RAPID FLOOD HAZARD ASSESSMENT FOR THE CENTRAL BUSINESS DISTRICT – AUCKLAND, NEW ZEALAND

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ABSTRACT (200 WORDS MAXIMUM)

Numerous streets in the Auckland Central Business District (CBD) are proposed to be upgraded into shared space areas - an urban design concept that aims to give pedestrians the right of way but also allow vehicles use of the street. The Auckland CBD shared space design includes reshaping the paving surface across the full width of the street with central drainage channels and removing kerbs and channels.

The proposed changes to the road cross-section could potentially affect overland flow paths and Stormwater (SW) flooding in the CBD area. To undertake an initial assessment of the potential effects of the proposed changes, AECOM developed a two dimensional (2D) above ground model for Rapid Flood Hazard Mapping (RFHM) analysis.

The RFHM model does not include the pipe network but utilises “rain on grid” to apply spatially and temporally distributed rainfall on the 2D ground model. AECOM developed a methodology to account for the SW volume losses through catchpits and roof downpipes through the use of adjusted rainfall hyetographs.

This paper outlines the methodology to develop the CBD RFHM model and the potential effects on the predicted SW flooding extents caused by the proposed shared space changes during a 20 and 50 year ARI design storm event.

KEYWORDS

Hydraulic Modelling, Two Dimensional Model, Flood Hazard Mapping, Rapid Flood Hazard Mapping

1 INTRODUCTION

Auckland City Council's (ACC) "CBD into the Future" strategy sets out the vision and principles to guide the transformation of the CBD into an internationally successful business and cultural centre. As part of the implementation of this strategy, ACC are proposing to upgrade a number of streets in the CBD into shared space areas: an urban design concept that aims to give pedestrians the right of way but also allow vehicles use of the street.

The shared space concept seeks to remarkably improve the environment for people, without needing to ban traffic. The Auckland CBD shared space design includes reshaping the paving surface across the full width of the street with central drainage channels, and removing kerbs and channels.

Figure 1: Darby Street currently

Figure 2: Artist impression of the proposed design for Darby Street

The proposed changes to the road cross-section could potentially affect overland flow paths and Stormwater (SW) flooding in the CBD area. ACC engaged AECOM to use 2D modelling techniques to undertake an initial Rapid Flood Hazard Mapping (RFHM) assessment of the potential effects on predicted flooding of the proposed changes.

2 MODEL SET UP

2.1 MODEL BATHYMETRY

The base bathymetry (ground model) was set up using LIDAR (light detection and ranging) data. In previous studies, it has been found that the elevation of the LIDAR data was generally within 0.3m of the surveyed elevation in areas with little vegetation cover and regular surface topography (Arthur et al, 2008). For the proposed shared space areas, recent survey data was used in place of the LIDAR data.

The base bathymetry was set up to represent the existing development scenario (i.e. before implementation of the shared space design philosophy). It is worth noting that this existing development scenario also incorporated the upgrades to the Queen Street footpaths following the recently completed streetscapes project. The LIDAR data, combined with the available survey data and updated Queen Street kerblines were then used to generate a ground model with a regular 2 metre grid.

In order to ensure that the overland flows went around (and not through) buildings, grid cells that correspond to building roof areas were set to an arbitrary higher elevation above the surrounding ground level. This method is referred to as setting grid cells “to land” and effectively removes the cells from the simulation calculation, forcing flows to go around buildings.

The proposed changes to the road cross sections were then incorporated into the shared space areas to generate the future development scenario ground model.

2.2 HYDROLOGY

The 20 year and 50 year Average Recurrence Interval (ARI) design storms from the Auckland Regional Council's (ARC) Technical Publication 108 (TP108) were used. These design storms were selected to be run because of the recommended pipe containment standard for the CBD area and flood protection requirements for business areas. (ACC and Metrowater, 2009).

The "rain on grid" method was used to enable the digital terrain to determine where the water would flow. This method works on the basis that any rain falling on the surface becomes runoff, with no infiltration losses.

The use of the "rain on grid" was deemed appropriate because, with the exception of two major park areas (Myer's Park and Albert Park), the CBD catchment can be regarded as being fully developed, with the majority of ground surfaces being almost entirely impervious. In the case of the two major park areas, it was assumed that during the large return period storms which are used for flood hazard mapping simulations, pervious surfaces would be saturated and hence would behave in a similar fashion to impervious areas, with rainfall essentially becoming surface runoff.

Because wet antecedent conditions have been assumed, initial losses were not taken into account (ARC, TP108).

This rapid flood hazard mapping methodology uses a three dimensional (3D) surface model to simulate 2D flow. The model representation does not include the piped SW network. It was therefore necessary to make adjustments to the TP108 design storm hyetographs to account for rainfall that enters the SW network.

