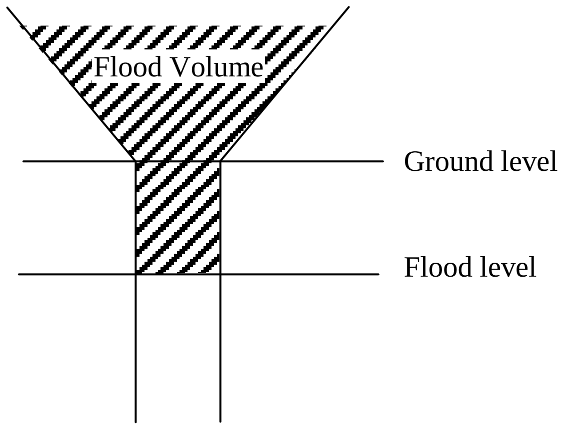
Flood Cone Calculations

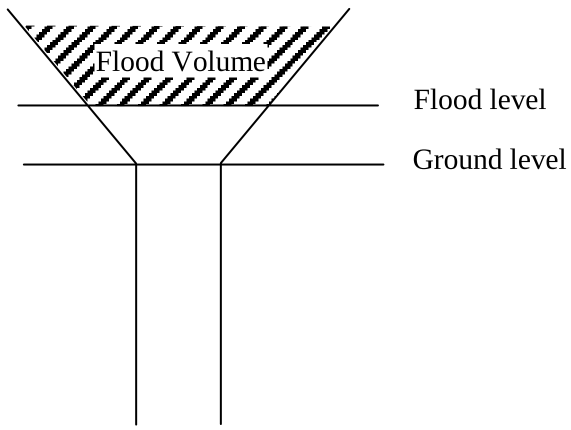
If the flood type ‘stored’ is chosen in InfoWorks ICM or CS, flood water fills an inverted cone.

The first thing to understand is the relationship between ground level and flood level. Ground level marks the transition from the top of the node shaft to the bottom of the flood cone, however the volume of flooding is defined relative to the flood level.

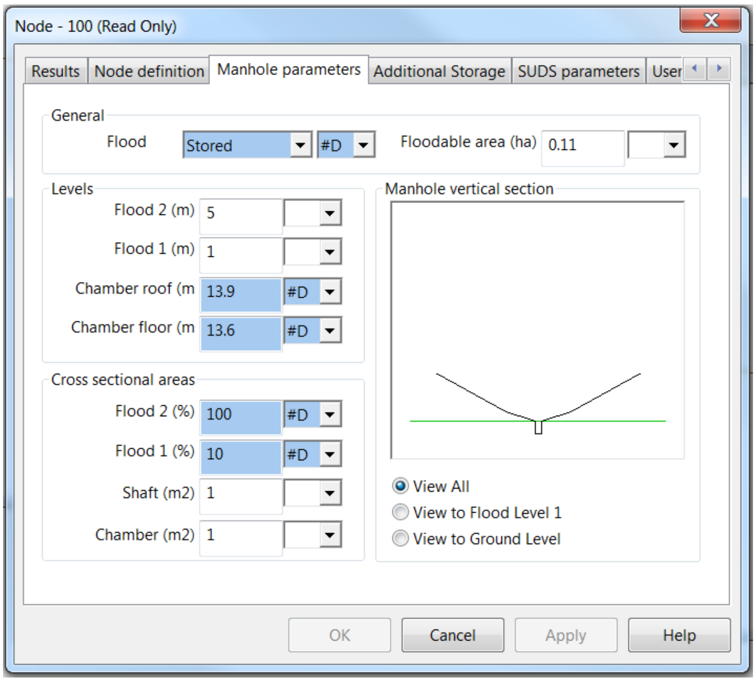
Therefore if the ground level and flood level are not the same, the reported flood volume will look like this:



Or this:



Consider the flooding in a stored manhole, with the following characteristics:



In this example, at a depth of 1 metre, the flood cone has an area of 0.11ha x 10% = 110 m^2. At a depth of 5 metres the cone has an area of 0.11ha x 100% = 1100 m^2. It can be seen that the shaft area in this example is 1 m^2.

The volume of a truncated cone = $(\pi h / 3)(R^2 + r^2 + Rr)$ (equation 1)

Where R is the larger flood radius, r is the smaller flood radius and h is the vertical distance between them.

If A = 1 m^2, r = 0.564 m
If A = 110 m^2, r = 5.916 m
If A = 1100 m^2, r = 18.712 m

Therefore at a depth of 1 m:
Volume = $(\pi \times 1 / 3)(5.916^2 + 0.564^2 + 5.916 \times 0.564) = 40.48\ m^3$

At a depth of 5 m:
Volume = $40.48 + (\pi \times 4 / 3)(18.712^2 + 5.916^2 + 18.712 \times 5.916) = 2117.84\ m^3$

Above flood level 2, the flood water occupies a cylinder (with volume A * h)

Therefore at a depth of 6 m:
Volume = $2117.84 + (1100 * 1) = 3217.84\ m^3$

If the flood cone is too ‘flat’, the simulation engine will adjust flood depths 1 and 2 such that:

$R / (r \times 100) > \text{flood depth}$ (equation 2)

Consider an example where flood depth 1 is reduced to 0.1 m and flood depth 2 is reduced to 0.2 m.

For flood depth 1, from equation 2:

5.916 / (0.564 x 100) = 0.105 m

Therefore flood depth 1 is increased to 0.105 m.

For flood depth 2, there are two constraints. First consider flood depth 1:

18.712 / (5.916 x 100) = 0.032 m

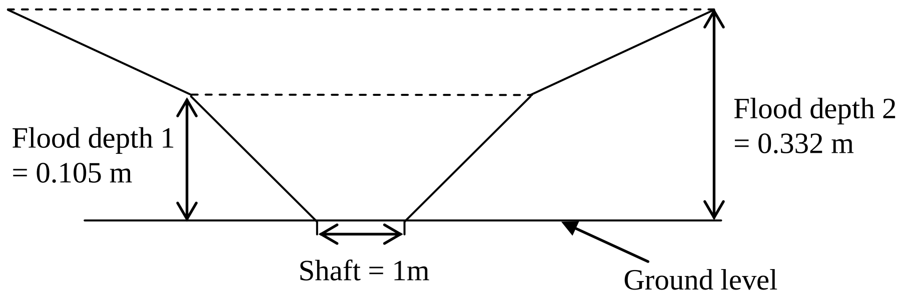
Therefore flood depth 2 minimum = 0.105 + 0.032 = 0.137 m

Then consider the shaft area:

18.712 / (0.564 x 100) = 0.332 m

Therefore flood depth 2 is increased to 0.332 m (as a results of the shaft area constraint in this example.)

The revised configuration looks like this.



From equation 1, at a depth of 0.105 m:
Volume = (π x 0.105 / 3)(5.916^2 + 0.564^2 + 5.916 x 0.564) = 4.25 m^3

At a depth of 0.332m:
Volume = 4.25 + (π x (0.227 / 3)(18.712^2 + 5.916^2 + 18.712 x 5.916) = 122.14 m^3

Note that if the flood depth exceeds flood depth 2, it forms a cylinder with an area equal to flood area 2.

The spreadsheet (flood cone calcs01.xlsx) and data (flood cone calcs01.iwc) used to produce these results are available from support@innovyze.com