S104 SuDS Guidance Document

Swales

Version 3 (October 22)

(This document should be read in conjunction with S104 SuDS Technical appraisal form for Swales)

Comment no.	Technical Guidance
Types of swales	
1	We will adopt communal systems serving two or more properties located outside of domestic property curtilage. If the system is at the start or 'head' of the adopted network, domestic flows must enter via a point inlet so as to provide a point of demarcation for adoptable network. It's essential that it is made clear what type of swale is being utilised within the design at an early stage to enable an effective assessment to be completed and this must be referenced correctly on the S104 Agreement Plan. The different types of swales are noted below; **Conveyance** A conveyance swale is a shallow vegetated channel providing treatment and attenuation – see chapter 17.1.1, 17.2 & 17.4.1.1 of CIRIA C753 along with figures 17.1.1 & 17.5 below for further guidance. **Dry** A dry swale is a conveyance vegetated channel that includes a filter bed of prepared soil that overlays an underdrain system. The underdrain provides additional treatment and conveyance capacity beneath the base of the swale and prevents waterlogging - see chapters 17.1.2, 17.2 & 17.4.1.2 of CIRIA C753 along with figures 17.2 & 17.5 below for further guidance. Conveyance swales and dry/enhanced swales deliver interception because there is usually no runoff from them for the majority of small rainfall events. An outlet pipe has to be provided from the swale channel (for conveyance swales) and/or underdrain systems (for dry/enhanced swales) to the point of discharge. Outlet structures are discussed in CIRIA C753 chapter 28. **Wet** A wet swale is the equivalent to a conveyance swale but it is designed specifically to deliver wet and/or marshy conditions in the base. They can be used on flat sites and where soils are poorly drained and/or to deliver the functionality or amenity or biodiversity requirements of a longitudinal pond/wetland component. Specific wetland planting will be required for the swale base and a minimum water depth of 150mm will be required in order to protect the vegetation from erosive flows - see chapters 17.1.3, 17.2 & 17.4.1.3 of CIRIA C753 along with figures 17.3 & 17.5 below. **Interception** Where there is infiltration capacity, infiltration is acceptable and the swale is designed is to facilitate even limited infiltration, then a simple infiltration design calculation will determine whether the swale is able to dispose of 5mm rainfall depth over the contributing catchment area – see CIRIA C753 chapter 25.6. Where there is no infiltration, but the natural surface soils (or imported/re-engineered soils) have water storage capacity, then interception design should follow principles set out in section 24.8 of CIRIA C753. Further information can also be found is chapters 3.3.1(a) & 17.4.2.
High level considerations, location & layout	
2	**Topography:** The surface should be level to allow distribution of flows across it. **Shape & location:** Swales should be constructed with a trapezoidal or parabolic cross section (see figure 17.5 below), it should not be constructed in symmetrical shapes or have any angular corners. Sharp bends should be avoided as these can cause erosion but long meandering bends are acceptable and promote slower flows, all these points relate to the function and performance. The gradient shall be varied (a single gradient around the perimeter would not be acceptable) and the minimum length of the component should be 5m. In certain locations some form of physical barrier may be appropriate to prevent vehicles parking on the swale edges (i.e. structural planting, bollards or low railings). Large boulders or rocks tend to lead to grass damage and scouring. Alternatively, the edge of the swale may be reinforced to prevent damage from vehicles. If the above cannot be met then justification and evidence will be required to ensure the risks to performance are acceptable – see chapter 3 of CIRIA C753 Swale **base widths** are to be between 0.5-2m. For swale widths > 2m, this may lead to low flow channelling, therefore consideration to be made to divide the cross-section with the flow divider / separator at the inlet (if required) – see CIRIA C753 chapter 17.2.

