BRANZ

ISSUE 509 BULLETIN

Sizing gutters and downpipes

April 2009

- Gutters and downpipes are the most common method of safely disposing of stormwater from buildings.
- It is recommended that internal gutters be designed to ensure that there is minimal chance of water entering the building.
- This Bulletin replaces Bulletin 350 *Sizing gutters and downpipes*.

1.0 INTRODUCTION

1.0.1 Gutters and downpipes are the most common method of disposing of surface water from buildings.

1.0.2 To ensure that water is safely disposed of, size and install gutters and downpipes so that the expected amount of water can be controlled with minimal chance of water entering the building and minimal risk of uncontrolled spillage.

1.0.3 This Bulletin replaces Bulletin 350 *Sizing gutters and downpipes* and can provide a more conservative Alternative Solution proposal than the Acceptable Solution E1/AS1 for the sizing of external and internal gutters and downpipes for surface water disposal.

1.0.4 This Bulletin does not cover concealed fascia gutter systems where the gutter is concealed behind a fascia.

2.0 STATUTORY REQUIREMENTS

2.1 NEW ZEALAND BUILDING CODE

2.1.1 Under the New Zealand Building Code (the Building Code) clause E1 Surface water, the performance requirement of clause E1.3.1 states that surface water resulting from an event having a 10% probability of occurring annually and which is collected or concentrated by buildings or sitework, 'shall be disposed of in a way that avoids the likelihood of damage or nuisance to other property'.

2.1.2 It also states in E3.1.2 that 'surface water, resulting from an event having a 2% probability of occurring annually, shall not enter buildings'. The comment to the clause limits the buildings under consideration to housing, communal residential and communal non-residential buildings.

2.1.3 This is normally achieved in urban areas by collecting rainwater from the roof by means of a gutter and downpipes connected to a surface water drain. This drain is then connected to a disposal system owned and operated by a network utility operator. In rural areas stormwater is either reticulated to storage tanks or disposed of by soakage on-site or reticulation to a natural watercourse.

2.1.4 The recommendations in this Bulletin are generally more conservative than the solutions given in E1/AS1 because this Bulletin uses the actual roof area in the calculations – the exception is for roofs with less than a 5° slope, where the difference in areas is small.

3.0 FACTORS TO BE CONSIDERED

3.0.1 Factors to be considered in the sizing of gutters and downpipes are:

- rainfall intensity
- actual contributing roof area (roof plane area)
- flow capacity
- gutter falls
- location of bends relative to the outlet positions
- location of outlets
- gutter cross sectional area
- number of gutter and/or in-roof outlets
- roof slope – steeper slopes have faster run-off
- additional wall or roof areas discharging onto the roof being considered
- downpipe size.

3.0.2 E1/AS1 defines a section of gutter as 'the length of gutter between a downpipe and the adjacent high point on one side only of that downpipe'.

3.1 RAINFALL INTENSITY

3.1.1 This Bulletin uses the actual roof plane area when calculating flow loads on gutters (Figure 1a). The rainfall intensity curves given in Appendix A of the Acceptable Solution E1/AS1 (given in mm/hour) are based on a 10% probability of such rainfall occurring annually for a period of 10 minutes.

3.1.2 Allowing for a minimum rainfall intensity of 100 mm/hour for a storm with a 10% probability of occurring annually, and a 10 minute duration, is adequate when sizing an external gutter for most parts of New Zealand. However, regions such as Arthur's Pass, Haast, Milford Sound, Fiordland, around Mt Taranaki and the Kaimai Ranges will have a higher rainfall intensity that must be allowed for.

3.1.3 Actual rainfall intensities for any area in New Zealand can be checked using E1/AS1 or by referring to the National Institute of Water and Atmospheric Research (NIWA) High intensity Rainfall Design System (HIRDS).

3.1.4 BRANZ recommends that designers consider changes in rainfall intensity that are likely to be experienced in the future through climate change. The Ministry for the Environment (MFE) has predicted that western regions of the country will experience an increase in both intensity and frequency of up to 5% in rainfall by 2040 and 10% by 2090.

3.1.5 The greater the rainfall intensity, the more water that will flow into the gutter to be removed by the downpipes, thus requiring a larger capacity gutter and more downpipes. This is particularly critical for internal gutters - refer Section 5.0 Internal gutters.