The assumptions regarding inletting capacity into the SW system are as follows:

1. **Catchpits**
    - Shared space areas and Queen St – Drainage capacity for the 20yr ARI design storm peak
    - All other areas - Each catchpit can drain 20l/s
2. **Building Roofs**
    - 10yr ARI design storm
3. **Private Property Paved**
    - Zero private drainage. Assume all paved areas contribute to road drainage

2.2.1 ADJUSTED HYETOGRAPH

An adjusted hyetograph was created to account for the water that would enter the SW system through the catchpits and building downpipes based on the assumptions. This effectively reduces the volume of water becoming surface water. Refer to Figure 3 and 4 for a graphical representation of the adjustments.

To achieve this, the TP108 hyetograph was adjusted to remove the area of graph that was less than the assumed capacity. This adjusted hyetograph therefore represented the volume of water that would become runoff once the inletting capacity has been exceeded.

Due to the cells within buildings being “set to land” and therefore no rain being simulated to fall on grid cells within the building footprints, the hyetograph was then increased proportionally to ensure the correct volume of water overall was accounted for.

The method does not allow for any residual or ponded surface water to enter the SW system once the drainage network sufficiently recovers and has sufficient inletting capacity. This therefore causes any low points to fill and not empty. This was overcome by adding “sink points” to low points in the bathymetry to allow the water to drain away. The capacity of each sink point was determined based on the existing infrastructure at each low point.

