Roof Drainage

Design

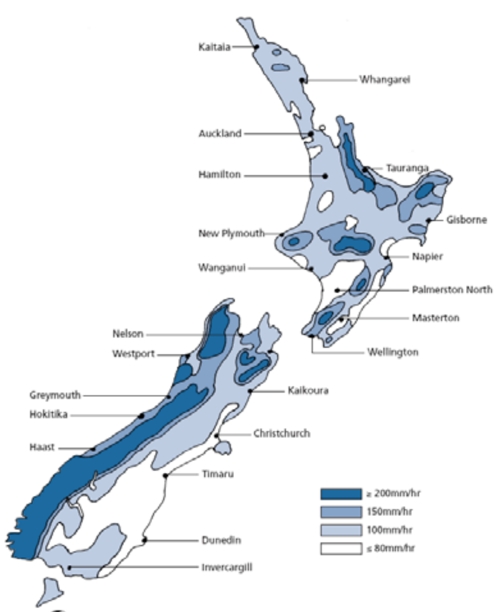
The primary objective of a gutter or spouting system is to remove water from the roof catchment area and channel that water to the ground drainage. Water ingress can have detrimental effects on property and health of the occupants and can also lead to monetary loss and inconvenience due to flooding. It should be noted that flooding, not related to gutter design or rainfall intensity, can occur when maintenance and inspection are not carried out on a regular basis.

When considering Roof drainage design the following should be taken into account:

- Rainfall intensity
- Catchment area
- Cross-sectional gutter area
- Sump design
- Cross-sectional area of downpipes
- Water disposal from downpipes
- Overflows
- Roof cladding profile capacity
- Roof pitch
- Penetrations which obstruct water flow

Rainfall Intensity

Rainfall intensity is calculated by measuring rainfall over a 10 minute period and is measured in millimeters per hour. Below is a map which shows the rainfall intensities for New Zealand. There is considerable variation across New Zealand and for confirmation a local Territorial Authority can determine rainfall intensity in a particular region.



MAP 8.2.

The information above has been referenced from the NZ Metal Roof and Wall Cladding Code of Practice Version 2 section 8. This document does not constitute design recommendations and is intended to highlight issues around roof drainage design. For further information or clarification of the information above please contact Metalcraft.

If designed to do so gutter overflow is acceptable on gutter eaves or freely discharging downpipes, but cannot be allowed to occur from internal gutters or downpipes.

Catchment Area

Wind Effect

The rain catchment area of a roof, or roof and wall, is affected by the wind. Wind driven rain will cause the catchment area to effectively be increased. There are a number of methods that can be used to calculate the wind drift effect, please refer to AS/NZS 3500 for these. This will provide a worst case scenario as in some situations the wind direction may result in shielding to occur which would decrease the effective catchment area. To allow for the wind effect a factor of 10% must be added to all sloped roof catchment areas with a pitch of greater than 10 degrees and openly exposed to the wind.

Multiple Roofs

In some cases shielding may occur on sites where there are multiple roof planes however for the sake of simplicity the sum of the roof areas should be used when calculating roof drainage requirements for internal gutters.

Adjacent Walls

In the situation where there are adjacent walls to a roof slope four situations arise

1. If the roof pitch is less than 10 degrees the catchment area is the sum of the sloped surface plus half the area of the vertical surface

2. If the roof pitch is 10 degrees or greater the catchment area is 1.1 times the sum of the sloped surface plus half the area of the vertical surface.

3. In the situation where a building has two adjacent walls at right angles to each and the roof pitch is less than 10 degrees the catchment area is equal to the sum of the sloped roof area plus half the area of each of the vertical surfaces

4. In the situation where a building has two adjacent walls at right angles to each and the roof pitch is 10 degrees or greater the catchment area is equal to 1.1 times the sum of the sloped roof area plus half the area of each of the vertical surfaces

	Roof Pitch	Catchment Area
All roofs freely exposed to the wind	< 10 degrees	Sloped Roof Area
All roofs freely exposed to the wind	> 10 degrees	Sloped Roof Area x 1.1
Vertical Wall(s) adjacent to the roof	< 10 degrees	[Sloped Roof Area + ½ Wall Area]
Vertical Wall(s) adjacent to the roof	> 10 degrees	[Sloped Roof Area + ½ Wall Area] x 1.1

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Having calculated the catchment area there are two simple methods for calculating the gutter and downpipe capacity.

