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Assessing attenuation storage volumes for SuDS

Anthony McCloy outlines the approaches to providing SuDS attenuation volumes, and highlights some important considerations when approaching attenuation designs or evaluations.

The author

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Introduction

Flooding is a primary concern across many parts of the UK and Ireland. Whenever catchment flows exceed the capacity of the receiving watercourse, the excess water is conveyed or stored in the floodplain. Whenever a site is developed the rate of runoff from the site significantly increases. In order to protect the floodplain we endeavour to control runoff rates form a development to match that of predevelopment (Greenfield runoff) rates. Attenuation storage is required to hold back this volume of water to the required rate.

However, as we cover a development site with hard surfaces we also lose the potential for water to percolate into the ground.

As a floodplain has a finite volume, we mitigate by holding back the additional volume of runoff until floodwaters have abated. The retention of this additional volume of runoff for a longer period of time is generally referred to by the industry as Long Term Storage.

The process of how attenuation storage volumes are derived is generally not well understood across the various disciplines who are involved in the design of SuDS schemes. Many of us rely on spreadsheets, modelling software, published maps and charts or a helpful colleague to provide us with the volumes and flow we require to facilitate our SuDS design.

To deliver well considered and designed schemes it is important that all disciplines, not just hydraulic modelling specialists, have a broader appreciation of the attenuation calculation process, if only to ensure they can act as an intelligent client, or ask the right questions.

This fact sheet does not seek to rewrite hydraulic manuals. However, a number of aspects relating to the estimation of flows and volumes for SuDS design have been considered from a less-technical perspective than found in manuals. It is hoped that this information will be understandable to a wider range of members of the SuDS design / SuDS Approval Body (SAB) evaluation team. It should also provide the SAB team with an increased understanding to assist with the assessment of uncomplicated schemes and identify when they may need to seek further advice from specialists.

The fact sheet covers the following aspects of attenuation design:

- Understanding fundamentals
- Making allowance for interception losses
- Selecting an appropriate Coefficient of volumetric runoff (C_v)
- Expressing attenuation storage volumes as m^3 for each m^2 of developed site area
- Approaches to determining storage volumes

Understanding the fundamentals of attenuation storage design

Prior to undertaking storage calculations it is important to understand a few of the basics of attenuation design. A few pointers are noted as follows:

- ✓ Water flows downhill! Levels of the site are vital and will be affected by approaches to managing volumes of water on the surface of the site.
- ✓ For flow rates to be attenuated / regulated, a flow control structure is required. This control could be an orifice, a weir or a more complex vortex flow control arrangement.
- ✓ It's likely to be more cost effective to store volumes of water across the site within each sub catchment as part of the SuDS management train, thus maximising the site potential, than storing at one location prior to discharge. Consequently, a number of flow controls are required to control flows and provide storage volumes along the management train.
- ✓ Anyone designing or evaluating attenuation volumes should know what 'ball park' volumes to expect prior to the calculation (or evaluation). This ensures that gross errors or model stability issues can be easily identified.
- ✓ If and when the specified design criteria for flows and volumes are exceeded, attenuation storage will overtop. Similarly, storage will not perform to design standards if any part of the system becomes blocked. Designing for exceedance or blockage is as, if not more, important as determination of exact storage volumes.
- ✓ SuDS are designed to mimic natural drainage processes; therefore an understanding of natural drainage processes should be fully appreciated by the designer.
- ✓ Don't overlook the linkage between stored volumes of water and the other aspects of SuDS such as water quality and amenity benefit. Storage volume areas should be multi-functional and should be at or near the surface wherever possible.

Don't expect exact answers from the calculation process, it is a usable approximation that can provide acceptable solutions for design. Most of the inputs are based on statistics and calibration factors; therefore we can only ever achieve an approximation of how the system will behave in reality. The results of calculations and modelling need to be used alongside professional judgement to provide the design.

Interception losses

It is generally considered that about 50% of each year's total rainfall occurs in events which are less than 5mm in depth. In a natural catchment, the first 4mm to 5mm of rainfall is lost due to natural processes such as soakage into the topsoil, infiltration, evaporation and transpiration (combined this is referred to as evapotranspiration); and therefore does not result in runoff. Source control techniques such as green roofs, permeable pavements and swales can be provided to replicate natural catchment processes.

www.UKSuDS.com provides a Storage evaluation tool which can provide estimates for flows and volumes.

