Technical Note 1: Level for Level Flood Compensation

Development infilling the floodplain or an area of surface water flooding can displace floodwaters and increase flood levels locally, at other properties and on access roads. See figures 1 and 2 below. Level for level compensation is the reorientation of the land by the lowering of ground levels. This ensures that the same volume of flood storage is available at all levels of flooding. For this reason development layout should consider the requirement for flood compensation. This methodology can be used for both river and surface water flooding.

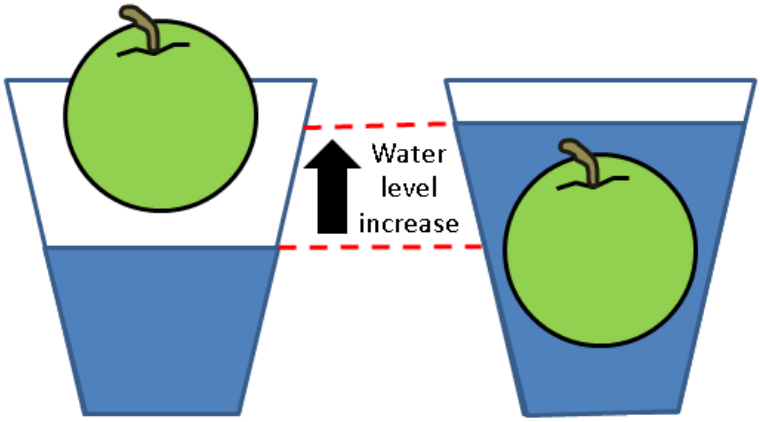

Figure 1 above shows how water levels raise when displaced by a solid object.

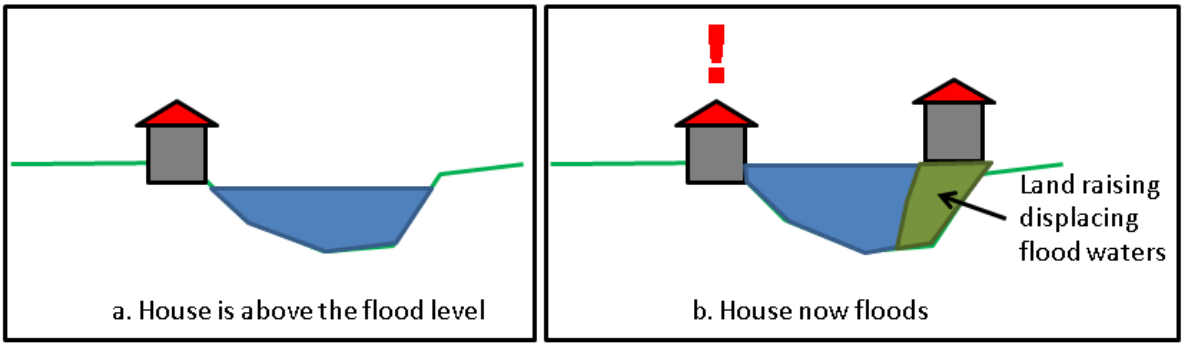

Figure 2 shows how development can displace flood waters and increase flood risk.

1. What type of development displaces flood water?

Floodwater can be displaced by:

- Solid buildings (i.e. building without voids)
- Raised terracing and decking
- Ground Raising

2. Compensation design requirements

For flood compensation areas to be deemed appropriately designed it should meet the requirements outlined below.

Level for Level:

- 100-300mm horizontal slices
- Cut volumes should be greater than or equal to the fill volume for each slice
- The highest levels are usually the hardest to achieve.
- Compensation should be provided up to the 1 in 100 plus climate change flood level.

Appropriately located

- The area should be as near as possible to where the loss of flood storage is occurring
- Should be hydraulically linked so the area of compensation floods from the same watercourse as the area of fill used to flood from.

Completely Free Filling and Draining

- This is to ensure the compensation area can fill and drain under gravity and so will be available should back to back flood events occur.
- Flood water should be able to fill the lowest levels of the compensation area even during the smaller flood events.

Does not use culverted or piped entry routes

- Culverts can become quickly blocked or have insufficient capacity for quickly raising flood waters
- Culverts may not be located appropriately to convey water especially on larger sites.

3. Demonstrating level for level compensation can be achieved

The easiest way to demonstrate that level for level flood compensation has been achieved is to provide a cut and fill table. Table 1 is an example of a cut and fill compensation table. The numbers in table 1 have been derived using the example shown in figure 3 (below).

