WELLINGTON REGION RUNOFF HYDROGRAPH CALCULATOR FOR STORMWATER RUNOFF CALCULATIONS

In 2016, Wellington Water Limited (WWL) released the *Reference Guide for Design Storm Hydrology* to provide guidance to stormwater modelling professionals and land developers for estimating flood hydrology for small ungauged urban catchments in the region managed by WWL. The purpose was to provide a consistent methodology to estimate runoff from a given catchment/sub-catchment, and appropriately plan for and manage the resulting runoff associated with any change in land use. One of the key drivers was to move away from a single design peak flow estimate (Rational Method approach) to a flood hydrograph approach. This was to account for event volume and support the design of stormwater attenuation infrastructure.

The methodology was similar to Auckland Council's *Guidelines for stormwater runoff modelling in the Auckland Region*, more commonly referred to TP108. Both methods are based on the Soil Conservation Service[1] (SCS) runoff curve number method, and use catchment area, rainfall, initial abstraction, time of concentration and a curve number rainfall-runoff factor to derive a design storm hydrograph. TP108 provided two methods for deriving the flood hydrograph: hydrological modelling; and a graphical approach. The WWL method required the development of a simple hydrological model (HEC-HMS software or equivalent) to derive flood hydrographs.

Following feedback from land developers for a simple alternative to a hydrological model, WWL have developed a simple(!!) Excel spreadsheet tool. This will be rolled out with the next version of the Reference Guide update in early 2023. This presentation highlights changes to the Reference Guide methodology, and development and use of the Runoff Hydrograph Calculator (RuHC).

Key changes to the Reference Guide are:

- Replacing the curve number map with soil group and land cover maps. This is to better reflect potential changes to soil groups and land cover with changes to land use. For example, a forestry block is being developed into residential housing. Under the previous approach, the curve number was read from a curve number map, which reflects the land cover at the time of development. The revised approach allows the pre-development scenario to be forestry land cover, and the post-development scenario to be urban.
- Clarity over the use of homogenous/heterogeneous sub-catchments. Where land cover and/or soil type across adjacent sub-catchments is similar, the resulting rate of runoff should be similar and a single time of concentration is representative of both areas i.e., runoff from pasture-crop and runoff from scrub/flax. The adjacent sub-catchments can be considered as one. Where land cover differs across adjacent sub-catchments, and the rate of runoff will be different i.e., runoff from

[1] Now known at the Natural Resources Conservation Service

forestry, compared to runoff from urban open space, the area should be divided into homogeneous sub-catchment areas.

- Reduction in the soil group for post-development scenarios. There are four soil groups to represent the drainage properties of the soil. Group A represents gravels, sand and loamy sand which have high infiltration and low runoff properties. Group D represents clay and silty clay with low infiltration and high runoff properties. The updated guidance now states that if you are developing a property, changes to the drainage characteristics must be considered and reflected in the post-development scenario. This will typically be through moving one band to a more conservative soil group. For example, a forestry block is being developed into residential housing. It currently has reasonable drainage, reflective of a soil group B. Following development and earthworks, in addition to the removal of forestry, the soils will be compacted and a layer of topsoil added. The post-development scenario should be modelled assuming a revised soil group C.

The Wellington Region Runoff Hydrograph Calculator (RuHC) is a simple calculator where the user inputs the catchment parameters, and the calculator gives the resulting peak flow and volume, as well as a simplified hydrograph (Figure 1).

WELLINGTON WATER LIMITED
Flood Hydrograph Estimator
v1 Jan 2023

Wellington Water

Input parameters should be based on the Reference Guide for Design Storm Hydrology.

Site ID	Aotea		
Event	1% AEP Climate Change		
Area (km2)	0.0500		
Initial Abstraction (mm)	21.6		
Soil Group	C		
Landcover	Forest		
Curve Number default	63		
Curve Number proposed	63	Justification for CN override:	
Time of Concentration (minutes)	10.0		
12-hour rainfall depth (mm)	139.2		
Peak flow (m3/s)	0.845		
Volume (m3)	2590.7		

Figure 1: Wellington region RuHC entry fields

The calculator has been developed from the SCS curve number principles, based on the relationship between precipitation, initial abstraction, time of concentration and the maximum storage potential of the soil.

Multiple curves were developed for different initial abstraction over precipitation (Ia/P) variables, for times of concentration from 10 minutes to 2 hours. This range of time of concentration reflects the likely range of time of concentrations for ungauged urban catchments across the Wellington region.

