Design Manual for Roads and Bridges

Drainage
Design

CD 527
Sumpless gullies

(formerly HA 105/17)

Revision 1

Summary
This document provides the requirements and advice for the design of sumpless gullies.

Application by Overseeing Organisations
Any specific requirements for Overseeing Organisations alternative or supplementary to those given in this document are given in National Application Annexes to this document.

Feedback and Enquiries
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Highways England team. The email address for all enquiries and feedback is: Standards_Enquiries@highwaysengland.co.uk

This is a controlled document.

Contents

Release notes

Version	Date	Details of amendments
1	Mar 2020	Revision 1 (March 2020) Revision to update references only. Revision 0 (April 2019) CD 527 replaces HA 105/17. The full document has been re-written to make it compliant with the new Highways England drafting rules.

Foreword

Publishing information

This document is published by Highways England.

This document supersedes HA 105/17, which is withdrawn.

Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

Introduction

Background

This document gives the requirements and advice related to the use of sumpless gullies. Similar to conventional gullies, sumpless gullies primarily form part of a kerb and gully drainage system.

Sumpless gullies offer an environmental advantage in situations where there is a risk of anaerobic liquor being washed into a watercourse. They may not be appropriate in all locations and the environmental advantages should be weighed against maintenance aspects and the practicalities of the downstream pipework.

The grating on conventional and sumpless gullies will trap very coarse debris. Though a conventional sump will trap some of the sediment they are relatively ineffective at reducing pollution and can, through poor maintenance practices, generate polluting materials. The Environment Agency have expressed their concerns that the principal source of pollution in conventional gullies arises from the bacterial action of degrading organic materials contained within the coarse debris and the sediment within the sump. The bacterial action creates a high biochemical oxygen demand (BOD), which means that the liquor will tend to remove the oxygen from any water into which it is discharged. Often referred to as the "first flush", highly polluted liquor is discharged during the initial stages of a storm event.

Although maintenance practices and cleansing operations should ensure this potentially polluting liquor is not washed into the drainage system, during dry periods, when there is no rainfall to provide a residual flow of water within the drain to dilute the liquor, there is a risk that severe pollution of the receiving water courses could occur.

Assumptions made in the preparation of the document

The assumptions made in GG 101 [Ref 6.N] apply to this document.

Abbreviations and symbols

Abbreviations

Abbreviations

Abbreviation	Definition
BOD	Biochemical oxygen demand
HADDMS	Highways Agency Drainage Data Management System

Symbols

Symbols

Symbol	Definition
k_s	Measure of linear effective roughness (Colebrook-White [Ref 6.I] equation)

Terms and definitions

Terms and definitions

Term	Definition
Chute type sumpless gully	Shallow rectangular structure with outlet at the rear wall and a base that slopes just below the frame seating at the front to the outlet pipe invert at the rear.
Conventional gully	A means of capturing surface water runoff and directing it to the drainage system via discrete entry points with the construction of a sump to trap debris and sediments.
First flush	The runoff from the first part of a rainfall event. NOTE: This usually is the most polluted runoff, especially when there is intense rainfall after long dry periods during which pollutants can accumulate on the road.
Kerb race	Foundation on which the units are laid (MCHW Series 1100 [Ref 2.I]and BS 7533-6 [Ref 3.I]).
Pot type sumpless gully	Circular gully pot with the outlet at the base of the pot - no sump.
Sumpless gully	A means of capturing surface water runoff and directing it to the drainage system via discrete entry points without the construction of a sump to trap debris and sediments.

1. Scope

Aspects covered

1.1 The requirements in this document shall be used in the design of sumpless gullies.

Implementation

1.2 This document shall be implemented forthwith on all schemes involving gullies on the Overseeing Organisation's motorway and all-purpose trunk roads according to the implementation requirements of GG 101 [Ref 6.N].

Health and safety

1.3 Safety risk mitigation measures shall follow the ERIC hierarchy - eliminate, reduce, isolate and control for each identified safety risk.

