2.4 Gutter and Downspout Sizing and Location Calculations

Both Metric and English units: Remember to save this spreadsheet to your own computer.

This spread sheet will help you calculate the gutter width and maximum distance between downspouts based on your maximum rainfall, roof area, and style of gutter. There are two major factors to consider when deciding a gutter design. The first is to make it wide and deep enough to collect all of the rainwater during the hardest rainfall. The second is to slope the gutter downward enough to allow good drainage and flow, but not so much that you drift so far below the edge of the roof that the water overshoots the gutter. We will calculate both simultaneously for you.

We will present calculations for four common gutter designs; a semicircle, a V trough of which you can very the inside angle; a box (square trough), and a trapezoid.

**First:** We'll decide what area of the roof is applicable to the calculations. This will dictate the amount of water that the gutter needs to be able to carry during the hardest rain storms. As you proceed, keep in mind the different areas of your roof that you measured in section 2.2 Calculating your roof area for rainwater harvesting.

**Second:** We will enter data about your highest intensity of rainfall, followed by an assumed gutter efficiency, and finally the friction factor of the material that you will make your gutter out of.

**Third:** If the distance between downspouts turns out to be too short for your home, we will let you enter trial gutter widths until the length, drop and width work well with each other.

**Fourth:** We'll discuss your downspout size, location and a few comments.

Results will be tabulated so that you can easily see results as you change variables. Detail drawings and dimensions will follow the table for each of the gutter designs.

**First:** Get the dimension of the roof areas that you want to gutter. These are the areas that you calculated in section 2.2 Calculating your roof area for rainwater harvesting. We are going to assume that values are in feet and square feet. As a reminder, the areas are Aa at 252 sq ft & 33' long, Bb at 190 sq ft & 15', Cc at 120 sq ft & 10', and Dd at 245 sq ft & 29'.

We are going to assume that you want to make your gutters around your home, look the same as far as material of construction, width and design are concerned. This allows us to size the gutters based on the longest length between downspouts. Any shorter lengths of gutter will have no problem handling the water volume or the slope. Pick the largest area to be drained between downspouts. This will dictate the width of the gutter. This isn't obvious in this example. Section Aa is 33 feet long with an area of 252 sq ft, but notice that section Bb and Cc share the same gutter. Their combined length is 25 ft and their combined area is 310 sq ft. We will need to do calculations on both areas to insure the right gutter size.

We will use the larger of the two or 310 sq ft for our first calculation.

**Second:** Enter Data

First we will find the maximum amount of rain that will be captured in gallons per minute

Enter the plan area of your first roof section(s) in square feet here

<table>
<thead>
<tr>
<th>Area</th>
<th>Feet²</th>
<th>M²</th>
</tr>
</thead>
<tbody>
<tr>
<td>First calculation</td>
<td>310</td>
<td>28.8</td>
</tr>
</tbody>
</table>

Enter the maximum rainfall intensity here in inches per hour. Use these default numbers if you can't find this data for your location.

<table>
<thead>
<tr>
<th>Rainfall Intensity</th>
<th>Feet/min</th>
<th>M/min</th>
</tr>
</thead>
<tbody>
<tr>
<td>First calculation</td>
<td>4.75</td>
<td>2.0</td>
</tr>
</tbody>
</table>

Gross gallons per minute = 15.3
Gross Liters per minute = 58

Assumed collection efficiency = 85 %

Note: Don't make this number too small, we are already assuming a 3/4 full gutter at its maximum depth. This efficiency number is to take care of splash and gable losses.

Net gallons per minute = 13.0
Net liters per minute = 49
Now decide on the material that the gutter will be made out of. We need this information to establish a friction factor for our calculations. You will find that the rougher the gutter material, the larger the gutter will need to be. The default friction factor of 0.02 is entered for galvanized metal. Simply select your friction factor from this table and type over the 0.02 already entered in the yellow box.