In calculation terms, where Source Controls are provided, an allowance can be made for interception losses by reducing rainfall depths by 5mm when deriving runoff generated (i.e. inflow to the attenuation storage calculation).

Selecting and appropriate coefficient of volumetric runoff (Cv)

The specification of a runoff coefficient attempts to represent the volume of flow from a particular surface. For example, in most circumstances you would anticipate less runoff from a grassed surface when compared to an impermeable road or roof surface. This is represented through the definition of Cv, with values ranging from 0% (no runoff from rainfall) up to 100% (all of the rainfall that occurs on a surface occurs as runoff).

The 'standard defaults' for the Coefficient of Volumetric Runoff (suggested by Modified Rational Method) consider that a proportion of sub-catchment contributing runoff to the drainage system is permeable. The Modified Rational Method guidance coefficients are 0.75 for summer and 0.84 for winter scenarios. This assumes that permeable parts of the sub-catchment will be wetter in winter and therefore produce more runoff.

However, the majority of attenuation volume calculations consider impermeable areas only as contributing to the drainage system. Therefore careful consideration needs to be given to the specification of Cv, as the default values used in software packages may not be appropriate.

Sewers for Adoption (7th Edition) recommends that a Cv of 1.0 should be used whenever calculating runoff from impermeable surfaces (*roofs and paved areas should have an impermeability of 100%*). When making an application the designer should demonstrate to the SAB that Cv has been suitably determined.

Sub-catchments and providing attenuation storage in various locations across the site

Attenuation storage volumes are generally expressed as a single volume for the entire site. Intuitively this has led to storage been allocated to a single location, i.e. site control. However, to develop SuDS schemes which are affordable and maximise the opportunity of the site, storage should be allocated across the site within each sub-catchment. To aid design an updated approach is required to express storage volumes

By expressing attenuation volumes in terms of 'm^3' for each 'm^2' of developed area, allows a much more flexible approach to allocating storage across the site rather than at a single location.

For example if 1 hectare of developed site area was calculated to require 700m^3 of attenuation storage. Then, for each **1 m^2** of developed area we would provide = 0.07m^3, or 70 litres, or **70mm depth of storage**

This change in approach, in terms of how the attenuation volumes are expressed allows for;

- easy allocation of storage to each sub-catchment as part of design
- allows more flexibility during design iterations without the requirement to remodel the entire system to calculate a new volume after each design iteration
- a more transparent figure for evaluation by the SAB.

> The attenuation volume on a m^3/m^2 basis can be deduced by dividing the calculated attenuation volume by the developed area of the site (Roof areas + roads areas + any other hard standing surface)

There are numerous benefits from allocating storage at source, which include;

- Making maximum opportunity of the storage available on the site through the use of existing landscape and permeable hard surfaces without the requirement of land to be used solely for storage of flow (generally located prior to the final discharge point from the site)
- The attenuation volume requirement for the site control is proportionally reduced
- Conveyance requirements are greatly reduced
- Greatly reduces risk of erosion as flow rates are significantly reduced
- Opportunity to provide water quality treatment (if appropriately designed)

Determining attenuation storage volumes

The SuDS Manual sets out two approaches for managing flows and volumes from a development site.

The 1st approach (**Approach 1**) requires that flows rates discharged from the site attenuation storage are controlled at a rate equivalent to the runoff from a Greenfield site for a 1 in 1 year return period (whenever a 1 in 1 year rainfall event occurs), up to the equivalent runoff from a Greenfield site for a 1 in 100 year return period (whenever a 1 in 100 year rainfall event occurs).