From the Reference Guide, the precipitation profile is a nested storm hyetograph using HIRDS rainfall, whereby the shorter duration rainfall intensities are embedded within the longer duration rainfall intensities. The benefit of this approach is that only one rainfall profile is needed to represent a range of durations events. From previous analyses a back-loaded 12-hour storm was recommended so the peak rainfall intensity occurs 8 hours into the event.

The distribution of rainfall intensity across a 12-hour storm varies across the Wellington region based on a number of factors including prevailing wind and topography. Within RuHC, one representative rainfall profile was selected from review of the cumulative rainfall profile at 12 different locations.

Output from RuHC is the peak flow, volume, and a triangular hydrograph (Figure 2).

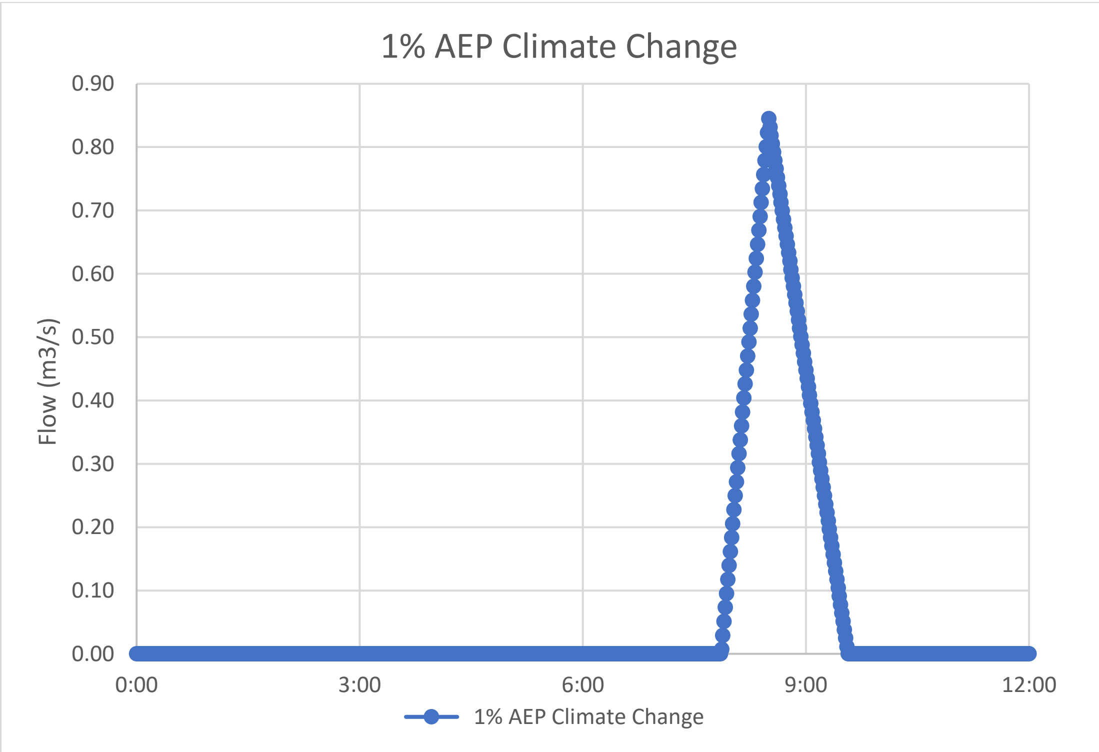

Figure 2 Example flood hydrograph

Results were compared to peak flow and volume estimates from a number of rainfall-runoff models across the region. On the whole, this method calibrated well, and within the depth standard error for HIRDS rainfall estimates.

RuHC provides a quick and simple method to estimate the peak flow and volume for design storm events. However, quick and simple means there are some trade-offs. These include:

- It has been developed based on a single rainfall profile from within the Wellington urban area. The rainfall profile will differ across the region, so there will be variations in the accuracy of the output.
- The flood hydrograph has been developed using a triangular distribution from the peak flow and volume. It does not take into account the temporal distribution of rainfall or shape of the catchment.

The intention of this calculator is to provide a simple approach for use by developers accepting of the limitations. WWL will continue to accept results from hydrological modelling. Hydrological modelling results are considered more accurate through the use of catchment specific HIRDS rainfall, Ia/P variables and time of concentration. Nonetheless, this will be a useful tool particularly for small scale land development projects.