

Auto Size Calculations

This topic outlines the approach taken by the network sizing engine and how it can be controlled.

The auto size process is completed based on the [Network Design](#) specified for the phase. Some aspects, such as Minimum Cover Depth, Velocities and Backdrops are optional and will only be used if turned on. However the auto sizing engine will always look to ensure that a pipe/channel has sufficient capacity to take the calculated flow. Equally the Design Level will be applied to align pipe/box culverts to one another.

Network design will begin at the head of the Flow path selected, which acts as the mainline. Typically the head of a Flow Path will normally be an Inflow (Area or Hydrograph). It will then move down each Pipe/Channel in the network sizing the pipe/channel in turn. Note: Notional connections (No Delay, Lagged Flow and Attenuated Flow) cannot be sized so will be ignored. This sizing is completed as follows:

1. **Establish Total Area & Base Flow** - The Inflows contributing to each connection will be summed (for the Rational Method and UK Modified Rational Method) and combined in parallel (for the Methode de Caquot) as the calculation moves down the network to establish the totals used for sizing:
 - a. **Area/Roof Area** - Depending on which Runoff Method the contributing area will be established as:
 - i. **Area Inflow** - Area * Preliminary CV
 - ii. **Roof Area:**
 1. **Time of Concentration** - Area * Proportion Drained
 2. **Time Area Diagram** - Total Area of Time Area Diagram
 3. **Green Roof** - Area * Proportion Drained
 - iii. **Hydrograph** - The peak flow of the Hydrograph will be considered as a base flow.

Note: Where there are multiple upstream branches the totals of all branches will be combined for the downstream pipe/channel totals.
2. **Set Initial dimensions for Pipes/Channels** - To ensure that the smallest possible size is considered the dimensions of the pipe/channel will be set to a suitable minimum before starting:
 - a. Pipe - The diameter is set to the Smallest pipe size in the Pipe Size Library.
 - b. Rectangular/Trapezoidal Channel - The Base Width is set to 600mm.
 - c. Triangular Channel - The Height is set to 0.2m as this is the dimension that is adjusted

Note: These are the dimensions that are increased when up-sizing the pipe/channel.
3. **Determine Travel Time** - The Travel Time is calculated as the largest upstream time of concentration taken from:
 - a. The Preliminary Time of Concentration on the incoming Area Inflows
 - b. The Travel Time through the Upstream connections
 - c. Min. Time of Concentration from the [Network Design](#) .

This is then added to the time of travel for the given connection, which is calculated using the Velocity of flow under full bore conditions and the length of the connection.
The travel time is then restricted to the Max. Travel Time from the Network Design Criteria which helps to prevent intensities dropping too low in a large network.
4. **Rainfall Intensity** - The Rainfall Intensity is determined from the IDF data, specified on the [Network Design](#) , based on the Travel Time for the given connection.
5. **Determine Flow** - The selected Calculation Method on the Network Design Criteria will then be used to establish the flow that the pipe/channel must have capacity to convey.
 - a. **Rational Method** : Flow = Rainfall Intensity x Total Area + Total Base Flow
 - b. **(UK) Modified Rational Method**: Flow = Rainfall Intensity x Total Area * Cr(1.3) + Total Base Flow
 - c. **Methode de Caquot**: Flow is calculated via the Methode de Caquot equations which are considerably more involved than the Rational Method or (UK) Modified Rational Method equations. The method's inputs are the Caquot (Base and Advanced) parameters, selected Desbordes rainfall parameters and the Runoff Path Length and Catchment Slope of the Inflows upstream of the pipes belonging to the auto-sized Flow Path. Further information can be found on the [Methode de Caquot](#) page.



Note

The calculated design flow is not allowed to reduce below the largest upstream value.