<table>
<thead>
<tr>
<th>Material</th>
<th>Possible friction factors to enter in the yellow cell below</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rough, sandy, or bumpy material like bamboo, rough wood, or shingles</td>
<td>0.07</td>
</tr>
<tr>
<td>Relatively smooth wood</td>
<td>0.04</td>
</tr>
<tr>
<td>Galvanized metal</td>
<td>0.02</td>
</tr>
<tr>
<td>Very smooth material like plastic</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Enter the friction factor from this list here → 0.02

Gutters need to slope to a downspout. This keeps the rainwater moving faster so the leaves and dirt have less chance to build up. It also reduces the chances of stagnant pools forming that will attract mosquitoes and other critter growth. A good slope would be 0.5° and it has been entered for you here. However, this 0.5° will not be consistent throughout the length of gutter. Slope the first 2/3 of gutter length one-half the amount of the last third of gutter. For example: we have entered a 0.5° slope for the last 1/3 of gutter length here and you would install the first 2/3 of gutter at half that slope. The slope is very important because it, and the gutter width, dictates how far you can go between downspouts. If you went too far between downspouts, the gutter would be so far below the roof edge that the rainwater would overshoot the outside edge of the gutter.

Type over the 0.5° if you want to see how other slopes will perform here

| slope the first 2/3 of gutter, farthest from the downspout | 4 mm / meter | 0.1570836 in / yard |
| slope the last 1/3 of gutter length just before the downspout | 9 mm / meter | 0.3141672 in / yard |

Enter larger gutter widths in the yellow boxes to find out how wide your gutters need to be given the length that you want to go between downspouts. Remember, two gutter lengths can share the same downspout, so if you calculate the max gutter to be 40 feet, you could put a downspout halfway in an 80 foot length.

Before going any further, let's go back to the beginning and see what would happen if we chose a very long run of gutter. Assume we connect areas Dd and Aa with one gutter. The total area would be 245 + 252 = 497 sq ft. The total length would be 29' + 33' = 62'. Go back to cell G21 and type in 497. Leave the slope at 0.5° and use the "what-if" calculator to see how wide your gutters need to be—given the length that you want to go between downspouts. Remember, two gutter lengths can share the same downspout, so if you calculate the max gutter to be 40 feet, you could put a downspout halfway in an 80 foot length.

Third: Increase gutter width if needed to increase distance between downspouts

Notice that as far as carrying the water is concerned in this example, you don't need much of a gutter width to get the job done (depending on the design you choose). Also, due to the 0.5 degree slope, if you use a V trough gutter you can go 27.7 ft or 8.5 meters before you need a downspout (double that if you put the downspout in the middle of a run). Areas Cc and Bb have a total length of only 25 ft or 7.6 m of connected gutter. We can conclude that a V trough, 92 mm across the top will work fine for these combined areas. There is no need to do any "what-ifs". You can see the detail design below.

Before going any further, let's go back to the beginning and see what would happen if we chose a very long run of gutter. Assume we connect areas Dd and Aa with one gutter. The total area would be 245 + 252 = 497 sq ft. The total length would be 29' + 33' = 62'. Go back to cell G21 and type in 497. Leave the slope at 0.5° for now. You will immediately notice that the calculated V trough, minimum width is 111 mm and you get 35.9 (10.9 m) before a downspout. We need 62'. You have several choices:

1. Leave the slope at 0.5° and use the "what-if" calculator to see what would happen with widths wider than 111 mm. Try it. Type in 111 mm in the yellow box at cell H54 and notice we get 35.7 feet to the downspout (just checking!). Now type in 150 mm. We get 63.9 feet. We needed 62', so this would be a good width. Go ahead and type in 150 for the other gutter designs. You'll notice that they will all give you 63.9 feet to a downspout, but notice the total width of building material column. If you made the gutter into a box, you would need more than twice the building material than if you made it into a V trough or Trapezoid!

2. Change the slope to 0.3° and you get almost 69 feet for a 123 mm wide V trough.

3. Leave the slope at 0.5°, use a 111 mm wide V trough, and put in two tanks, one at the d-a corner of the house and one at the B corner.

My recommendation would be to put in one tank as shown in the example drawing: run the gutters at a 0.3° slope; use a 90° V trough design 125 mm (5") wide (or a 117 mm (4 1/2") semicircle); make the gutter out of galvanized metal; connect areas D and A with one gutter; connect areas C and B with one gutter; then run two downspouts to the storage tank as shown on the house drawing.