Swales

3	**Maintenance considerations:** Where the swale component is not located in a verge, other public open space or the boundary between the highway and a private garden, provision should be made for access including any specific features that are likely to pose maintenance difficulties and any associated mitigation measures that have been put in place – see chapter 32 of CIRIA C753 for guidance. Swales should not be sited near extensive areas of trees due to potential shading which will limit the growth of vegetation and reduce the effect of evaporation. Consideration should be given to planting of trees etc. which may hinder access for the maintenance particularly around ancillaries and access points.
4	**Flood risk to existing features**: No surrounding properties or features should be at risk – see chapter 36 of CIRIA C753 for guidance
Design requirements	
5	**Hydraulic assessment information criteria for all swale types;** **Representing component for hydraulic calculations**: Components must be labelled correctly in the model as part of the online piped network (i.e. dry swale containing an underdrain). If labelled as a storage component then it must be explained how this is linked in the model as part of the online network. The pipe diameter in the model must represent the base width of the component. As an example, if the width is 0.7m then the diameter represented in the model would be 700mm. Any impermeable areas around the component need to be included within the design. **Inflow velocities** for extreme events should be kept below 1m/s (2m/s if slope stability, soil erosion and safety conditions allow) to prevent erosion. Where the design proposes high velocities; check dams and appropriate pre-treatment systems can be used to improve both hydraulic and water quality performance of a swale system by reducing velocities, increasing residence time and storage. Any erosion protection must be reflected in the hydraulic model by applying a **headloss** of 0.5 at the point of outfall. The same headloss value of 0.5 needs to be applied for catch pits and check dams where applicable. **Design capacity:** A swale should be designed to convey the peak design flow rate which is specified as the 1 in 30yr event (this should be conveyed before overland flow is permitted) – see chapter 24.11.1 of CIRIA C753 for further guidance. See chapter 17.4.5 & 36 (table 36.1) of CIRIA C753 for guidance on acceptable flood routing options and velocities for exceedance **Underdrain / perforated pipes** are a requirement for **dry swales** and need to be sufficient to deal with design storm event (2yr event) and increase the pipe roughness to 0.35 to accommodate for the perforations to the pipework, this will confirm the complex network is adequate, providing a factor of safety. A separate hydraulic file will be required to represent this for assessment. **Component drain down time** must be within 24hrs and will need to be supported with calculation. **Water depths** should be no greater than 400mm, with a **freeboard** to the top of the bank at least 150mm above max design flow. The maximum water level must be at least 500mm below the lowest FFL of any adjacent properties – see CIRIA C753 section 17.4 for further information **Flow control diameter should** usually be a minimum of 100mm, however if the flow control has robust upstream protection which prevents debris this could be reduced to a minimum of 50mm **Designing for exceedance & considering overland flow** Overland flows from surrounding land must be considered particularly if adoptable components are designed to accept surface inflow. Flow routes for significant offsite flow paths must be provided as part of the overall site design and should be separated from any new adoptable network design See chapter 36 (table 36.1) of CIRIA C753 for guidance on acceptable velocities for exceedance.

