the safety and free flow of traffic on the adjacent carriageway.

4.2.3 Not withstanding the above, any work carried out around soakaway systems, whether during construction or as part of maintenance procedures should be carried out with due consideration of health and safety. The Management of Health and Safety at Work Regulations 1999 (SI 1999 No 3242), The Management of Health and Safety at Work Regulations (NI 2000), The Confined Spaces Regulations 1997 (SI 1997 No 1713) and The Confined Spaces Regulations (Northern Ireland) 1999 (SR 1999 No 13) are particularly pertinent. Advice should also be sought from the Overseeing Organisations.

4.2.4 The mandatory implementation of appropriate Health and Safety procedure in the design, construction and maintenance of soakaway systems is described in HD 33 (DMRB 4.2).

5 MAINTENANCE AND MANAGEMENT OF SOAKAWAY SYSTEMS

5.1 Routine Maintenance

5.1.1 Road runoff contains a significant amount of particulate material, in the form of road stone and tyre fragments, mud and dust. Without periodic removal of this, the discharge system will eventually become blocked. In designing a discharge system, an effective means of trapping sediment should be provided, in an easily accessible area for periodic emptying and maintenance.

5.1.2 A Management Plan should be developed for the entire drainage system for each road (refer also HA 103 (DMRB 4.2)). This Management Plan should set out a system's objectives, formulate an annual programme of maintenance and provide opportunities to review behaviour of the drainage system. This should include for advice to be adopted for the management and maintenance of soakaways, any pre-discharge treatment and any other elements associated with the system. The Management Plan should prescribe the various maintenance operations which may be required. Specific maintenance requirements are suggested below, however these should be adapted as necessary to site and system specific requirements.

5.1.3 The frequency of inspection of soakaways should be determined during the immediate post construction period. It is suggested (CIRIA C609) that, for the first six months, monthly inspection is carried out to determine the rate of accumulation of sediment in both soakaway and pre-discharge treatment devices (particularly silt traps). This procedure will then allow the long-term frequency of inspection/cleaning to be determined. This frequency may be subsequently reduced if conditions allow. Cleaning requirements and frequency will depend upon the size and type of area drained. A suggested maintenance schedule is set out below, although these requirements should not be interpreted rigidly, and a proactive approach based on site specific requirements, is to be encouraged:

- removal of debris from the floor of chamber and sediment traps. (minimum annual frequency);
- check observation wells/inspection tubes for clogging and to ensure soakaway is emptying (annual);
- inspect area around soakaway for ground settlement or sediment loss (annual);
- removal and washing of exposed stones on the trench surface (annual);
- trimming any roots that may be causing blockages (annual).

If annual inspections show significant performance deterioration, granular materials surrounding the soakaway may have become clogged – these may need replacement and or overhaul. The frequency for these more intrusive actions can only be assessed on a site specific basis and will be very variable, perhaps in the range between 10-30 years.

5.1.4 Maintenance will usually be carried out by hand, although a suction tanker can be used for debris removal. If maintenance is not undertaken for very long periods, deposits might become hard-packed and require considerable effort to remove.

5.1.5 The area draining to the infiltration device should be regularly swept to prevent silt being washed off the surface.

5.1.6 A problem frequently encountered with drains and sewers is the ingress of tree roots through poor joints or cracks in the network. This occurs because roots are drawn to the presence of water and hence is a common problem with soakaways where a permeable structure is a design feature and roots can grow through the soakaway walls, reducing the passage of water.

5.1.7 In the maintenance and cleaning of open pit type soakaways, advice should be sought from an ecologist, or other appropriately qualified environmental specialist, to ensure that the operation may be carried out with safeguards in place to protect protected species or breeding birds that may have colonised the pit. Similarly plant removal or trimming should be undertaken following advice of both an ecologists and, as necessary landscape specialists. Further advice on these aspects of maintenance is provided in HA 103 (DMRB 4.2).

5.1.8 It is essential to ensure that sediments cleaned out from one part of the system are not allowed to migrate further downstream in the drainage system or allowed to enter the water environment. Consideration must be given to the disposal of sediment and plant waste as these will retain contaminants from the road runoff. Assuming it is planned to send the removed material to landfill for disposal, this waste will be subject to The Landfill Regulations (England and Wales) 2002 (SI 2002 No 1559) (as amended). The Landfill Regulations (Scotland) 2003 (SSI 2003 No.235) (as amended) and The Landfill Regulations (Northern Ireland) 2003 (Statutory Rule 2003 No 496) (as amended) apply in these respective countries.

5.1.9 According to the level of contamination within the waste, it may be classified as inert, non-hazardous or hazardous, in accordance with waste acceptance criteria set out in amendments to The Landfill Regulations. Advice of the Environmental Protection Agency and the Overseeing Organisation should be sought with respect to classification of any waste generated during maintenance and cleaning operations.