The following are detailed gutter design drawings based on the data that you entered above. They will automatically

Caution: Remember which width you chose above before you go any farther! Was it green, purple, blue or violet? You will need to ignore the other colored blocks.
These are dimensions based on the larger gutter width needed for longer distances between downspouts.

These are dimensions based on the Minimum Gutter Width needed to carry the water.

### Semicircle Gutter inches

- **Semicircle width**: 3.5292478 in
- **Subtracting 3/4" under the roof edge and 1/8" outside edge allowance**: 2.65425 in
- **Maximum TOTAL gutter drop before any downspout**: 1.85759 in
- **Maximum distance to first downspout**: 26.6 feet

### What-if values

- **Semicircle width**
  - In Inches: 3.937 in
  - In mm: 100 mm

### Semicircle Gutter mm

- **Semicircle width**: 90 mm
- **Subtracting 20mm under the roof edge and 3mm outside edge allowance**: 67 mm
- **Maximum gutter drop before any downspout**: 47 mm
- **Maximum distance to first downspout**: 8.1 meters

### What-if values

- **Semicircle width**
  - In Inches: 3.937 in
  - In mm: 100 mm

### V Trough inches

- **V Trough inside wall length**: 2.62764 in
- **V Trough top opening width**: 3.71605 in
- **Subtracting 3/4" under the roof edge and 1/8" outside edge allowance**: 2.84105 in
- **Maximum TOTAL gutter drop before any downspout**: 2.00817 in
- **Maximum distance to first downspout**: 28.8 feet

### What-if values

- **V Trough inside wall length**: 2.7839 in
  - In Inches: 3.937 in
  - In mm: 100 mm

### V Trough mm

- **V Trough inside wall length**: 67 mm
- **V Trough top opening width**: 94 mm
- **Subtracting 20mm under the roof edge and 3mm outside edge allowance**: 71 mm
- **Maximum TOTAL gutter drop before any downspout**: 51 mm

### What-if values

- **V Trough inside wall length**: 71 mm
  - In Inches: 3.937 in
  - In mm: 100 mm
Maximum distance to first downspout

### In Inches

**Square box height and width**

- 1.61554 in

**Square Box inches**

- Subtracting 3/4" under the roof edge and 1/8" outside edge allowance: 0.74054 in
- Maximum total gutter drop before any downspout: 0.10931 in
- Maximum distance to first downspout: 1.6 feet

### In mm

**Square box height and width**

- 41 mm

**Square Box mm**

- Subtracting 20 mm under the roof edge and 3 mm outside edge allowance: 18 mm
- Maximum total gutter drop before any downspout: 3 mm
- Maximum distance to first downspout: 0.5 meters

### In Inches

**With sides at 30°**

- The length of each side is 1.45523 in
- The width at the top is 2.91045 in

**Trapezoid inches**

- Subtracting 3/4" for under the roof edge and 1/8" outside edge allowance: 2.03545 inches
- Maximum total gutter drop before any downspout: 1.29744 in
- Maximum gutter length to a downspout: 18.6 feet

### In mm

**With sides at 30°**

- The length of each side is 37 mm

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Total width of material = 4.84662
If you are going to use something thick like wood, remember to add two times the thickness of the wood to the bottom length.

This is the width that is available for the rainwater to enter the gutter.

This assumes 4.7" per hour maximum rain intensity.

Don't forget that one downspout can have this length of gutter on both sides of it (put the downspout in the middle).

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Total width of material = 4.36568
If you are going to use something thick like wood, remember to add two times the thickness of the wood to the bottom length.

This is the width that is available for the rainwater to enter the gutter.

This assumes 2 mm per minute maximum rain intensity.

Don't forget that one downspout can have this length of gutter on both sides of it (put the downspout in the middle).

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Total width of material = 5.90551
If you are going to use something thick like wood, remember to add two times the thickness of the wood to the bottom length.

Maximum total gutter drop before any downspout: 2.03545 in

This assumes 4.7" per hour maximum rain intensity.