Swales

6	**Gradients:** **Conveyance & wet swales** Longitudinal slopes should be between 0.5-6% (approx. 1 in 17 – 1 in 200). Check dams should be incorporated on slopes greater than 3% (approx. 1 in 33). Permanent reinforcement matting should be considered where velocities are above those recommended for standard designs. Where conveyance swales have gradients slacker/flatter than approx. 1 in 66 (<1.5%), wet swales can be considered in this scenario – see chapters 17.2 & 17.4.2 of CIRIA C753 along with figures 17.2 and 17.5 below. **Dry swales** Underdrains are recommended on conveyance swales of gradients slacker/flatter than approx. 1 in 66 (<1.5%) which would then mean the component would become a dry swale and would requiring designing accordingly– see chapters 17.2 & 17.4.2 of CIRIA C753 along with figures 17.2 and 17.5 below.
7	**Side slopes** need to be within a gradient of 1:3 and 1:5 for the perimeter of the component, 1:5 is preferred around any access to ancillaries (i.e. inlets & outlets) **UU will not adopt a feature with the minimum slope around the entire perimeter of the surface SuDS feature.**
8	Inflow into an adoptable SuDS feature must have appropriate **pre- treatment**. United Utilities will only adopt pre-treatment associated with domestic run-off as part of the in-line system. If United Utilities allow highway drainage run off to enter the adopted network upstream pre-treatment measures for the highway runoff such as filter strips, sediment forebays will need to be adopted by the highway authority as part of the section 38 adoption agreement. For systems with multiple inlets distanced apart, pre-treatment should be provided at or upstream of each inlet. Adoptable pre-treatment can be provided in the form of forebays and catch-pit details, or in the case of infiltration systems proprietary treatment systems such as vortex separators. A forebay area must be at least 10% of the total component. If the area is <10m2 then the depth of the forebay should be 200mm deep, if the area is >10m2 it should be 300mm deep – see CIRIA C753 chapter 18.8.1 (EQ.18.2). Each forebay should be accessible and easily maintained. A fixed sediment depth marker is recommended to monitor silt levels over time. Consideration can be given to a concrete lined forebay as this would also protect from erosion and can facilitate desilting (without damage to a liner for example). If using catch pit manholes, they must be sufficiently sized and representative of the upstream catchment with sump depths between 300-500mm. Maintenance access should be provided and the maintenance document must consider potential increase for desilt activities. Ideally sediment should be managed by an upstream component management train – see chapters 26 & 28.4.8 of CIRIA C753 along with figure 17.5 below for further guidance.
9	**Erosion protection** will be required for any outfall to a SuDS component and should extend to the base of the component. It can be in the form of a gabion mattress, rip rap, large stone spillway or can be incorporated into a forebay design if applicable. For swales, erosion protection will also need to be considered on the opposite side of the swale where flow may hit, to prevent damage. **Energy dissipation** measures can comprise of check dams, gravel flow spreader or flow dividers – see CIRIA C753 chapters 17.9.2 (conveyance), 17.9.3 (dry/enhanced), 17.9.4 (wet), 28.4.6 & 28.4.7 for further guidance, specifications and visual images (figure 17.13 below provides an example of a check dam design).