Method 1 – Gutter and Downpipe capacity determined by graph

The following assumptions were made when determining the gutter and downpipe capacity on the following graphs.

Roof pitches less than 10 degrees and greater than 3 degrees
Roof areas between 50m^2 and 300m^2
Minimum Cross-sectional area of gutter of 4000mm^2
Flat gutter or spouting
No restrictions such as spouting, gutter or downpipe angles
Free discharge into a sump or rainwater head with overflow
Rainfall intensity = 100mm/hour
Downpipes are external and vertical

Gutter Type	**Capacity**
Box Gutter 125mm	8435 mm^2
Box Gutter 175mm	19250 mm^2
Box Gutter 300mm	27000 mm^2
Hiline	7550 mm^2
Squareline	6090 mm^2
Metalline Quad Gutter	5550 mm^2
Half Round Gutter	5650 mm^2
Ribline Internal Gutter	7550 mm^2

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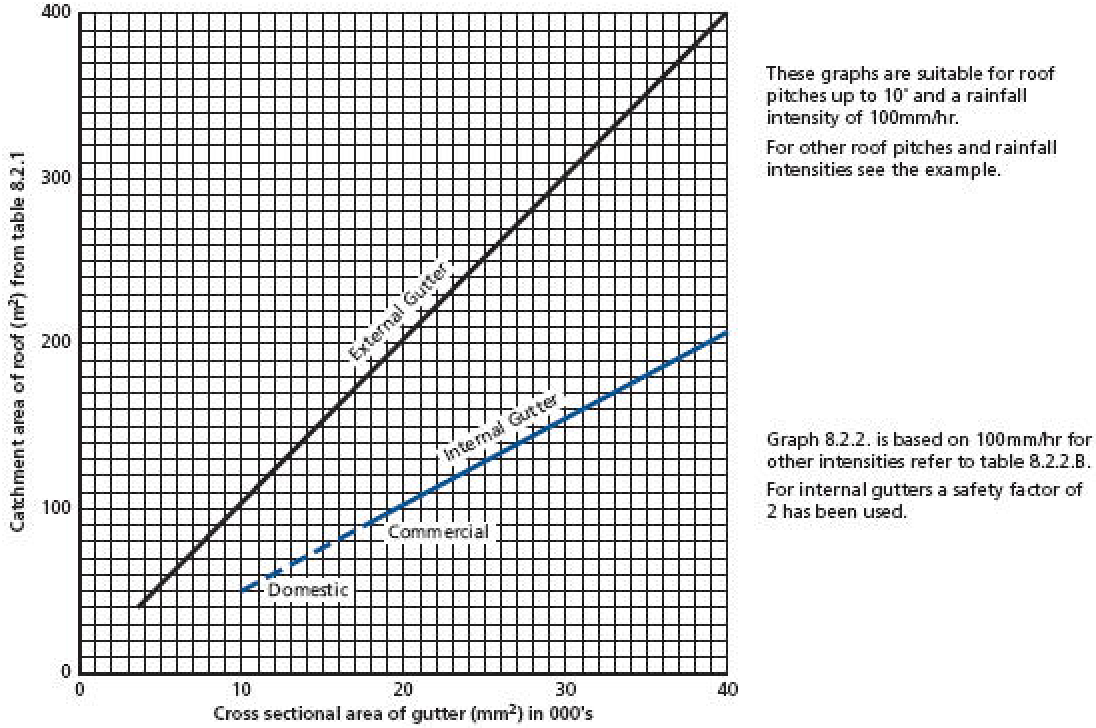
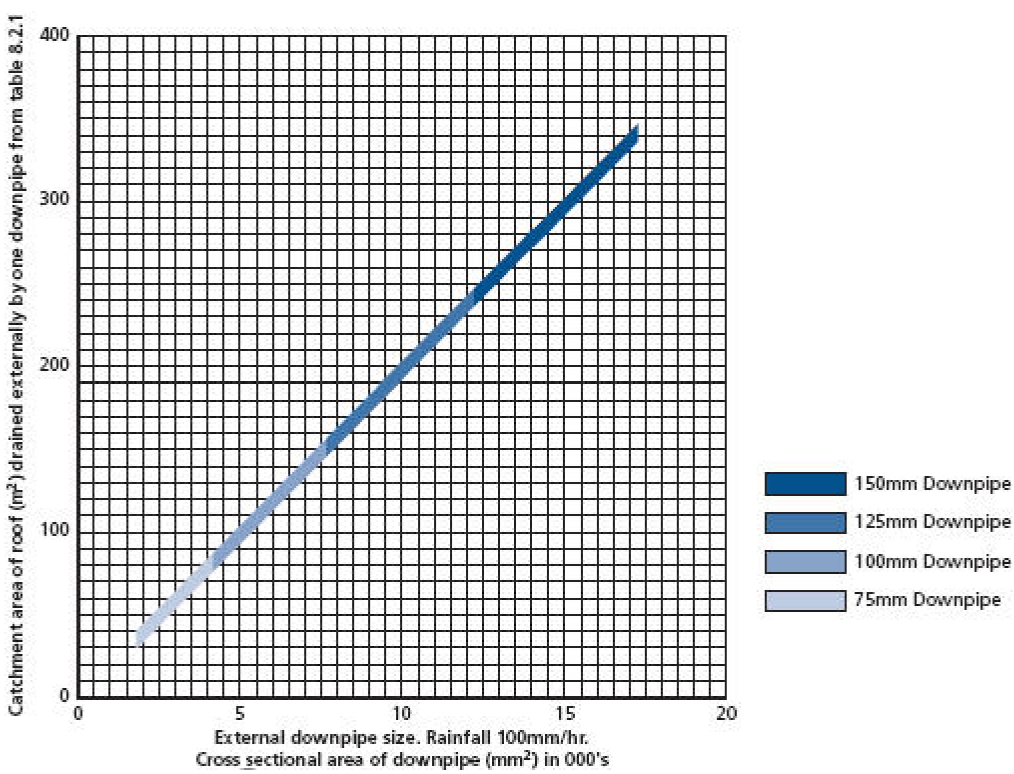


