CATCHMENT PLANNING – WHAT LEVEL OF DETAIL IS APPROPRIATE WHEN MODELLING FUTURE DEVELOPMENT SCENARIOS

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ABSTRACT

Introduction

Proper management of stormwater is greatly aided in catchments where a stormwater catchment management plan has been developed. As part of developing this plan, analysis of both stormwater quantity and quality is required. This analysis varies greatly between Councils and catchments sometimes involving just broad-brush calculations and in other instances involving much more detailed modelling.

Even where modelling is undertaken the level of detail also varies considerably. This paper focuses on flood modelling (stormwater quantity) for Tauranga City Council for both existing and future scenarios. It examines different techniques and levels of detail applied in different catchments. It examines which techniques are appropriate where, and when it is better to use more or less detail. In particular it focuses on the issues surrounding modelling future development scenarios, where the level of detail of the future development can vary enormously.

Background

Commonly when modelling a catchment, two base scenarios are included in the analysis. The first is the existing scenario, i.e. modelling the catchment in its current state. The other is a future scenario which usually includes allowances for climate change and sea level rise. The future scenario also usually allows for further development of the catchment. A term often referred to is Maximum Probable Development or MPD.

Modelling the existing development situation is useful for defining the current flooding in the catchment. Flood maps produced from such modelling are an invaluable tool for engineers and planners when granting approval or consents for work within the catchment. Data from the flood maps produced also inform LIM reports for properties within that catchment.

For these reasons therefore it is important that this modelling is as accurate as possible. While not always entirely true, it generally follows that the more detail put into a model the better it will represent the real world giving more accurate results. (Care however needs to be taken that the model is able to deal with this additional detail. An example where this is not the case is using rain on grid for steep urban catchments. Although rain on grid may seem like it should give better results than lumping flow directly into the pipe network, experience has shown that in steep catchments the rain on grid approach can flow straight over cesspits, due to lack of kerb definition in the grid etc.)

Working out the level of detail to include when modelling the maximum probable development scenario can be even more problematic as shown by the following examples in Tauranga;

Mount Maunganui

Mount Maunganui is a catchment where the method developed for modelling the maximum probable development scenario worked well. The existing development model is a rain on grid model coupled to the full stormwater network including sumps and sump leads. Being a generally flat catchment, the catchpits (which are mostly in low points rather than being on grade) capture flow from the rain on grid overland flow and the pipe network flows full in large storm events. The amount of runoff is determined by a 2d infiltration grid. Impervious road and footpath cells have close to zero infiltration, while gardens and berms have much higher infiltration. Infiltration for roof cells reflects typical soakhole reticulation rates (most houses in Mount Maunganui drain to soakholes).

As the popularity of Mount Maunganui increases, lots are being subdivided and housing density is increasing. The maximum probable development imperviousness has been estimated by Council on a zoning basis, with residential MPD imperviousness estimated at 70% and some growth node areas zoned for even higher imperviousness. To include this extra imperviousness in the model the infiltration layer in the Mike 21 rain on grid model was modified on a lot by lot basis using GIS techniques. The infiltration of previous areas within a lot was reduced on a weighted basis to reflect the MPD imperviousness for the zone in which the lot sits. The model was then re-run for the future scenario with increased runoff (decreased infiltration) matching the estimated MPD imperviousness of that catchment.

Papamoa West

The approach successfully adopted for Mount Maunganui was also applied to Papamoa West. However, Papamoa West is not such a mature catchment and still includes a few blocks of land that have not been developed at all. As per Mount Maunganui the infiltration layer was modified on a lot by lot basis to reflect future development imperviousness. While this system worked well in Mount Maunganui for brownfield intensification, for large undeveloped residential zoned blocks in Papamoa West this technique was not as suitable. This is because these blocks have not been earthworked and the existing terrain often includes self-contained (inter-dunal) ponding areas. While this ponding is realistic for the existing scenario, when the blocks are developed in future they will be earthworked to all drain away. By merely changing the infiltration layer this reduced ponding was not accounted for and therefore the model under predicted future scenario flows into the main drainage channels.

Papamoa East

Papamoa East is even less developed than Papamoa West but has been earmarked for major future development. About 10 years ago two large blocks of land were consented for future development. Part 1 – Wairakei is now over 50% developed housing thousands of Tauranga's growing population. Part 2 – Te Tumu is expected to commence development in the next few years. Consenting for development of these blocks required a number of specific stormwater mitigation measures including additional stormwater retention volume, increased culvert capacity at road crossings over the Wairakei stream and a high-level overflow to the Kaituna River.

There was however no specific roading or landform plan, so it was clear these future development areas could not be modelled in 2d. Instead a schematic representation of these developments was modelled. Lumped hydrological catchments were modelled and loaded into storage nodes which were in turn connected to the main Wairakei Stream.

While this technique is much simpler than the sophisticated lot by lot GIS techniques applied to Mount Maunganui and Papamoa West catchments, in this situation it is far more appropriate. It also does not have the drawback of neglecting the issue of post-earthwork removal of inter-dunal ponding.

Over time the Part 1 – Wariakei area has been developed. Council has required that the developer's landforms be inserted into the model and checked prior to the earthworks being undertaken. This is to ensure that there are no nasty surprises with brand new houses appearing as flooded when the next round of flood modelling is undertaken.

While inclusion of these design landforms has allowed detail to be added to the overall model, the detail for the planned areas is nowhere as great as in existing areas. For example, while existing areas include the full reticulation network this was not included in the soon to be developed areas where only the developer's landform was available. Similarly building and road footprints were not available to put into the 2d roughness (Mannings 'n') and building footprint layers. Instead 'averaged' infiltration and manning 'n' values were applied over the whole design landform.

In reality stormwater will quickly enter the pipe or overland flow (road) network where infiltration is likely to be minimal. Using 'averaged' infiltration rates over the design landform may in fact overestimate infiltration. Similarly, the lack of pipe network and averaged Mannings 'n' values may overestimate the catchment response times.

While this lack of detail of infiltration and roughness potentially compromises results, the increased detail of 2d modelling (compared to the simplistic lumped hydrograph approach) of the design landform is still an invaluable first pass check of the developer's landforms. It gives confidence to Council that the main overland flowpaths have been correctly designed and buildings will not be flooded.

Kopurererua Stream Catchment

The Kopurererua catchment is another Tauranga catchment in which considerable development has recently occurred with more planned. The major developments are the ‘Lakes’ residential development on the true right bank with the ‘Tauriko Business Estate’ industrial development on the true left bank.

In this catchment however, future works were covered by many separate consents compared to the comprehensive stormwater consent in Papamoa East. Unfortunately, this led to significant future consented works not being included in the Maximum Probable Development Scenario. This included significant future floodplain filling and mitigation works such as stormwater ponds and channel widening being missed out of the model. Instead the Maximum Probable Development Scenario differed from the existing scenario model only in terms of imperviousness, climate change and sea-level rise,

In missing the planned and consented major works in the catchment, the initial future scenario modelling was somewhat meaningless. Tauranga City Council have worked hard since these initial runs and future scenario modelling now includes these future works.

Summary

The modelling of future scenarios can be difficult, especially in catchments where significant development is planned. While a 2d modelling approach can initially appear to be more accurate, this needs to be considered carefully, as without including the post development landform, pipes, and infiltration details, merely increasing imperviousness may not be that meaningful. As always there is no one size fits all correct method, but instead needs to be tailored on a case by case basis.

KEYWORDS

MPD, Imperviousness, Future scenarios