Swales

10	**Water Quality:** For the 1yr, 15 minute event (component draining highway); Average residence time in swale > 9 minutes for effective treatment (18 minutes from the top of the swale if the swale has lateral flows along its length) Flow height to be < 100mm Velocity < 0.3m/s for effective treatment This is for water quality to ensure good pollutant removal performance – see CIRIA C753 chapter 17.4.1.1 for further guidance. The time in component can be calculated by the following; length of component (m) / velocity (m/s)* = residence time (seconds) / 60 = residence time in component (mins) *Velocity through the component must be less than 0.3m/s during a 1yr 15min event Additionally, vegetation within a conveyance swale should be 75-150mm to prevent flattening during flow events (or suitable planting specified for a greater depth of flow). The pipe roughness should be a minimum of 0.35 where the vegetation is the same height as the grass and should increase where larger plants and/or greater range of plant sizes are used. Short grass is not a recommendation in wet swales as this reduces pollution removal performance.
11	**Perforated pipes/underdrains** collect water from the system and convey it downstream, they may not be required if the system is designed to infiltrate. If the design objective is to convey flows to a discharge point, the bottom of the system can be shaped to define a flow path towards the underdrain - see CIRIA C753 section 18.8.2 (figure 18.14) for examples. Perforated pipes should be a 100mm diameter as a minimum with 150mm of 5-20mm clean gravel above the pipe, the gravel and pipe should be enclosed by geotextile membrane. Perforated pipe should start and end in line with the component, non-perforated pipework to be utilised as rocker pipes into and out of the traditional/catch pit manholes or connection to an upstream or downstream sewers. Inspection pipes points should be provided to underdrains for performance observations and cleaning in accordance with the manhole standards set out in the Design & Construction Guidance (DCG). Detailed underdrain design guidance is set out in CIRIA C753 chapter 18.8.2 and guidance for the materials for underlying filter media / underdrains is set out in CIRIA C753 chapter 18.9. A chamber would be required at any intermediate points linking a chain of systems together or where the component is proposed to be longer than 90m, this would be located in a raised culverted section. Connections from sewers should not be made into a perforated underdrain.
12	**Inlet and outlet connections** Inflow for these components could enter laterally at surface along its length or via a point inlet. Lateral surface inflow details are usually relevant to highway flows, pre-treatment details are provided in the SuDS manual in the relevant sections. There are various point inlet details within the DCG and CIRIA SuDS manual which can differ based on pipe size, component type and application, if discharging via piped network inlets up to 350mm diameter, are to be constructed as per the standards set out in the Design & Construction Guidance (DCG) or our inlet headwall details drawing located within our SuDS technical library on our website Inlets greater than 350mm diameter, are to be constructed as per our inlet headwall details drawing or our standard detail drawings which can be found within our S104 technical library on our website. Outlet construction details can be based on the inlet details above. For dry features the outlet invert level should be set to the base of the headwall detail (**only applicable for conveyance/wet swales**) For **lateral flow connections** into the component, considerations need to be made to ensure there's minimal risk of deterioration in performance or failure of the component - See chapter 28.4.3 of CIRIA C753 along with some images of lateral connections extracted from figures 28.3 & 28.4 below for further guidance.
13	**Lining considerations:** Below is a list of information/considerations required when lining is proposed; Unlined components should not be used on brownfield sites unless it has been demonstrated that the risks posed by leaching of contaminants is managed to acceptable levels. Specification of chosen liner will be required. Geosynthetic barriers should be designed in accordance with BS EN 13361 or BS EN 13362 (see section E2.45 of Design & Construction Guidance), this includes tensile load, tear resistance and puncture resistance. These should have welded joints, taping would not be acceptable.

Swales

14	The **full design detail** should show all individual components which may include; inlet, lateral connections, forebay, underdrain, vegetation/planting, check dam, flow spreader/divider, outlet etc. as applicable. **Materials** should be shown on the **sectional drawing** i.e. filter media, underlying soils, perforated pipe/underdrain, geotextile membranes, geosynthetic barrier etc. as applicable. See CIRIA C753 chapters 17 (Swales), 30 (Materials including specification for liners – see 30.5.4) and 31 (Construction) along with chapters 21 (Soils) & 22 (Materials), of CIRIA C768 for further guidance

Construction

Construction of Swales should be in accordance with the guidance provided in the appropriate chapters of CIRIA C753 (17.11) and CIRIA C768 chapter 30 along with CIRIA C753 Appendix B: Construction assessment checklist.