This graph is applicable for roof pitches less than 10 degrees and a rainfall intensity of 100mm/hour. For other rainfall intensities and roof pitches please see Method 2.

For internal gutters a safety factor of 2 has been used.



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Method 2 – Gutter and Downpipe capacity determined by calculations

Determination of Gutter and Downpipe capacities can be done by using the following tables

Cross-sectional area per m^2 for 100mm/hour rainfall intensity

This table gives the relationship between m^2 of roof area and cross-sectional area of gutter at a rain intensity of 100mm/hour. For example at that rain intensity 100mm^2 of gutter capacity is required for every m^2 of catchment area.

External gutter or spouting	100 mm^2
Internal gutter	200 mm^2
Vertical external downpipe	50 mm^2
Horizontal downpipe < 15 degrees	100 mm^2

Rainfall

Where rainfall intensity differs from 100mm/hour use the following table to factor an increase or decrease

80mm/hour	multiply by	0.8
100mm/hour	multiply by	1.0
150mm/hour	multiply by	1.5
200mm/hour	multiply by	2.0

Roof Pitch

Roof Pitch affects the rate at which the water runs off. The catchment area must be increased to allow for this where the roof pitch is greater than 10 degrees

10 – 25 degrees	multiply by	1.1
26 – 35 degrees	multiply by	1.2
36 – 45 degrees	multiply by	1.3
46 – 55 degrees	multiply by	1.4

Example:

- Freely exposed lean to roof in Wellington.
- Rafter Length of 5.9m and building length of 10m.
- Roof Pitch is 24 degrees.