Figure 3: Example Hyetograph for Developing Adjusted Hyetographs

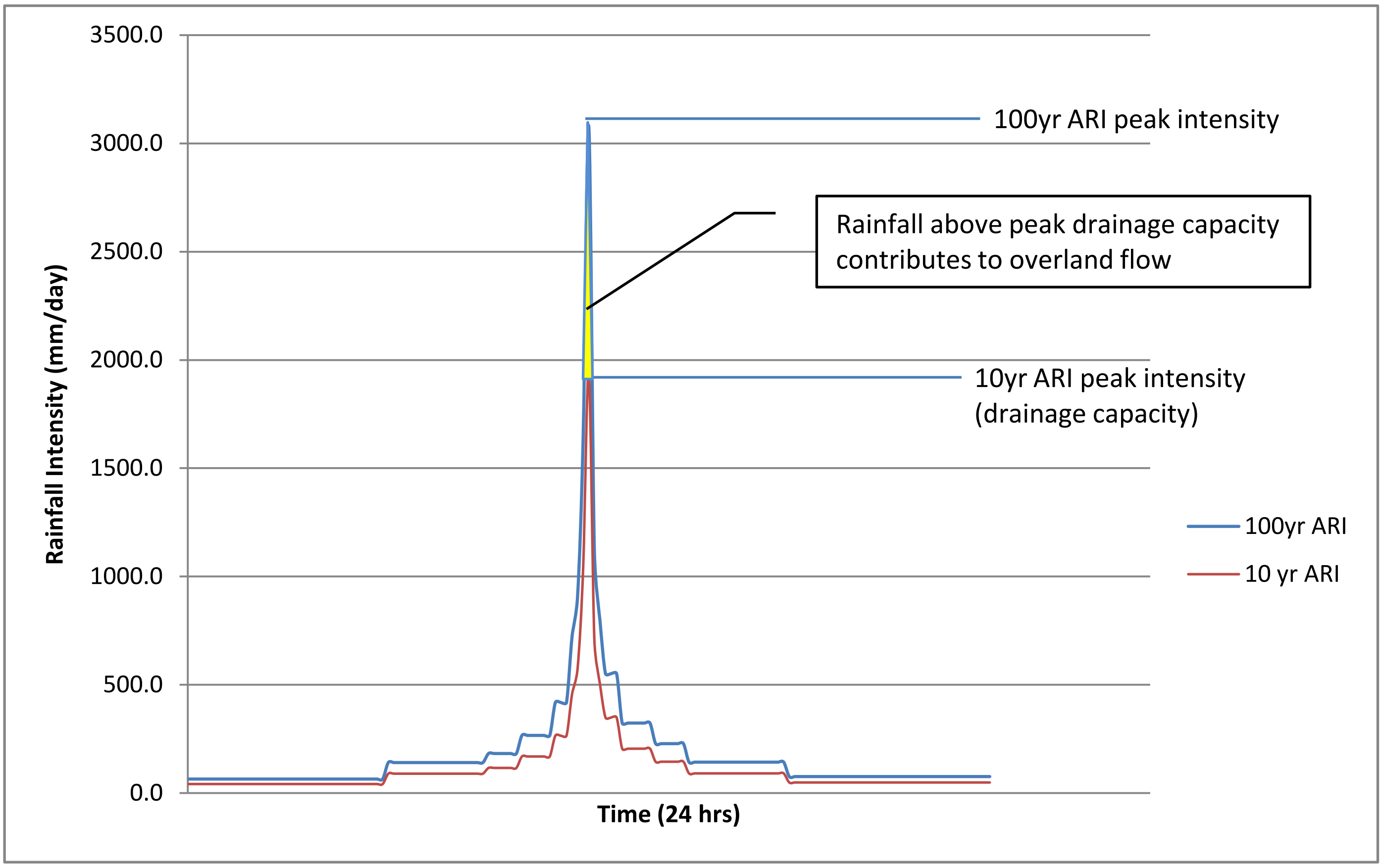
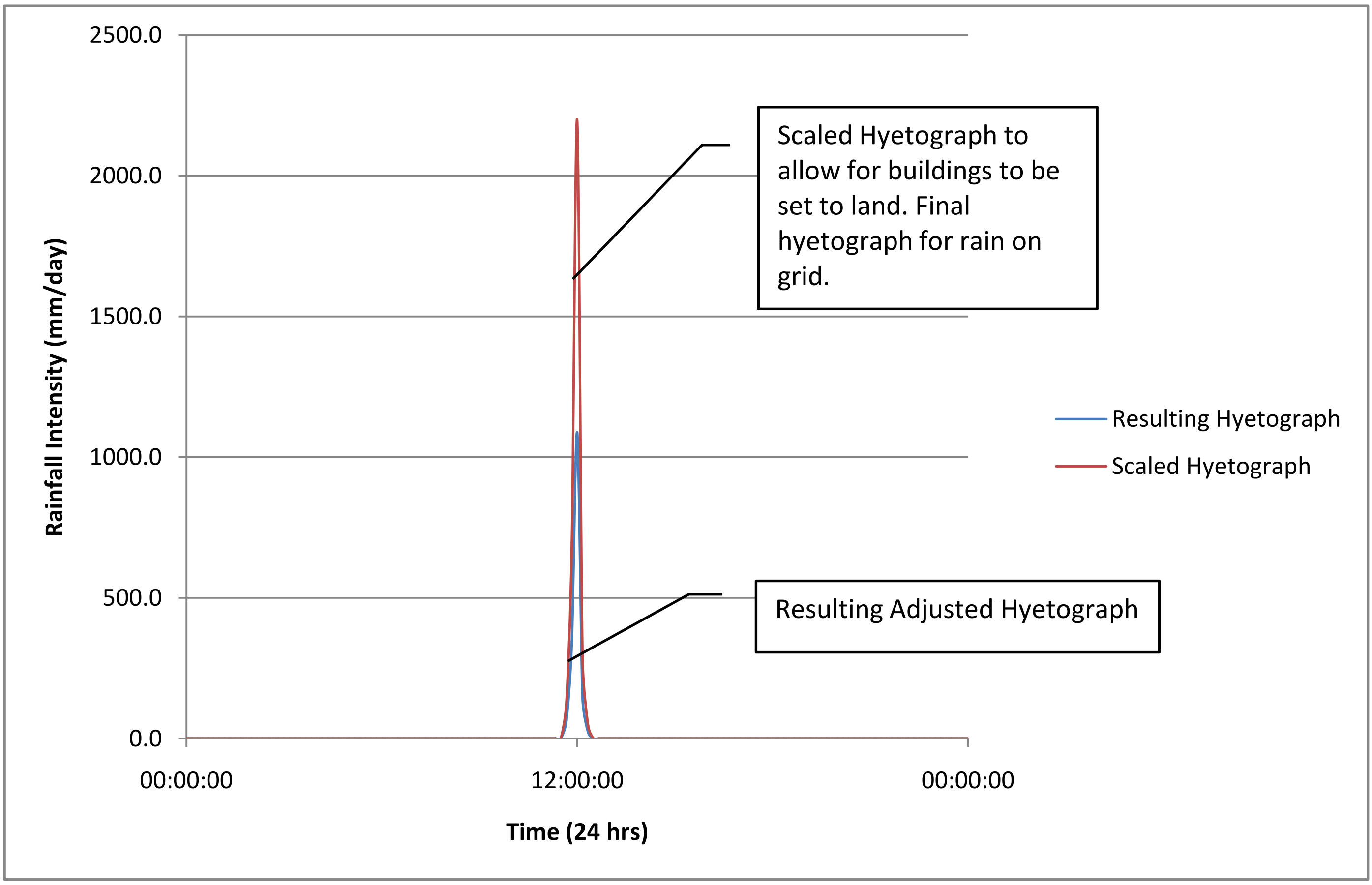


Figure 4: Final Scaled Hyetograph for Rain on Grid



2.3 SIMULATION SET UP

The "rain on grid" method is very computationally demanding, resulting in long simulation times.