1.4 This document shall be read in conjunction with CD 524 [Ref 4.N].

1.5 This document shall be read in conjunction with CD 526 [Ref 7.N].

NOTE The vulnerable road user requirements in CD 526 [Ref 7.N] are particularly relevant to the application of this document.

Use of GG 101

1.6 The requirements contained in GG 101 [Ref 6.N] shall be followed in respect of activities covered by this document.

2. Design requirements

General

2.1 Sumpless gullies design shall not retain oil or sediment.

2.2 The positioning of sumpless gullies shall be as described in CD 524 [Ref 4.N].

2.3 Sumpless gullies shall be located at the carriageway edge or in the central reserve.

2.4 The grating and frame of sumpless gullies shall be in accordance with CD 534 [Ref 1.N].

2.5 The supporting of the grating and frame for sumpless gullies shall be the same as conventional gullies.

2.6 The spacing of sumpless gullies shall be in accordance with CD 526 [Ref 7.N].

2.7 The spacing of sumpless gullies shall be in accordance with CG 501 [Ref 2.N].

2.8 The outlet of a sumpless gully shall be at the base of the sumpless gully.

2.9 The base of a sumpless gully shall be shaped so the flow of surface water is channelled into the outlet pipe.

2.10 Sumpless gullies shall not discharge into a combined or foul sewer.

NOTE There is no trap in a sumpless gully to prevent the escape of noxious odours.

2.11 Where sumpless gullies are used as a retrofitting measure, the requirements of the relevant Overseeing Organisation shall apply.

2.12 Sumpless gully shall be either the chute or pot type.

NOTE Further information on sumpless gully types is provided in tabular form in Section 2, in the terms and definitions, and in Appendix A.

2.13 The internal surfaces of a chute type sumpless gully shall slope towards the outlet pipe of the sumpless gully.

2.14 A chute type sumpless gully shall have a vertical face above where the outlet pipe connects to the sumpless gully.

2.15 The chute shall be designed to tolerate the expected traffic loading without damage.

2.15.1 A chute type sumpless gully may be fitted with extension pieces between the chute and frame to increase the chute depth.

2.15.2 Chutes may be made from plastic, concrete, ductile or cast iron.

2.16 A pot type sumpless gully shall have a cylindrical body with a spherical base.

2.17 The pot type sumpless gully shall be designed to tolerate the expected traffic loading without damage.

2.17.1 A pot type sumpless gully may be made from clay or concrete.

2.18 A pot type sumpless gully made from plastic shall have concrete backing in accordance with the detailing of a conventional gully.

2.19 The outlet pipe for a pot type sumpless gully shall be at the lowest point of the base of the sumpless gully.

2.20 The outlet pipe for a pot type sumpless gully shall not be vertical.

Application

2.21 Sumpless gully types shall be used as described in the table selection criteria for sumpless gullies (Table 2.21).

Table 2.21 Selection criteria for sumpless gullies

Carriageway gradient	Suitable types of sumpless gully in order of preference
Steeper than 1/90	1) Shallow chute to carrier pipe; 2) Deep chute or sumpless pot to carrier pipe; and 3) Shallow chute discharging directly to ditch.
1/91 - 1/150	1) Deep chute or sumpless pot to carrier pipe; 2) Shallow chute to carrier pipe with catchpits; and, 3) Shallow chute discharging directly to ditch.
Flatter than 1/150	1) Shallow chute discharging directly to ditch; and, 2) Deep chute or sumpless pot to carrier pipe with catchpits.

NOTE *Further guidance on the benefits of using sumpless gullies over conventional gullies is contained in Appendix A.*

2.22 The design of a drainage system which includes sumpless gullies shall include calculations to demonstrate:

1) the presence of catchpits;
2) maintenance requirements with regards to sedimentation;
3) effects on the downstream drainage system with regards to sedimentation;
4) pollution effects to the receiving watercourse; and,
5) the volume and method of sediment capture.