Step 1:

Wellington Rainfall Intensity = 150mm/hour
Factor = 1.5 (from Rainfall Table)

Step 2:

Roof Pitch = 24 degrees
Factor = 1.1 (from Roof Pitch Table)

Step 3:

Catchment Area = 10m x 5.9m = 59m^2
Freely exposed to the wind
Factor = 1.1
Adjusted catchment area = 59m^2 x 1.1 = 65m^2

Catchment area = 65m^2 x 1.5 x 1.1 = 107m^2

External gutter	= 107 x 100mm2	= 10700mm2
Internal gutter	= 107 x 200mm2	= 21400mm2
Vertical downpipe	= 107 x 50mm2	= 5350mm2
Horizontal downpipe < 15	= 107 x 100mm2	= 10700mm2

Step 4:

Gutter and Downpipe Capacity Tables

Gutter Type	**Capacity**
Box Gutter 125mm	8435 mm^2
Box Gutter 175mm	19250 mm^2
Box Gutter 300mm	27000 mm^2
Hiline	7550 mm^2
Squareline	6090 mm^2
Metalline Quad Gutter	5550 mm^2
Half Round Gutter	5650 mm^2
Ribline Internal Gutter	7550 mm^2

Downpipe	**Capacity**
Round 65mm	3318mm2
Round 80mm	5027mm2
Round 100mm	7854mm2
Round 150mm	17671mm2
Rectangular 75mm x 55mm	3712mm2

Results:

External Gutter or Spouting selected = Box Gutter 175mm
One vertical downpipe = Round 100mm

Please Note: in this instance if a second downpipe is added the capacity requirement would halve as the water flow would be sent to either end of the gutter run. In that case Box Gutter 125mm would suffice with two 65mm downpipes (2 x 3318 > 5027)

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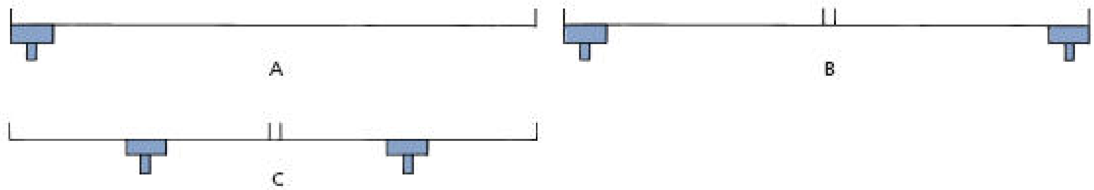
Internal Gutters would normally require a 20mm freeboard; however using the simplified method of calculation the internal gutter would effectively be over designed. Internal downpipes having no overflow to the exterior of the building could be under designed and must have a 25% safety factor applied. Flooding will usually occur through a lack of capacity at the drain rather than the downpipe.

For domestic and light commercial buildings, standard gutters and downpipes offer the most economical method of complying with capacity requirements. If large gutters are required these should be custom made to specific dimensions

Outlet positioning can make a significant difference to the type of gutter required.



Based on a roof with the same catchment area for each example, Type B would require one half the gutter capacity of Type A whilst Type C would require one quarter the capacity. The downpipe capacity required for both Types B and C would be half that of A.

For internal gutters it is recommended that the proportion of base width to height be 2:1. The minimum recommended height for commercial internal gutters is 70mm or 1/60th of the overall length. The larger measurement of the two on a case by case basis should be taken. In residential situations the minimum is 45mm.

Key points to note are that dropper outlets should not be used on internal gutters and sumps or rainwater heads must be used to drain all internal gutters and also be placed at gutter angles.

When an external spouting has a dropper outlet or an external angle, the capacity of the spouting should be reduced by 10% for each outlet or angle. Outlets should be placed within 2m of an angle.

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Profile Capacity

The height of the side lap is the determining factor for overflow and water ingress. The capacity of the profile is related to its inherent geometry but also the structure it is attached to and the environment in which it is situated. Sheets installed at below their recommended minimum pitch must have the side lap sealed. Drape curving is an example where this would be required.

All profiles apart from Corrugate have enough capacity for a rainfall intensity of 100mm/hour. Corrugate profile should have a maximum catchment area per sheet of 30m2 (effectively 40m sheet) with a rainfall intensity of 100mm/hour. The sheet length will rise and fall dependent on differing rainfall intensities. It is recommended to increase the minimum pitch by 1 degree for every 10 metres over 40 metres in total length where the rainfall intensity is 100mm/hour or greater. A step in the roof or any penetration will require an increase in the drainage capacity of the profile.