Due to the shape of the TP108 hyetographs and the adjustments made to the hyetographs to remove rainfall that can enter the SW system through downpipes and catchpits, surface runoff only started to occur approximately 20 minutes before the peak of the storm. Therefore the whole 24 hour TP108 design storm was not required to be simulated. Simulations were run from 11.30am to 3pm of the 24 hour storm. This was deemed acceptable as the majority of flooding would occur close to the peak of the design storm and should begin to recede after a few hours.

2.4 SENSITIVITY ANALYSIS

A sensitivity analysis was carried out to determine how critical the assumed catchpit and down pipe capacities were.

The sensitivity analysis was carried out on the existing base scenario and was as follows:

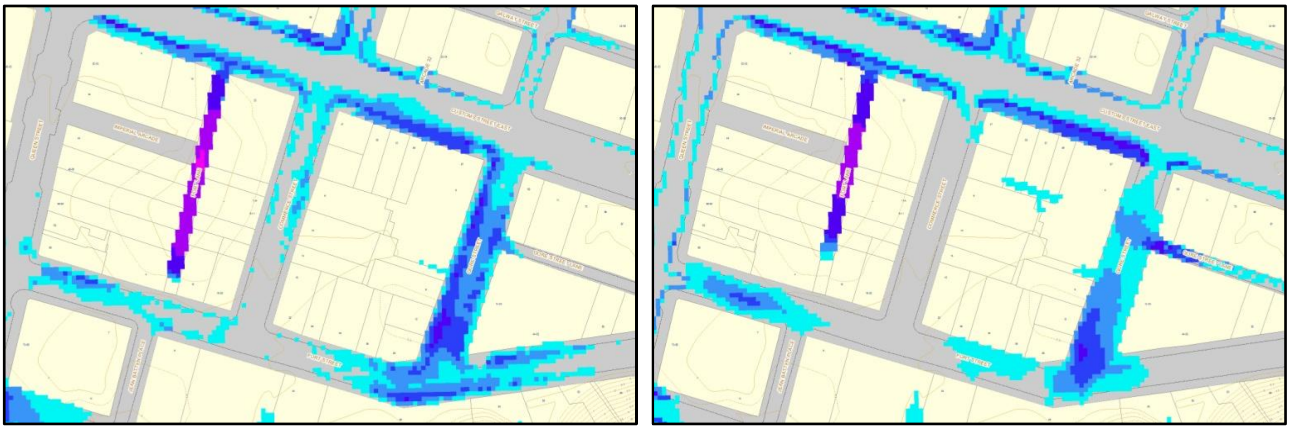
	Roof downpipe capacity	**Catchpit capacity**
Sensitivity Check 1	5 year ARI	10l/s
Sensitivity Check 2	No private roof drainage (assume all downpipes blocked	10l/s

As expected the private roof drainage component of the network is critical to the overall distribution of SW. The sensitivity analysis showed that by changing our assumption regarding roof downpipe capacity, this will affect the predicted flood depths and extents significantly, particularly when private drainage assumed to be completely blocked.

3 NATURE OF RESULTS OBTAINED

Figure 5 below shows how the flood extent model results have altered between the pre and post development scenarios in a particular area in the CBD. The main reason for the differing flood extents is the proposed adjustments at the Fort Street/ Queen Street intersection. In the existing scenario (pre shared space development) more of the overland flow is directed past Fort Street and contributes to the ponding in Gore Street via overland flow along Custom Street East.

Figure 5: Pre shared space development vs Post shared space development results



4 MODEL VALIDATION

Validation of pre-development results were undertaken through meetings with Metrowater Operations staff familiar with the catchment to confirm predicted flooding areas and they confirmed predicted flooding results.

5 MODEL LIMITATIONS

The RFHM assumes that the pipe network has capacity to convey flows that enter the system through the catchpits and downpipes.

The RFHM ignores any backwater effects from tidal influences.

Results were to be used to gauge relative differences in predicted flood levels for the pre and post shared space development.

6 CONCLUSIONS AND FURTHER WORK

The RFHM proved useful in showing the relative changes to predicted flooding extents due to the proposed shared space developments. The 2D model development was considered "rapid" because of time savings from not setting up a pipe model and delineating sub-catchments, however more effort was required to pre-process the hyetographs to set up the model hydrology. Overall it proved to be a quicker model build, providing a better representation of predicted overland flowpaths when compared with a one dimensional (1D) pipe based model developed previously.

Detailed modelling is currently being carried out to incorporate a 1D pipe model and couple this to the 2D model developed during the RFHM. This would better represent the pipe network capacity and make allowances for backwater effects. Results from the detailed 1D/2D coupled model can be used to check the results obtained from the RFHM.

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