5.1.10 It is likely that sediment and plant waste will require pre-treatment prior to disposal at a landfill site. This can take place either as the material is extracted or at the landfill site itself. The disposal of non-hazardous or hazardous waste is expensive and disposal facilities are limited. The benefits of testing, screening, separation and mechanical de-watering of the sediments using mobile plant, should be considered. This not only facilitates the separation of the materials into high and low contamination levels (thereby minimizing disposal costs) but also reduces the volume and weight of any material that has to be landfilled by removing excess water. The sand and pressed cake so produced is in a form that can be accepted by landfill sites under the terms of the Landfill Regulations, which ban high moisture content wastes

5.1.11 This maintenance guidance is primarily aimed at chamber and trench type soakaways. Procedures will need to be adapted to the particular soakaway design used. Guidance on maintaining vegetative systems for highways is provided in HA 103 (DMRB 4.2) with suggested frequencies for inspections of different components of these drainage systems.

5.2 Spillage Control

It is important to prevent gross pollution, such as may occur following a major road accident, from entering a soakaway. HD 33 (DMRB 4.2) discusses the provision of control systems, such as notched weirs or penstocks, to prevent drainage water that is grossly contaminated from moving down the drainage system. Any such pollution control devices incorporated within a drainage system will require signing to allow quick identification and location by emergency services so that control measures can be safely and effectively deployed as soon as possible. Requirements for signage of these systems is provided in HD 33 (DMRB 4.2).

6. REFERENCES

Building Research Establishment (BRE) Digest 365 Soakaway Design.

British Standard 5930 Code of Practice for Site Investigation.

Construction Industry Research and Information Association (CIRIA): Report 156 Infiltration drainage – manual of good practice.

CIRIA C521 Sustainable urban drainage systems – design manual for Scotland and Northern Ireland.

CIRIA C522 Sustainable urban drainage systems – design manual for England and Wales.

CIRIA C523 Sustainable urban drainage systems – best practice manual.

CIRIA C609 Sustainable drainage systems – Hydraulic, structural and water quality advice.

Design Manual for Roads and Bridges (DMRB)

- HD 33 Surface and Sub-surface Drainage Systems for Highways (DMRB 4.2)
- HA 103 Vegetative Drainage Systems for Highway Runoff (DMRB 4.2)
- HA 216 Environmental Assessment Techniques: Road Drainage and the Water Environment (DMRB 11.3.10).

Policy and Practice for the Protection of Groundwater, Environment Agency, 1998.

Guidance Manual for Constructed Wetlands. R&D Technical Report P2-159/TR2 Environment Agency. 2003.

The Construction (Design and Management) Regulations 1994 (SI 1994 No 3140).

The Confined Spaces Regulations 1997 (SI 1997 No 1713).

The Groundwater Regulations 1998 (SI 1998 No 2746).

The Groundwater Regulations (Northern Ireland) 1988 (Statutory Rule NI 1998 No 401).

The Landfill Regulations (England and Wales) 2002 (SI 2002 No 1559) (as amended).

The Landfill Regulations (Scotland) 2003 (SSI 2003 No 235) (as amended).

The Landfill Regulations (Northern Ireland) (Statutory Rule NI 2003 No 496) (as amended).

The Management of Health and Safety at Work Regulations 1999 (SI 1999 No 3242).

The Water Environment (Water Framework Directive) (England and Wales) Regulations 2003 (SI 2003 No 3245).

The Water Framework Directive (2000/60/EC).

British Standard BS EN 752-4:1998: Drain and Sewer Systems Outside Buildings – Part 4: Hydraulic Design and Environmental Considerations.

The Scottish Building Standards: Technical Handbook: Domestic.

7. GLOSSARY

Aerobic In the presence of oxygen (air).

Advection The process by which solvents (e.g. dissolved ‘pollutants’) are transported by the bulk movement of flowing groundwater.

Adsorption The uptake and retention of one substance onto the surface of a another.

Anaerobic In the absence of oxygen (air).

Capillary fringe The zone at the interface between the saturated and unsaturated zones where water is drawn upward by capillary force.

Controlled waters In England, Wales and Scotland surface waters and groundwater are collectively known as Controlled Waters (this term is not used in Northern Ireland, but in this document these represent groundwater and surface water).

Diffusion (In groundwater) the dispersion of a solvent caused by the kinetic activity of the ionic or molecular constituents of the solvent and groundwater. (In vapour) – mixing caused by the kinetic activity of ionic or molecular constituents.

Dispersion The spreading and mixing of chemical constituents in groundwater caused by differential velocities within and between the pore spaces in an aquifer.

Geo-cellular unit Proprietary units, usually modular and of plastic construction, which may be used as infill to excavated soakaways of trenches. These provide high void space and surface perforations to allow both high water storage and rapid dispersal.

Infiltration Herein used as synonymous with percolation – the generally downward flow of water through the unsaturated zone to the water table.

Permeability A measure of an aquifer’s capacity to transmit groundwater through a unit metre of its saturated thickness (units in m/day).

Unsaturated zone The zone between the top of an aquifer (limited above by the ground surface) and the water table (i.e. the top of the saturated zone).

Volatilisation Changing of liquid to gaseous phase.

8. ENQUIRIES

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