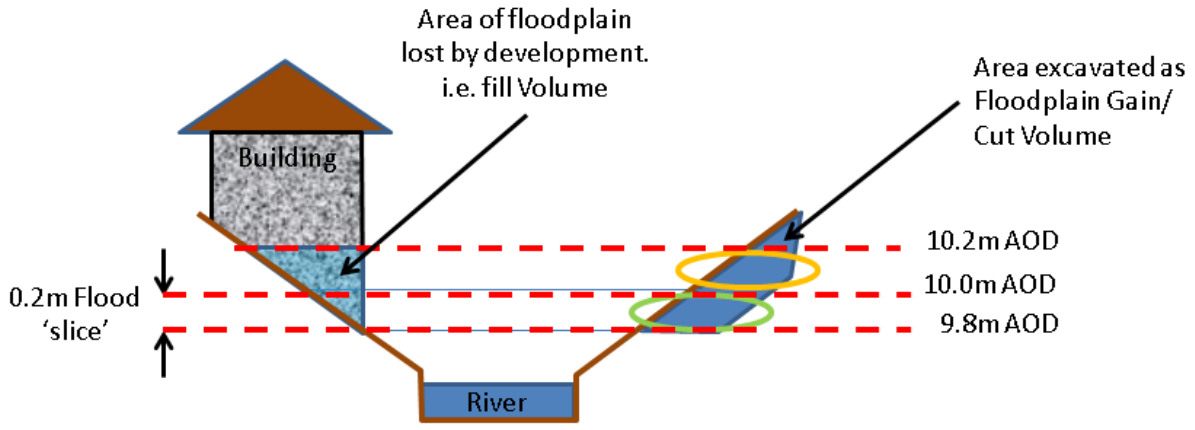

Figure 3 (above) shows and example of how to calculate what volume of flood water is displaced by a new building in the floodplain and what volume is being provided by the compensation area.

Flood Slice (m AOD)	Depth (m)	Loss of Floodplain		Floodplain Gain		Total Volume (B-A)
		Area of Slice (Sq m)	Volume A	Area of slice (sq m)	Volume B	
10.2m-10.0m	0.2	20.0	4.0	45.0	9.0	5.0
10.0m- 9.8m	0.2	7.0	1.4	18.0	3.6	2.2
9.8m-9.6m	0.2	0.0	0.0	0.0	0.0	0.0

Table 1 (above) shows the results of the figure 3 example as a **'cut and fill' table.**

The elevation over which the displacement is occurring is divided into flood 'slices' (horizontal sections of equal size). See figure 3 above. For each flood slice, the volume of floodplain lost (also known as the fill volume) through the development at that floodplain slice elevations should be calculated and entered into the table. The corresponding volume of floodplain gained (also known as the cut volume) should also be calculated for that particular flood slice. To be an acceptable compensation scheme, the volume of flood gained in each particular slice should be greater than the volume lost for that same slice.

The reason why flood 'slices' are used is that they help to ensure that the shaping of compensation area mimics that of the original floodplain. This is important because if the compensation volumes are provided at the wrong elevation then flood waters can still be displaced even though the overall volume provided may be the same as what was there before. For example; if less compensation volume is provided in the lower level slices than what was there originally, then flood water will still be displaced even if the higher flood slices contains extra compensation volumes to make up for this. This is easiest to understand by looking at a small flood event where the flood waters only floods the lowest level slices where there is insufficient compensation volumes provided. Providing the extra compensation higher up does not prevent flood waters being displaced during this smaller flood.

4. Common Mistakes

It is often easier to provide excess compensation for the lowest flood slices but to be unable to provide enough compensation for the highest elevation flood slice. In these circumstances, a common mistake is to add together the volume difference column of the compensation and try and show that the overall compensation being provided is greater than the overall volume being lost. This is incorrect and will increased flood risk.

Level for level compensation is about ensuring that the floodwaters behave in a similar way after the development compared to before the development. The timing of how flooding occurs is particularly important for achieving this. If you infill the floodplain but don't provide same volumes at the same ground levels elsewhere you will change the way the flood waters behave. The lower flood slices will fill first so by the time the higher flood slice is reach by floodwaters all the compensation provided at the lower level is already full. This means that having extra compensation at a lower level will not provide any flood risk benefit at the higher ground level. For example, with the example in table 2: At the lower flood slice (9.8m-10.0m) there is an excess in the floodplain gain volumes (an extra 2.2m^3 is being provided –see the volume difference column) so flood risk will be decreased at this level. But at the high slice (10.0 -10.2m), there will be a reduction in floodplain storage (by -0.4m^3 see the volume difference column) so water will be displaced at this level, increasing flood risk at this higher ground level.

Flood Slice (m AOD)	Depth (m)	Loss of Floodplain		Floodplain Gain		Volume Difference (B-A)
		Area of Slice (Sq m)	Volume A	Area of slice (sq m)	Volume B	
10.2m-10.0m	0.2	20.0	4.0	18.0	3.6	-0.4
10.0m- 9.8m	0.2	7.0	1.4	18.0	3.6	2.2
9.8m-9.6m	0.2	0.0	0.0	0.0	0.0	0.0
Total			**5.4**		**7.2**	**1.8**

Table 2 (above) shows how **not** to calculate flood storage with an example of the most common errors. This proposed scheme will displace flood waters at the higher flood slice, thereby increasing flood risk even though the sum of the volume difference column suggest that there is an net increase in storage.

5. What Information should be provided

Below is a list indicated what information should be submitted when trying to demonstrate that level for level compensation has been achieved for the site.

- **A plan showing where flood waters are being displaced** by the development (i.e. where are new buildings and ground raising occurring in the floodplain).
- **A plan showing where the compensation area is located**
- **A cut and fill table** demonstrating that floodplain compensation can be provided on a level for level basis.
- **A topographical survey of the site.**
- **The 1 in 100 plus climate change flood level for the site (or the flood mitigation level if using Hart District Council's Surface water flooding proforma).** This is the flood level that the National Planning Policy Framework requires new development to be designed to. In the case of ground raising, where flood levels are not available (for example where the Environment Agency have no detail flood modelling) the maximum elevation to which the ground is being raised to can be used in place of the 1 in 100 plus climate change flood level.

6. Further information

Further advice and guidance regarding the provision of floodplain compensation can be found in CIRIA C624 appendix A3.