2.23 The crown and haunch of the outlet pipe from the sumpless gully shall be lower than the adjacent kerb race.

2.24 Where sumpless gullies are located on embankments and discharge to toe ditches at the base of the embankment, the system shall be designed to ensure that there is no detrimental effect on the embankment slope stability.

2.25 Sumpless gullies located on embankment shall have a kerb as part of the overall carriageway design.

2.25.1 Sumpless gullies may be used on the approaches to over-bridges.

2.25.2 Sumpless gullies should be used where the approach to an over-bridge is on embankment.

Pipe network

2.26 The drainage system's pipe network shall be designed in accordance with CD 523 [Ref 3.N] and the requirements within this document.

2.26.1 Where the drainage system design includes sumpless gullies, the calculation of sediment load, gradient, flow and discharge rate in accordance with CD 523 [Ref 3.N] may be amended by the requirements within this document.

2.26.2 Due to the increase in sediment load, steeper pipe gradients than those in CD 523 [Ref 3.N] may be used to achieve the minimum self-cleansing velocities in the downstream pipe network in accordance with the tables in the design requirements.

NOTE 1 Sumpless gullies can cause an increased amount of sediment to be passed to the downstream drainage system due to no sediment load being stored in the gully.

NOTE 2 It can be advantageous for a drainage system design utilising sumpless gullies to also utilise a vortex separator in accordance with CD 528 [Ref 8.N].

2.26.3 Where sumpless gullies are considered as a retrofit or as part of an improvement scheme the existing drainage system may have to be reassessed for the additional sediment load.

2.27 Where sumpless gullies form part of the drainage system design, sediment shall be transported through the downstream pipe network without deposition.

2.27.1 The drainage system should allow for deposition at the catchpits or vortex separator only.

2.28 Where self-cleansing velocities in the downstream pipe network cannot be achieved in accordance with CD 523 [Ref 3.N] and the requirements within this document, sumpless gullies shall not be used as part of the drainage system design.

2.29 When designing the pipe network for a drainage system which includes sumpless gullies, the pipe roughness k_s in the Colebrook-White [Ref 6.I] equation shall equal 3mm.

2.30 The tables for minimum velocities for pipe network cases A, B, C and D shall be used for the design of minimum velocities at pipe-full conditions.

Table 2.30a Minimum velocities for pipe network case A

Pipe internal diameter (mm)	Minimum velocity (m/s)
150	0.69
200	0.78
225	0.82
250	0.89
275	0.96
300	1.03
350	1.17
375	1.24
400	1.32
450	1.48
500	1.63
600	1.84

Table 2.30b Minimum velocities for pipe network case B

Pipe internal diameter (mm)	Minimum velocity (m/s)
150	0.67
200	0.71
225	0.72
250	0.73
275	0.76
300	0.79
350	0.84
375	0.87
400	0.89
450	0.97
500	1.05
600	1.21
700	1.38
750	1.47
800	1.56
900	1.76

Table 2.30c Minimum velocities for pipe network case C

Pipe internal diameter (mm)	Minimum velocity (m/s)
150	0.67
200	0.71
225	0.72
250	0.73
275	0.74
300	0.75
350	0.76
375	0.77
400	0.78
450	0.79
500	0.81
600	0.85
700	0.91
750	0.93
800	0.96
900	1.00

Table 2.30d Minimum velocities for pipe network case D

Pipe internal diameter (mm)	Minimum velocity (m/s)
150	0.67
200	0.71
225	0.72
250	0.73
275	0.74
300	0.75
350	0.76
375	0.77
400	0.78
450	0.79
500	0.81
600	0.82
700	0.85
750	0.86
800	0.86
900	0.87

2.30.1 Where the required internal pipe diameters of the drainage system are not included in the tables for minimum velocities for pipe network cases A, B, C and D, the required flow velocities may be interpolated from the pipe diameters.

2.31 The tables for minimum velocities for pipe network cases A, B, C and D shall be used as stated in Table 2.31 (design options and use of tables for minimum velocities for pipe network cases A, B, C and D) for the two types of sumpless gully.