Snow

There are no extra provisions required in terms of gutter capacity for areas that get snow fall. The installation of snowguards is required to allow the melt water to drain away. In snow areas all internal gutters must have snowguards. In areas where there are prolonged sub zero temperatures melt water can refreeze and cause ice dams to form. To prevent water ingress it is recommended that an impermeable membrane be installed and supported between the last two purlins to discharge into the gutter. Purlin spacings at the eave should also be reduced to allow for the added snow load.

Penetrations such as chimneys or vents from a heated building are best placed at the ridge or as close to the edge of the building as possible. Diurnal temperature variation can result in thaw/freeze cycles that will test any sealed flashing.

Hail like snow can cause blockages to gutters and hence subsequent damage. In all areas prone to hail of snow spouting, gutters and associated support brackets should have additional fixings and have reduced spacings.

Gutters

External Gutters should be installed with the back face lower than the fascia board or cladding. Gutters need to have cross-sectional properties fit for purpose and rainwater heads and downpipes must not obstruct the flow from the gutter. In some instances limited fall is an issue, in these cases consideration should be given to non ferrous alternatives.

Gutter Installation

Gutters must not return or be folded back under the roof cladding or be fastened to it, as this will prevent free thermal movement and expansion to occur. All internal gutters must be hooked.
The roof cladding must overhang the gutter by not less than 50mm with a down turned drip edge where the pitch is less than 8 degrees. To prevent premature corrosion due to the build up of contaminants it is recommended that internal gutters have a flat base.

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Gutter Support Systems

The gutter bracket system must be able to withstand the potential weight of a gutter full with water. In areas where there is snow loading external gutters and spouting must be fitted with snow straps at a maximum of 600mm centres.

All bracket material must be compatible with the gutter and brackets for prepainted gutters should be powder coated before installation. Gutter brackets must be installed to ensure a fall towards the outlets.

Internal gutters must be flat and able to support the gutter when full of water. They must also be able to withstand a point load of 1.1kN

Gutter brackets for external gutters < 180mm should be at no greater than 750mm, for Gutters 180mm – 300mm it is recommended that bracket spacings do not exceed 600mm. Brackets should also be located at all stopends, sumps and rainwater heads. To prevent permanent deflection in internal gutters it is recommended that full support of the base be provided by plywood lining. Underlay is required to prevent condensation having adverse effects on the metal due to the timber treatment.

Eaves Gutters

Eaves gutter systems should be designed such that no water can flow back into the building and no ponding will occur. The back height of the gutter determines the capacity. Whilst leaf guards can prevent larger organic matter from entering the gutter they afford little protection against fine particles. The accumulation of fine particles will overtime cause accelerated corrosion unless a regular maintenance program is adhered to.

Vertical Outlets to eave gutters must have an area equal to half the cross-sectional area of the gutter and horizontal outlets must have an area equal to the cross-sectional area of the gutter.

Eave gutters should have an outlet with 2 metres of an external corner, where this cannot be provided extra fall must be employed to prevent ponding.

Internal Gutters

Internal Gutters must be made from materials that will last 50 years when they are difficult to replace and their failure could cause major disruption to the building below. Only non ferrous alternatives can achieve this, for example Stainless Steel. Copper should be used with caution as contact direct or through water splash will cause steel cladding to corrode at an accelerated rate.

Internal gutters are subject to the same requirements as eaves gutters except that they are designed with a much greater safety factor.

Secret gutters occur when the roof edge runs at an obtuse angle to a wall, secret gutters are governed by the same requirements above as they are difficult to replace. Therefore as above it is recommended that they are made from non ferrous materials.

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Fascia Gutters

A fascia gutter is an eaves gutter that has a high front that shields the ends of the profiled cladding from view. Where the fascia gutter system would be difficult to replace or in situations where a minimum fall cannot be achieved a non ferrous material must be used. The design must ensure that should the gutter become blocked water ingress will not occur to the soffit or overflow into the building.

Concealed Gutter Systems

Concealed gutter systems are proprietary and can be installed with or without a fascia. They consist of an external fascia with an internal gutter. Brackets are attached to soffit bearers to provide support, the external fascia is spring clipped to the brackets, therefore concealing both the gutter and the brackets. Concealed gutter systems should be installed before the roof is fixed.