6. **Sizing routine** - The auto size calculation will then attempt to size each connection to achieve both the required capacity for the calculated flow as well as the sizing options selected.
This works as follows:
 - a. **Determine initial upstream and downstream levels** - Considering the min cover depth (if applicable) and the incoming pipes determine what the minimum depth at each end of the pipe is. This will ensure that the pipes have sufficient cover and align to the lowest incoming soffit/invert level based on the Design Level.

i **Notes**

Channel section types will always be aligned as level inverts regardless of the Design Level setting.

Where a Design Flow leads to a reduction in pipe size between two pipes they will also be laid as level inverts to prevent permanent water levels.

If there are differing cover levels at the downstream end of the incoming connection(s) and upstream end of the outgoing connection(s) the lowest value for all of them will be used to ensure the correct alignment.

If the connection is the first in a run (first in either the flow path or a branch line), and minimum cover depth is not checked in the network design criteria, then the initial upstream level will remain at the connections upstream invert level, so long as it is non-zero and does not break cover.

If Reduce Channel Depths is checked on in the network design criteria, any rectangular or trapezoidal channels now have their depths set to match the largest, non-zero, down stream depth of incoming connections. If no non-zero depths exist, or if no incoming connections exist, the depth of the channel remains the same.

- b. **Determine the range of slope** - The min and max slope entered in the sizing criteria will be compared to the initial slope calculated from the initial levels as well as the range of Min/Max slopes available for the pipe sizes.
- c. **Perform sizing** - The auto size calculation will then start from the flattest slope and attempt to find a diameter that gives sufficient capacity to take the calculated flow as well as providing a valid velocity (if selected)
 - i. **Upsizing a connection** - the Pipe/Channel does not have capacity it will be up-sized:
 - *Pipe* - The next pipe size from the entered Pipe Size library will be selected. if the largest pipe in the file is not big enough for the flow then the program will continue based on the Additional Increment specified (75mm by default) until sufficient capacity is reached.
 - *Rectangular/Trapezoidal Channel* - the base width is increased by 100mm.
 - *Triangular Channel* - The Height is increased by 20mm.
 - ii. **Adjust slope** - When a solution has been found for a given slope it is recorded and the calculation will make the pipe slightly steeper and repeat the check.
 - iii. **Selecting the solution** - The solutions for different slopes are considered and the one providing the minimum cover depth at the downstream end, as well as meeting the velocity checks if applicable, will be selected and assigned to the pipe.
- d. **Branch lines** - These will be sized in the same way as the main line with the upstream area and base flows summed and used to size each connection as above. However when the branch line connects into the main line its downstream level needs to be considered as it may be above, or below, the pipes in the main line (or other incoming branch lines). When they are not aligned the calculation will attempt to align them all based on the Design Level. It is however possible to allow a backdrop on the Sizing Criteria, which will leave any backdrop above the minimum, but below the maximum, and then remove any below and align any above to the maximum.

Locked Pipe/Channels

it is possible to lock a Pipe/Channel to prevent it being sized, by toggling the Auto Size setting (hidden by default) on the Connections form for a given connection(s). When the Auto Size calculation encounters this, it will not adjust the dimensions of that connection. The Area and Base flow totals will still be determined and passed downstream, and the downstream connections will still be aligned to the locked connection.

Locked Slopes

Where a locked slope option is selected on the Sizing Criteria the engine will bypass the standard sizing routine. Instead the software attempts to size the connections as follows:

Slope

This option will stop the Network Design from adjusting the slopes of the connections in the current path. Only the diameter/height of section will be adjusted until the connection has capacity and then the connections will be aligned based on the cover depths and design level options. This is restrictive and is likely to lead to pipes being deeper than necessary.

Slopes and Invert Levels

Only the connection diameter/height can be adjusted by the engine with the soffit level being adjusted to accommodate any change in the height. This option prevents triangular sections from being sized as the calculation is unable to adjust the height given this is simply the distance between the cover level and the invert level.

Slopes and Soffit Levels

Only the connection diameter/height can be adjusted by the engine with the invert levels being adjusted to accommodate any change in the height.