Table 2.31 Design options and use of tables for minimum velocities for pipe network cases A, B, C and D

Type of gully	Downstream pipe system			
	Catchpits		No catchpits	
Sumpless gullies (pot or chute)	Upstream of catchpit 1	Case A	Whole system	Case A
	Between catchpits 1 and 4	Case B		
	Between catchpits 4 and 10	Case C		
	Downstream of catchpit 10	Case D		
Sumpless gullies (pot or chute)	Upstream of catchpit 2	Case C	Whole system	Case C
	Downstream of catchpit 2	Case D		

NOTE 1 In the table of design options and use of tables for minimum velocities for pipe network cases A, B, C and D the catchpits are numbered starting at the most upstream end of the system. Downstream of junctions in branched systems, the catchpit number is counted from the upstream end of the branch having the largest number of catchpits.

NOTE 2 When catchpits are used the sediment concentration decreases towards the downstream end of the system. This reduces the required values of minimum velocity and enables the pipes to be laid at flatter gradients than would be the case with benched manholes that do not trap any sediment.

3. Design for operation and maintenance

3.1 Sumpless gullies shall be recorded, on new and existing drainage systems, as a point asset in accordance with HADDMS HADDMS [Ref 5.N] and include a specific attribute for not having a sump.

3.2 The design of a drainage system, which includes sumpless gullies, shall deliver a maintenance frequency which is the same as a drainage system including conventional gullies.

3.3 Where the design of the drainage system includes sumpless gullies, the catch pits within the system shall be designed to have the volume required to store the increased sediment load.

NOTE Designing the catchpits within the system to have the volume required to store the increased sediment load can cause the drainage system to have catchpits at more frequent intervals.

4. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Ref 1.N	Highways England. CD 534, 'Chamber tops and gully tops for road drainage and services'
Ref 2.N	Highways England. CG 501, 'Design of highway drainage systems'
Ref 3.N	Highways England. CD 523, 'Determination of pipe roughness and assessment of sediment deposition to aid pipeline design'
Ref 4.N	Highways England. CD 524, 'Edge of pavement details'
Ref 5.N	http://www.hagdms.co.uk. HADDMS, 'http://www.hagdms.co.uk'
Ref 6.N	Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges'
Ref 7.N	Highways England. CD 526, 'Spacing of road gullies'
Ref 8.N	Highways England. CD 528, 'Vortex separators for use with road drainage systems'

5. Informative references

The following documents are informative references for this document and provide supporting information.

Ref 1.I	CIRIA. CIRIA R141, 'Design of sewers to control sediment problems'
Ref 2.I	Highways England. MCHW Series 1100, 'Manual of Contract Documents for Highway Works. Volume 1 Specification for Highway Works. Series 1100 Kerbs, Footways and Paved Areas.'
Ref 3.I	BSI. BS 7533-6, 'Pavements constructed with clay, natural stone or concrete pavers - Part 6: Code of practice for laying natural stone, precast concrete and clay kerb units'
Ref 4.I	HR Wallingford. ESCARAMEIA M., TODD A.J., MAY R.W.P. & HIRD A. HRW SR 604, 'Sumpless gullies for highway drainage. Project Report'
Ref 5.I	Thomas Telford. HR Wallingford and Barr D I H. HRW Tables, 'Tables for the hydraulic design of pipes, sewers and channels'
Ref 6.I	Institution of Civil Engineers. Colebrook, C, F. Colebrook-White, 'Turbulent flow in pipes, with particular reference to the transition region between the smooth and rough pipe laws.'

Appendix A. Generic details

A1 Debris and sediment

Debris accumulates on the carriageway from a number of sources. They can be actual pieces of vehicle, typically windscreen and headlamp glass, tyre debris, pieces of bumper or exhaust or simply corroded steel. Debris can also originate from material thrown from moving vehicles, for example cigarette ends and packets, drinks bottles, cans and paper, etc. The third source of debris is organic in nature. This can derive from plant die-back, leaf and tree debris, and dead animals. A further source of debris and sediment is the pavement itself resulting from resurfacing works, abrasion/removal of grit and salting operations.