3.2 ROOF PLANE AREA

3.2.1 The roof plane area (see Figure 1a) for roof pitches between 5° and 50° will typically provide a more conservative assessment of the amount of water collected by the roof. As noted earlier, at roof slopes up to 5° the difference is small. E1/AS1 uses the plan area of the roof to calculate gutter and downpipe sizing. (Plan area is not confined to building dimensions and needs to include any overhangs.) BRANZ recommends that the actual roof plane area is used when calculating gutter and downpipe sizes.

3.3 ROOF SLOPE

3.3.1 As roof slope increases the area of the catchment area of the roof and the speed at which the water drains from the roof also increases. This increases the load on the gutter system during rainfall.

3.4 FLOW CAPACITY

3.4.1 The actual volume of water, in litres/minute, can be calculated by identifying the specific rainfall intensity that will be encountered in the area the building is located. Refer to

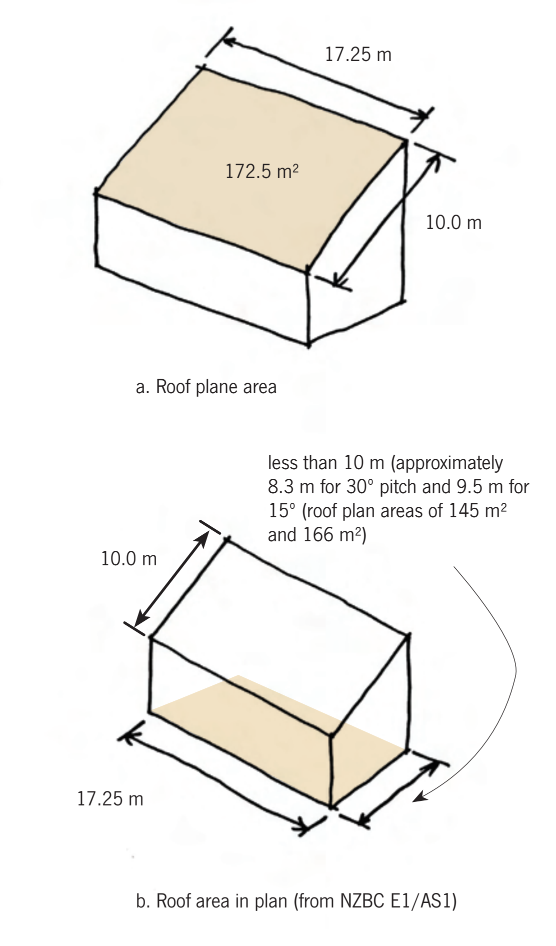

Figure 1. Roof area calculation.

TABLE 1. FLOW LOAD FACTORS FOR GIVEN RAINFALL INTENSITIES

Rainfall intensity (mm/hour)	Flow load factor l/m
50	0.83
75	1.25
100	1.67
125	2.08
150	2.50
175	2.92
200	3.33

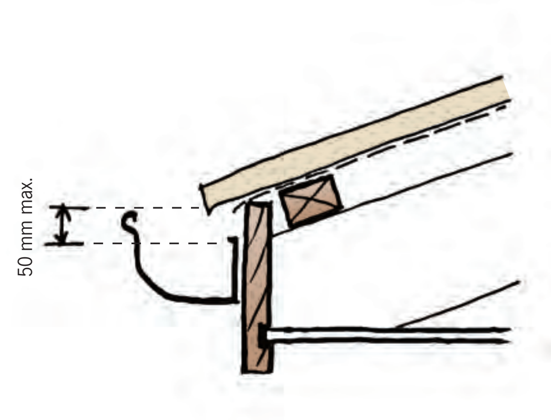

Figure 2. External gutter.

Appendix A, of E1/AS1 Rainfall intensity maps, or for more accurate and up-to-date information, refer to NIWA HIRDS.

3.4.2 Table 1 identifies a flow load factor for various rainfall intensities that can be used to calculate the actual flow of water in litres per minute.

3.4.3 By multiplying the flow load factor by the roof plane area, the actual flow of water in litres/minute, or flow capacity (FC), can be found.

3.4.4 British building regulations require that the design rate run-off from the roof should not exceed 90% of the gutter capacity.