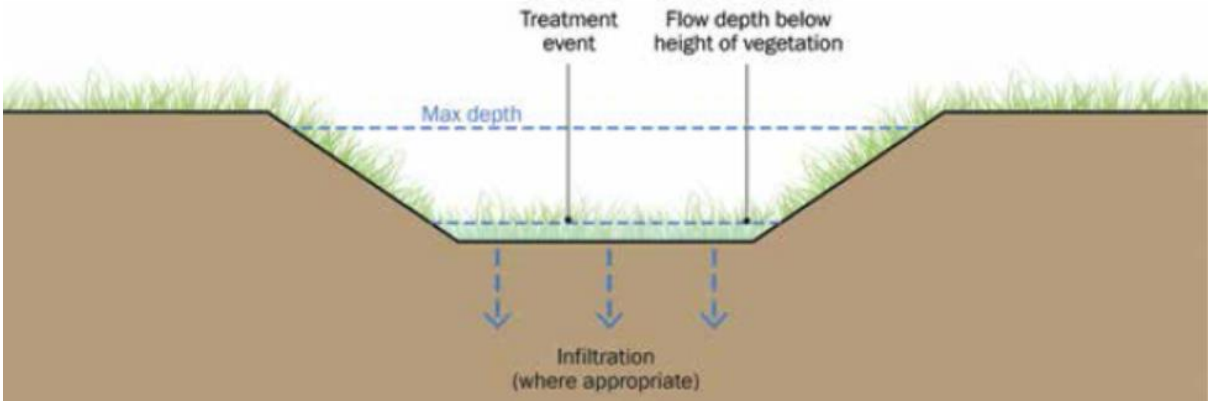

Figure 17.1.1

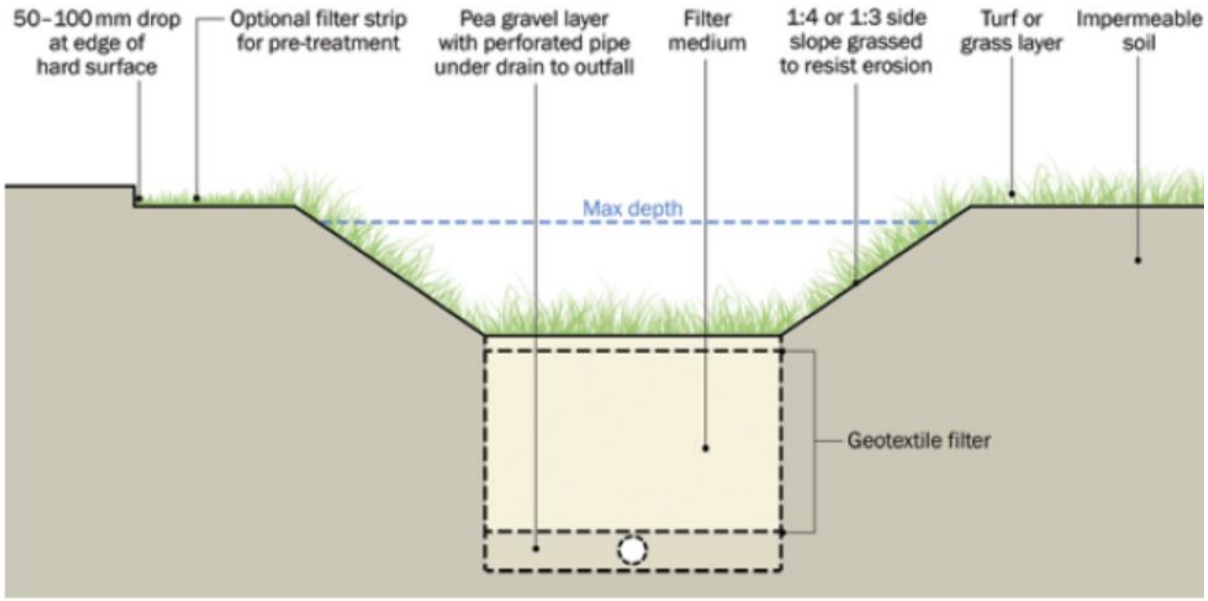

Figure 17.2 Typical dry swale

Swales

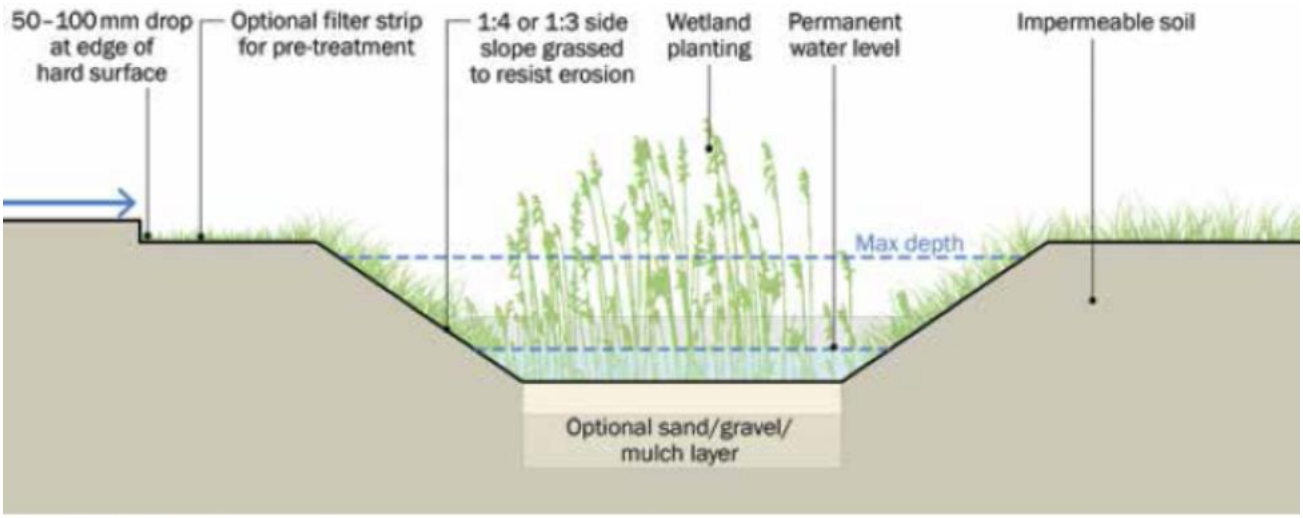