It is imperative that the material comply with durability requirements of the NZBC where the gutter is not easily replaced or does not achieve the minimum fall requirement. To prevent water ingress to the soffit or building overflows should be installed within 1 metre either side of an outlet. The overflows must be capable of discharging the total catchment area served by the downpipe. Where a valley or downpipe discharges into a concealed gutter system an overflow must be situated within 2 metres.

Fall

All metal internal gutters must have a minimum fall of 1:200 (5mm per metre) and all metal eaves gutters must have a minimum fall of 1:500 (2mm per metre). Regular maintenance is required to ensure no build up of organic matter, this is particularly important at eaves gutters where trees are in the vicinity. Permanent ponding voids warranties and is classified as when water does not evaporate from the sole of the gutter within three days of drying by the wind or sun.

Downpipe

Downpipes transport the water from the gutter to the storm water disposal system. The capacity can be improved by using rainwater heads and sumps.
The cross-sectional area of an external downpipe must be half the cross-sectional area of the gutter. All internal downpipes must be sealed to internal sumps by a compression ring or similar fitting and must have access to clean at the base where they are connected directly to the drain. All hidden downpipes must be seamless and must be able to withstand a water test with a 1.5 metre head without leakage to comply with the 50 year durability requirement of the NZBC.
Internal downpipes that are easily replaced require 15 year durability. Vertical downpipes sealed to the drain require a cross-sectional area at least half the cross-sectional area of the internal gutter. In the event of blockage the exterior junction or manhole must be vented to allow for free discharge.
It is recommended that ground outlets be built up so that surface water cannot enter the drain and debris will not obstruct the drain. An air break should be allowed for to ensure that water does not back fill the downpipe.

Exterior downpipes must be a minimum of 50mm above the grated gully trap or oversized pipe. Sealed water systems such as symphonic tank systems must have an overflow capacity of 200mm/hour. Downpipes must have a cross-sectional area equal to that of the gutter where the angle they are fixed at is less than 105 degrees. Downpipes must be compatible with the roof and gutter material. This is particularly important where upper levels drain to lower ones. Copper spouting and downpipes must not drain onto metal roof or wall cladding unless the cladding is also copper.

Downpipe Spreaders

Spreaders are required where an upper level discharges water onto a lower one. The spreader ensures a distribution of the water to prevent water ingress through flooding of the side laps. Spreaders must not be installed where water will discharge over fixings or a lap and must have holes equaling twice the cross-sectional area of the downpipe. The minimum length for a spreader is 400mm.

Maximum catchment area above and downpipe size discharge onto a lower roof must be:

- 60m^2 and 63mm for Corrugate and symmetrical trapezoidal profiles
- 80m^2 and 75mm for asymmetrical trapezoidal profiles

Please note: Downpipes 100mm or greater should not be drained onto a lower roof. If the downpipe is working at maximum capacity the profile could overflow. It is recommended in this situation that the downpipe be directed to separate drain at ground level.

Sumps

The discharge capacity of a gutter increases with the depth of water over the outlet; the best way to increase the head is to discharge the open end of the gutter into a sump. Outlet position is important as swirl will decrease the capacity. Sumps must be the same width as the gutter and have a minimum depth of 300mm and internal sumps must have an overflow. This prevents the sump from acting as an overflow and causing damage. Outlets must be placed at a distance less than or equal to the outlet diameter from the nearest vertical side.

Overflows must provide a conspicuous warning that maintenance is required and must discharge clear of the building. Sumps require grating or leafguard the same area as the sump and must not be placed directly over the outlet. Accumulated debris should be cleared during routine maintenance.

Rainwater heads should be placed on the outside of the building to ensure that the gutter does not overflow. This provides a head of water that will maximize downpipe flow.

Outlets and Overflows

Overflows are designed to give conspicuous warning of inadequate capacity. Overflows must discharge clear of the building. Overflow openings must have a cross-sectional area equal to the gutter cross-sectional area for both internal and external gutters. The overflow must be no higher than 25mm below the base of the gutter.

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