3.5 GUTTER FALLS

3.5.1 E1/AS1 requires gutters to fall to the outlet but gives no minimum slope requirement. Designers should also check specific manufacturer's requirements.

3.5.2 BRANZ recommends that all gutters have a minimum fall of 1:600 for external gutters and 1:300 for internal gutters (1:300 for external and 1:100 for internal is preferable).

3.5.3 The total fall of an external gutter may be limited by the depth of the fascia and by the visual effect of the gutter installed to a fall. The top of the back edge of an external gutter should not be more than 50 mm below the discharging roof (see Figure 2). When using a fall of 1:300, additional downpipes may be required to accommodate the fall within the fascia width and to minimise the visual effect of the fall. (See comment on Figure 2.)

3.6 POSITION OF BENDS

3.6.1 The capacity of the rainwater system can be affected by the inclusion of bends in the gutter and the proximity of these bends to an outlet. For a gutter less than 6 m total length, a right angle bend more than 2 m from an outlet may reduce flow by as much as 14% and a bend within 2 m of the outlet, by as much as 40%. This effect can become critical for the drainage of internal gutters.

3.6.2 Where possible, bends should be avoided.

3.7 LOCATION OF OUTLETS

3.7.1 The position of the outlet in the gutter affects the required minimum cross-sectional area of the gutter. For example:

- for a centrally positioned outlet (see Figure 3), the gutter each side of the outlet shall be sized to cater for half the roof plane
- for an off-centre outlet the gutter shall be sized to cater for the larger of the roof areas drained
- for an outlet at one end of the gutter it shall be sized to cater for the total roof area.

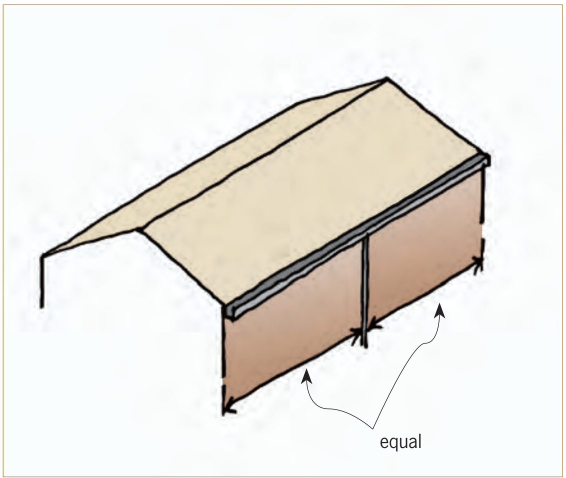

Figure 3. Centrally positioned outlet.

3.7.2 Downpipes must be sized for the specific area of roof area catchment. A maximum spacing of 12 m (40 mm fall at 1:300) is recommended provided catchment areas in Table 2 are not exceeded.

3.8 DESIGN OF OUTLETS

3.8.1 Outlets from gutters into downpipes will dispose of water better when:

- there is a positive fall to the outlet
- the outlet incorporates a sump to reduce water turbulence – the amount of water a downpipe can carry increases as the depth of calm water over the outlet increases because the amount of air in the water flow is reduced
- there are rounded entry points (minimum 25 mm radius) as these improve performance by enhancing flows
- the outlet incorporates a grate or guard to prevent the entry of debris into the system.

3.8.2 Siphonic roof outlets incorporating a sump and a baffle exclude air from a downpipe and allow the downpipe to run at full capacity.

3.9 DOWNPIPES

3.9.1 In E1/AS1 downpipes are acceptable provided their cross-sectional area is no less than that required by Table 5 of the Acceptable Solution, and they permit passage of a 50 mm diameter sphere. Table 2 of this bulletin is a modified version of Table 5 of E1/AS1 incorporating roof plane area rather than roof plan area.

3.9.2 When selecting the type of external or internal downpipe, a square or rectangular profile requires 10% more cross-sectional area than round downpipes.

3.9.3 All internal downpipes within the building fabric must have:

- all joints sealed
- the installation pressure-tested before the downpipes are enclosed or concealed
- where concealed, a durability of not less than 50 years.

3.9.4 E2/AS1 limits the roof catchment area of an upper roof discharging through a downpipe and spreader onto a lower roof to 25 m².