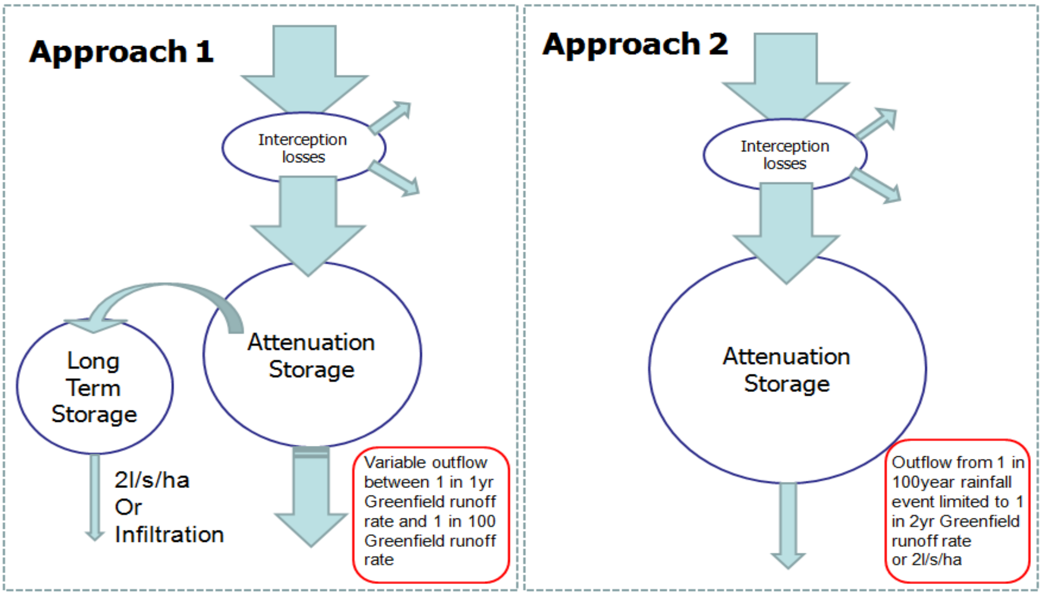
Greenfield runoff rates are generally 3-4 times greater for the 1 in 100 year rainfall event when compared to the 1 in 1 year rainfall event. To capitalise on the use of the 1 in 100 year Greenfield runoff allowance, **long term storage** must be provided; whereby a specified volume of water is held on site for a longer period in comparison to the attenuated storage volume.

The application and design of Long Term Storage will be described in a follow on Fact Sheet.

Provision of long term storage may not always be achievable, therefore a second approach has been devised which attains similar results in terms of protection of the floodplain.

The 2nd approach (**Approach 2**) requires that flows from the attenuation storage are controlled at 1 in 2 year Greenfield runoff rate, for all rainfall events up to and including the 1 in 100 year rainfall return period.

Figure 1 - Two approaches for managing flows and volumes from a development site



There are a few aspects to consider when determining which approach to adopt, outlined as follows:

- Can Long Term Storage be provided on the site to accommodate the additional volume of runoff generated.
- Approach 2 will generally result in a higher overall storage volume for the site.
- Approach 2 will have longer drain-down times, and it may be difficult to achieve 50% drain down within 24 hours. However the adoption of 24 hour half drain down times for design events of 1 in 100years plus allowances for climate change is questionable and a more considered approach may be reasonable (eg. ensuring that the drain down in 24 hours provides room for a subsequent 1 in 10 year event).

Summary

In summary, there are a number of important aspects to consider whenever approaching design or evaluation.

- Expressing volumes in an understandable format such as **m^3 per m^2** of developed site area**,** or mm depth per m^2, makes the approach to design more flexible and simplifies the evaluation process.
- Runoff coefficients need to be carefully considered whenever calculating runoff from impermeable surfaces. **Standard defaults may not always be appropriate**.
- Designing for **exceedance** or blockage is as important in design terms as defining attenuation storage volume. Design of outlets and flow control should ensure that they robust, not prone to blockage and have overflows to cover any failure.
- The calculated storage should replicate what is on the drawings and what is installed,
- Levels are vital! SABs should make specific drawing checks on levels and storage and continue to do so through the design and installation process.

It is important to remember that there are <u>NO</u> absolute answers in the estimation of storage volumes; however there are certain 'ball parks' that the calculated outcomes should be within. Any calculation, regardless how refined, can only ever be an approximation of the actual functioning of natural system; for example a SuDS management train which should perform like a natural system!

References

CIRIA (2004). **Sustainable drainage systems, hydraulic, structural and water quality advice**. CIRIA Report C609.

CIRIA (2007). **The SuDS Manual**. CIRIA Report C697.

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HR Wallingford. **www.UKsuds.com**