During periods of rainfall, sediment can be washed on to the carriageway from the adjacent unpaved areas, and under moderate wind conditions is blown on to the carriageway from considerable distances. This sediment is generally in the form of fine silt particles or coarser granular sediment. The debris and sediment are carried along in the surface water runoff from the carriageway to the gullies. To minimise the amount of sediment and debris entering (the pipeline or) the receiving watercourse, measures are taken throughout the drainage system.

The rate of sediment deposition is a function of sediment load, pipe diameter, pipe roughness and pipe gradient. This is because these attributes influence the velocity of flow within the pipe. Tests carried out in support of this document, (HRW SR 604 [Ref 4.I]) showed that only minor deposition would be likely to occur with sumpless gullies if the downstream pipe gradients are 1 in 100 or steeper. The most common method of improving the sediment transport capacity of a pipeline is to increase the gradients of the pipes. Transport capacity can also be increased by slightly relaxing the self-cleansing requirements and designing the pipeline to operate satisfactorily with a small amount of sediment deposition. A more detailed explanation of the process can be found in CIRIA R141 [Ref 1.I]. The table within the design requirements section of this document were produced using methods recommended in CIRIA R141 [Ref 1.I] and described in HRW SR 604 [Ref 4.I], with the following assumptions: pipe wall roughness of 0.6mm; and maximum depth of sediment deposit equal to 1% of the pipe diameter giving an effective overall roughness of about $k_s = 3mm$.

A2 Conventional gully pots

The efficiency of a conventional gully pot to retain debris and fine sediment is a function of flow rate and sediment particle size. Conventional gully pots can be effective at retaining some 90% of sediment of $d_{50} = 0.8mm$. This efficiency drops considerably to around 25% if the retained sediment level approaches the maximum level before blockage of the outlet occurs.

The principle behind the use of gully pots is to reduce the amount of coarse sediment that enters the drainage system. The presence of sediment in the drainage system increases frictional forces leading to a reduction in the flow velocity and ultimately to blockages. The conventional gully pot comprises a sump below the level of the outlet pipe. The outlet can be trapped, meaning that there is a form of "weir" to reduce the risk of debris being washed into the connection and the carrier drain. As oil floats on water the provision of the trap will retain oils within the pot and prevent them being washed into the drain. The outlet from the pot to the trap is below the water level in the pot. The second, less common form of conventional gully has no trap, simply having the outlet connection above the sump in the pot. This type of pot will not retain oils, but will retain most of the coarser sediments.

A3 The benefits of sumpless gullies

The use of sumpless gullies can provide benefits by:

1) preventing contaminated silt and liquor accumulation;
2) helping to eliminate the "first flush" of heavily polluted flow as the gully starts to operate;
3) eliminating or reducing the need to clean the pots with the risk of contaminated water from the pot being used in the cleaning process.

The chute type of sumpless gully is more appropriate for either steep carriageways, where steep downstream pipework is achievable, or for flat carriageways in low-lying areas where the individual outlets pipes can be steep.

There can be significant variation in the time and energy required to install the supporting surrounds to different types of sumpless gully. This should be considered when investigating the relative merits of each type of sumpless gully system.

Appendix B. Worked example

This example illustrates how a carrier pipe system should be designed for a road drained by sumpless gullies. The drainage pipe system includes five catchpits, where sediment is collected, and pipework receiving nine gully connections between adjacent pairs of catchpits. It is assumed that the flow rate from each of the gullies is the same, equal to 2.8 l/s. The catchpits are numbered from upstream: C1, C2, etc.

In this example, the objective is to determine the pipe diameters and gradients necessary to achieve minimum self-cleansing velocities in the whole system. In this example the 'Tables for the hydraulic design of pipes, sewers and channels (HRW Tables [Ref 5.I])' were used for the determination of the pipe sizes and diameters that would ensure flow velocities equal to, or greater than, those given in design requirements of this document.