4.0 EXTERNAL GUTTERS

4.0.1 External gutters should be designed to allow water to spill to the exterior (usually between the back of the gutter and the fascia) should they overflow due to high rainfall or should a downpipe become blocked. The front face of the gutter should be higher to restrict the potential for water being blown up under the bottom edge of the roofing – see Figure 2.

4.1 SIZING DOWNPIPES

4.1.1 Table 2 provides the roof plane area of a building that can be served by downpipes of various sizes, serving external gutters, for a given roof slope. This Table is based on a rainfall intensity of 100 mm/hr for a 10 minute period. Refer to 5.0 for internal gutters.

TABLE 2 – DOWNPIPE SIZES FOR GIVEN ROOF PITCH AND ROOF PLANE AREA
(Table 5 of E1/AS1 modified to incorporate roof plane area)

Downpipe size (mm) (1)	Roof pitch			
Minimum internal size	0 - 25°	25 - 35°	35 - 45°	45 - 55°
	Roof plane area served by the downpipe (m²)			
63 mm diameter	60	50	40	35
74 mm diameter	85	70	60	50
100 mm diameter	155	130	110	90
150 mm diameter	350	290	250	200
65 x 50 rectangular	60	50	40	35
100 x 50 rectangular	100	80	70	60
75 x 75 rectangular	110	90	80	65
100 x 75 rectangular	150	120	105	90

Note (1) This table increases the conservatism of the design by incorporating the slope factor and therefore the run-off rate when roof plane area is used.