Figure 17.3 Typical wet swale

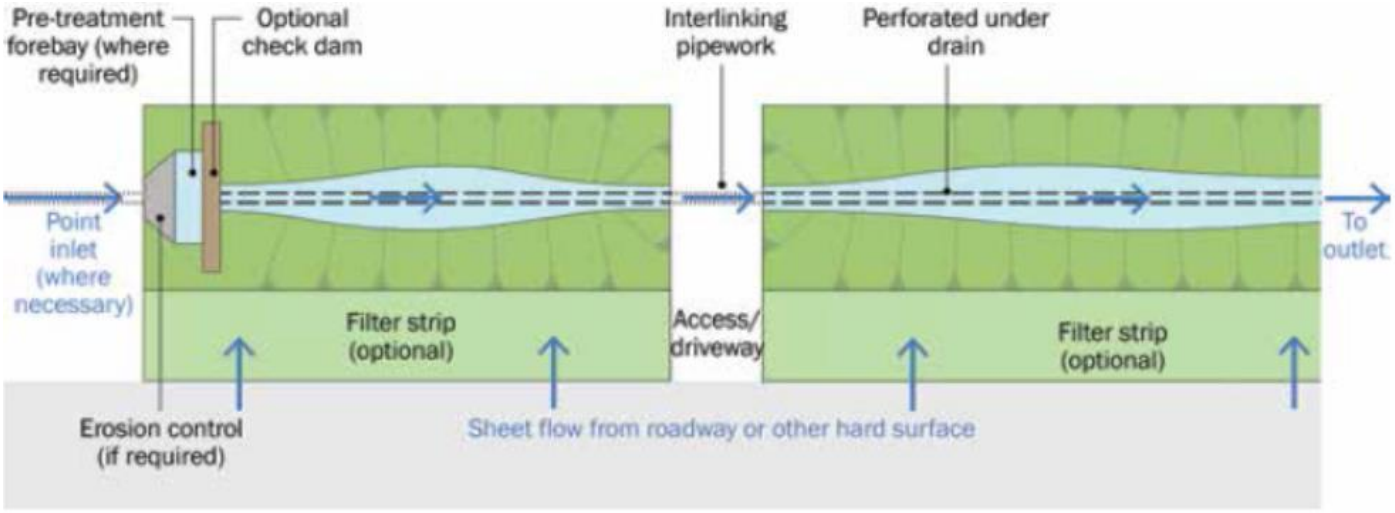

Figure 17.5 Typical plan view of a swale

Swales

(courtesy Illman Young)

(courtesy Illman Young)