The 'Tables for the hydraulic design of pipes, sewers and channels (HRW Tables [Ref 5.I])' are based on the Colebrook-White [Ref 6.I] equation and the roughness value used was $k_s = 3mm$. When more than one pipe diameter satisfied the requirement for minimum flow velocity, the criterion used was to select the pipe diameter associated with the flattest gradient. From the table for design options and use of tables for minimum velocities for pipe network cases A, B, C and D for a system consisting of sumpless gullies and five catchpits, the values of minimum flow velocity are obtained from tables for minimum velocities for pipe network case A to C within the design requirements.

In each pipe run between catchpits, the pipe section immediately upstream of the catchpit has the highest sediment concentration, whereas the pipe section immediately downstream of the catchpit will have the lowest concentration, since the sediment will tend to deposit in the catchpit. In this example pipe sizes and gradients were determined for each of these upstream and downstream sections.

B1 Upstream of Catchpit 1, C1:

First pipe section; Q = 2.8l/s

Choose minimum pipe size, 150mm diameter. From case A of Section 2, the minimum self-cleansing flow velocity is 0.69m/s. From the hydraulic design, a 150mm diameter pipe at 1/125 gradient will convey 12.2 l/s with V=0.693m/s. This pipe will flow part full.

Section u/s of C1; Q = 25.2l/s

Assume pipe diameter of 200mm; from case A of Section 2, the minimum self-cleansing flow velocity is 0.78m/s. From the hydraulic design tables, a 200mm diameter pipe at 1/133 gradient will convey 25.7 l/s with V=0.818m/s (>0.78m/s). [If the designer chooses a large pipe diameter than required, they should check the larger diameter pipe still satisfies the minimum flow velocity].

B2 From C1 to C2:

Section d/s of C1; Q = 25.2 l/s

200mm diameter; 1/133 gradient.

Section u/s of C2; Q = 50.4 l/s

Assume pipe diameter of 225mm; since this section is downstream of Catchpit 1, from case B of Section 2, the minimum self-cleansing flow velocity is 0.72m/s. A 225mm diameter pipe at 1/63 gradient will convey the required flow but the gradient is considered too steep. Consider a 275mm diameter pipe; from case B, the self-cleansing velocity is 0.76m/s. This pipe will convey the flow at 1/182 gradient with velocity = 0.869m/s > 0.76m/s. [If the designer chooses a large pipe diameter than required, they should check the larger diameter pipe still satisfies the minimum flow velocity].

Section d/s of C2; Q = 50.4 l/s

275mm diameter; 1/182 gradient.

Section u/s of C3; Q = 75.6 l/s

Assume pipe diameter of 300mm; from case B of Section 2, the minimum self-cleansing flow velocity is 0.79m/s. A 300mm diameter pipe at 1/133 gradient will convey the required flow at a velocity above the self-cleansing velocity. [If the designer chooses a large pipe diameter than required, they should check the larger diameter pipe still satisfies the minimum flow velocity].

B3 From C3 to C4:

Section d/s of C3; Q = 75.6 l/s

300mm diameter; 1/133 gradient.

Section u/s of C4; Q = 100.8 l/s

Assume pipe diameter of 375mm; from case B of Section 2, the minimum self-cleansing flow velocity is 0.87m/s. A 375mm diameter pipe at 1/238 gradient will convey the required flow at a velocity above the self-cleansing velocity.

B4 From C4 to C5:

Section d/s of C4; Q = 100.8 l/s

375mm diameter; 1/238 gradient (V=0.934m/s larger than minimum self-cleansing velocity of 0.77m/s, in case C – this table is applicable because the section is downstream of Catchpit 4).

Section u/s of C5; Q = 126 l/s

Assume pipe diameter of 450mm; from case C of Section 2, the minimum self-cleansing flow velocity is 0.79m/s. A 450mm diameter pipe at 1/417 gradient will convey the required flow at a velocity above the self-cleansing velocity. A 400mm pipe at a 1/217 gradient would equally satisfy the requirements.