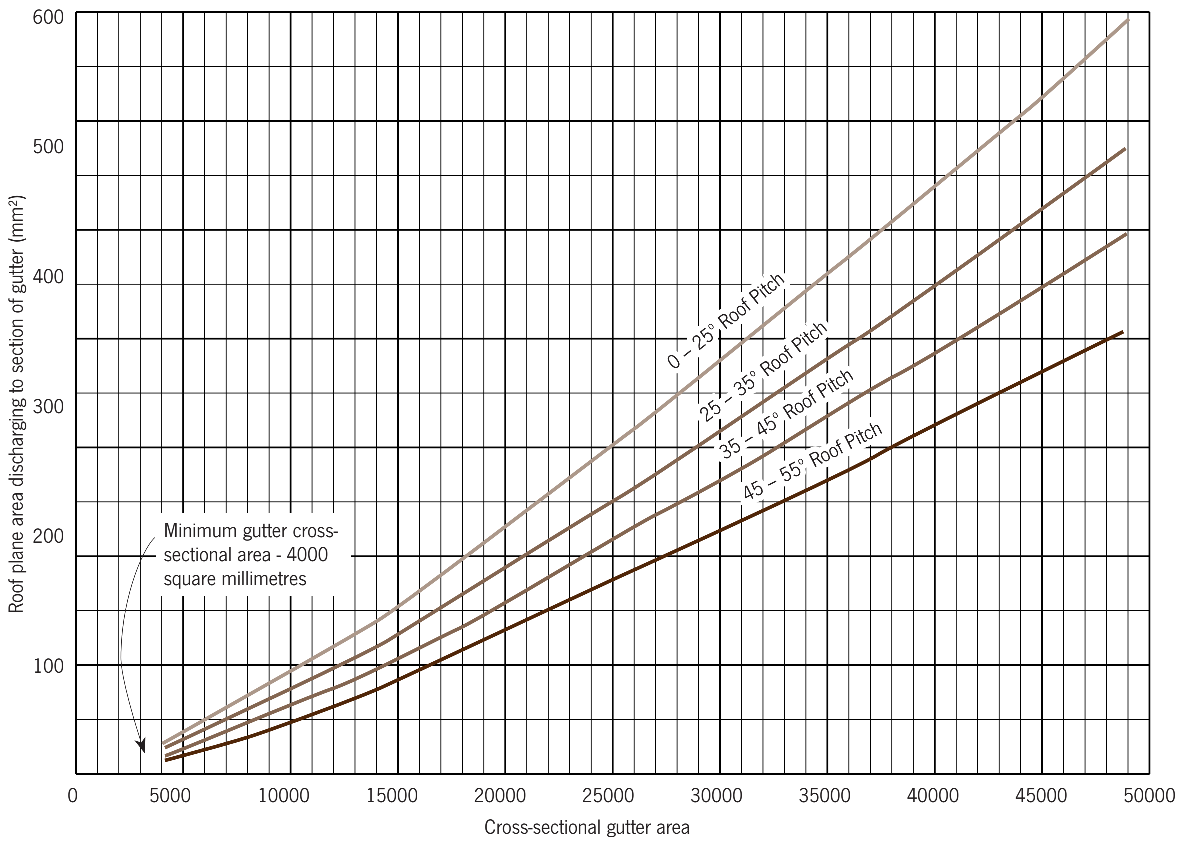

Figure 4. Cross-sectional area of external gutter (mm²). Based on rainfall intensity of 100mm/hr)adjusted for roof plane area. (Adapted from E1/AS1.)

4.1.2 Figure 4 provides a graph from which can be read the cross sectional area of an external gutter serving the roof plane area, of varying pitches for a rainfall intensity of 100 mm/hr for a storm with a 10% probability of occurring annually and having a 10 minute duration. Where the rainfall intensity (I) exceeds 100 mm/hr, the required gutter size shall be increased by taking the value read from the figures and multiplying it by the ratio of I /100.

4.1.3 Designers must also include the roof plane area of roofs at a higher level that discharge onto the roof area being considered. In addition flat wall surfaces above a roof (which are common in many designs) will discharge a quantity of water onto a roof below. To accommodate this in the flow calculation, consider the wall area has a catchment of approximately half the roof area – e.g. if the wall area above the roof and directly draining onto is 30 m² in area then add 15 m² to the roof catchment area.

5.0 INTERNAL GUTTERS

5.0.1 The sizing and design of internal gutters is critical. Leakage or overflow may allow water into the building, damaging fittings, furnishings and building elements. The deterioration of building elements from water entry will over time cause threats to the structural integrity and to the health and safety of occupants.

5.1 ACCEPTABLE SOLUTION E1/AS1

5.1.1 The Acceptable Solution (Figure 16 of E1/AS1) provides the cross-sectional areas for internal gutters with a rainfall intensity of 100 mm/hr for a storm with a 10% probability of occurring annually and a 10 minute duration. It also requires that:

- where the rainfall intensity (I) exceeds 100 mm/hr the required gutter size shall be increased by taking the value read from the figures and multiplying it by the ratio of I/100
- the minimum cross sectional area is 4000 mm²
- all internal gutters are fitted with an overflow of equal cross section area to the downpipe
- the top of the overflow outlet be set at least 50 mm below the top of the gutter and discharge to the exterior of the building.

5.2 BRANZ DESIGN RECOMMENDATIONS

5.2.1 Because of the likely effects of an internal gutter becoming blocked or overflowing and the likelihood of more extreme weather conditions due to climate change, BRANZ recommends that:

- a minimum 10 minute rainfall intensity of not less than 200 mm/hour be used for sizing internal gutters, downpipes and overflows. A higher figure may need to be used in high rainfall areas of New Zealand. Refer to NIWA HIRDS for actual intensities for high rainfall areas
- the maximum spacing between outlets is 12 m provided catchment areas given in Table 2 are not exceeded
- a minimum of two outlets and overflows be provided for each gutter section. It is less likely that both outlets will be blocked at the same time – if one outlet is blocked the gutter detailing can be designed to allow the water to build up and flow over the high point and discharge through the second outlet.
- the minimum size of each outlet is such that it allows a 50 mm sphere to pass
- outlets should be provided to each section of gutter (avoiding

bends or corners)
- overflows of equal number and capacity to the outlets are provided
- overflows ideally discharge directly to the exterior of the building
- a minimum fall of 1:100 is used for all internal gutters
- all internal gutters are at least 300 mm wide to facilitate cleaning/maintenance
- internal gutters are fully supported to prevent sag
- gutters are designed with sufficient freeboard to prevent overflowing due to wind action – typically 50 mm below the top of the gutter; for example, sizing the gutter from Table 3 then making it 50 mm deeper
- gutters are formed with rounded corners for metal gutters and with 20 mm fillets for membrane gutters
- metal gutters have an allowance made for thermal movement.