Swales

Examples of lateral connections



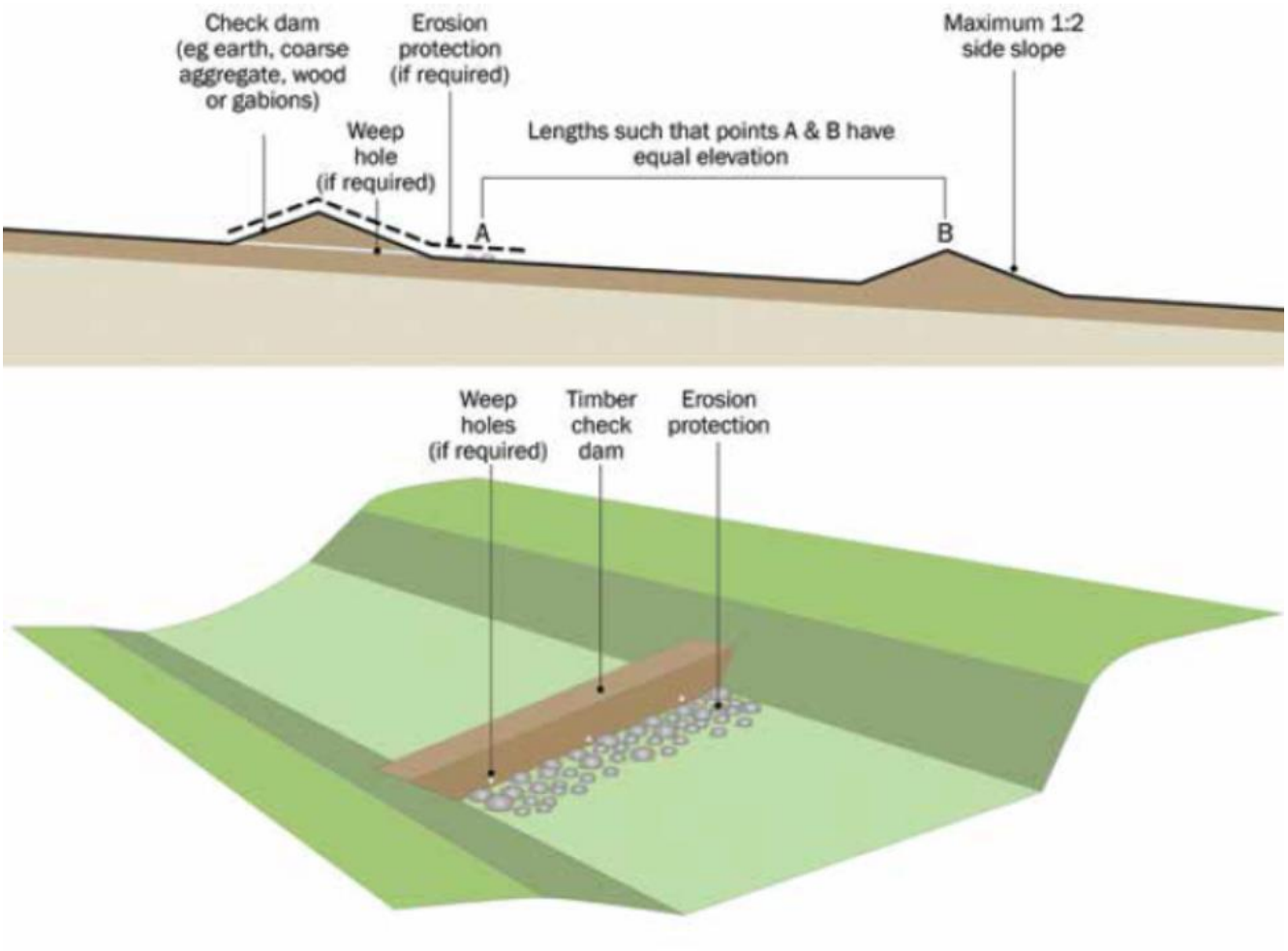

Figure 17.13 Typical check dam details