Don't forget that one downspout can have this length of gutter on both sides of it (put the downspout in the middle).

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Maximum gutter length to a downspout: 18.6 feet

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Total width of a flat piece of building material = 11.811 in

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Total width of a flat piece of building material = 3.0315 in

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Total width of a flat piece of building material = 31.2 ft

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Maximum distance to first downspout

**Don't forget that one downspout can have this length of gutter on both sides of it (put the downspout in the middle).**

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Subtracting 3/4" under the roof edge and 1/8" outside edge allowance: 0.74054 in

This is the width that is available for the rainwater to enter the gutter.

This assumes 4.7" per hour maximum rain intensity.

Don't forget that one downspout can have this length of gutter on both sides of it (put the downspout in the middle).

---

Subtracting 20 mm under the roof edge and 3 mm outside edge allowance: 18 mm

This is the width that is available for the rainwater to enter the gutter.

This assumes 2 mm per minute maximum rain intensity.

Don't forget that one downspout can have this length of gutter on both sides of it (put the downspout in the middle).

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With sides at 30° the length of each side is 1.45523 in

This is the width that is available for the rainwater to enter the gutter.

This assumes 4.7" per hour maximum rain intensity.

Don't forget that one downspout can have this length of gutter on both sides of it (put the downspout in the middle).

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With sides at 30° the length of each side is 37 mm

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Total width of material = 111 mm

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Maximum total gutter drop before any downspout: 2.03545 in

This assumes 4.7" per hour maximum rain intensity.

Don't forget that one downspout can have this length of gutter on both sides of it (put the downspout in the middle).

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Total width of material = 123 mm

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Maximum gutter length to a downspout: 18.6 feet

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Total width of a flat piece of building material = 150 mm

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Don't forget that one downspout can have this length of gutter on both sides of it (put the downspout in the middle).
The width at the top is 74 mm. Subtracting 20mm for under the roof edge and 3mm outside edge allowance gives 51 mm. This is the width that is available for the rainwater to enter the gutter. The maximum total gutter drop before any downspout is 33 mm. This assumes 2 mm per min maximum rain intensity. Maximum distance to first downspout is 5.7 meters. Don't forget that one downspout can have this length of gutter on both sides of it (put the downspout in the middle).

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**Fourth: Downspout size, location, and a few other comments.**

I don't recommend that you size your downspout based on pipe sizing tables or equations. I recommend you go outside and look at trees that overhang your roof. You'll need to put in a downspout that won't clog with the leaves that are going to land on your roof. For most of you, that will be a 4 inch or 110mm pipe. You might need to make this out of a piece of flexible material. Simply bend it into a semicircle with a diameter that is about the same size as the semicircle dimension that was calculated for you above. This will be plenty big for both the water and debris. You might want to visit the gutter manufacturer web sites to get an idea of how they would size a downspout.

http://www.hunterplastics.co.uk/rainwater/gutterdesign/default.html
http://copper.org/applications/architecture/arch_dhb/gutters_downspouts/downspouts.html

Some manufacturers recommend a gutter slope of only 0.1 degrees. That's equivalent to about 1/2 inch of drop in 20 feet of length or about 1:500. Metrically that's only 1 mm in 5 meters. I would recommend you keep at least 0.3° (about 1:200) to 0.5° (about 1:115) for the last third of your gutter run, and half that for the first two-thirds.

Most manufacturers recommend maximum gutter lengths before a downspout of 20 to 40 feet (you can have 20 to 40 feet on each side). This will reduce problems with expansion, trash buildup in the gutter, maximum weight of the gutter when it gets full of rainwater, and is their rule of thumb given most manufacturers have fixed gutter widths that they are selling. They also do this because they have little incentive to reduce the number of downspouts. They are simply planning on dumping the water to the ground. Our requirements are different because we need to collect it; hopefully in a single tank. You will be able to confidently size your gutter based on calculators in this spread sheet, but keep in mind that gutter runs in excess of about 40 feet are going to drop several inches from the roof edge giving the gutter a distinct "Water Harvesting" look.