5.3 CROSS SECTIONAL AREA OF EXTERNAL GUTTERS

5.3.1 To calculate the cross sectional area of an external gutter:

1. Take the Flow Load Factor from Table 1 for a rainfall intensity of 100 mm/hour (or greater if in an area with a rainfall intensity of greater than 100 mm/hour) (1.67)
2. Multiply this by the Roof Plane Area in m^2 (say 172.5 m^2, as in Figure 1) to obtain the Flow Capacity (FC) required. 172.5 x 1.67 = 290 litres per minute
3. The final step is to determine the minimum gutter cross sectional area in mm^2 to accommodate the flow capacity – $A(gutter) = (FC/0.0016)^{0.8}$

Minimum area of gutter required (A) in $mm^2 = (290/0.0016)^{0.8}$ = 16092 mm^2

5.4 CROSS SECTIONAL AREA OF INTERNAL GUTTERS

5.4.1 To calculate the cross sectional area of an internal gutter:

1. Take the Flow Load Factor from Table 1 for a rainfall intensity of 200 mm/hour (or greater if in an area with a rainfall intensity of greater than 100 mm/hour) (3.33)
2. Multiply this by the Roof Plane Area in m^2 (say 172.5 m^2, as in Figure 1) to obtain the Flow Capacity (FC) required. 172.5 x 3.33 = 575 litres per minute
3. The final step is to determine the minimum gutter cross sectional area in mm^2 to accommodate the flow capacity – $A(gutter) = (FC/0.0016)^{0.8}$

Minimum area of gutter required (A) in $mm^2 = (575/0.0016)^{0.8}$ = 27825 mm^2

5.4.2 Table 3 gives the calculated flow capacity for a range of gutter cross sectional areas.

5.4.3 The sizes determined from Table 3 are based on 'no fall' and 'an outlet at one end' and for a gutter less than 6 m length with 1:600 fall, no bends and an outlet at one end which gives a 32% increase in capacity. Other adjustment factors that can applied to the figures in Table 3 for the calculated flow capacity for a gutter with no fall and an outlet at one end are:

- gutter less than 6 m length with 1:600 fall and a right angle bend within 2 m of outlet - reduce by 2%
- gutter less than 6 m length with 1:600 fall and a right angle bend 2 – 4 m from the outlet – increase by 15%
- gutter at least 6 m length with 1:600 fall, no bend and outlet at one end – increase by 40%
- gutter at least 6 m length with 1:600 fall and a right angle bend within 2 m of outlet – increase by 5%
- gutter at least 6 m length with 1:600 fall and a right angle bend 2 – 4 m from the outlet – increase by 22.5%.

TABLE 3 MAXIMUM FLOW CAPACITY IN LITRES/MINUTE FOR GIVEN CROSS-SECTIONAL AREA

Cross sectional area (mm^2)	Calculated flow capacity for a gutter with no fall and an outlet at one end (1)	Calculated flow capacity for a gutter < 6 m length with 1:600 fall and an outlet at one end (+32%)	Cross sectional area (mm^2)	Calculated flow capacity for a gutter with no fall and an outlet at one end (1)	Calculated flow capacity for a gutter < 6 m length with 1:600 fall and an outlet at one end (+32%)
4000	50	66	10000	160	211
4500	59	77	11000	180	237
5000	67	88	12000	200	264
5500	75	99	13000	222	293
6000	84	110	14000	243	320
6500	93	122	15000	265	349
7000	102	134	17500	322	425
7500	116	145	20000	380	501
8000	147	159	25000	502	662
8500	150	171	30000	631	832
9000	140	184	40000	905	1194
9500	150	198	50000	1196	1578
Note (1)	BRANZ recommends gutters be installed with a fall.				

5.5 CROSS SECTIONAL AREA OF OUTLETS

5.5.1 It is recommended that outlets for internal gutters be sized from Table 2 so that they allow a 50 mm sphere to pass, but the number of outlets and overflows should be doubled; that is, the roof plane area served is halved.

5.5.1 For internal gutters a proprietary grating or domed outlet should be specified to prevent leaves and other foreign objects from entering or blocking the rainwater system. It is important to check with the manufacturer that these will not restrict the flow of water into the downpipe. Additional outlets or outlets of a larger diameter may be required to compensate for any loss of flow into the downpipe.

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