Review of report by R J Hall and Associates Ltd
“Pinehaven Stream:
ARI 100 Hydrological Assessment
Various Development Scenarios”
November 2019
including ADDENDUM A: At-A-Site Evaluation of Appropriate CN Numbers 2019-9-27

Modelling methodology

Mr Hall has built a hydrological model in HEC-HMS, software from the US Army Corps of Engineers. HEC-HMS works with “lumped” catchments rather than a grid of points, so that the calculations are carried out using parameters averaged over the sub-catchment.

In determining suitable catchment parameters, Mr Hall has relied on two reports:

- "Report on Infiltration Tests" by A Ross, (including two appendices)
- "Sub-catchment B - Time of Concentration calculations" by S Pattinson and A Ross

Rainfall depths with an Average Recurrence Interval (ARI) of 100 years have been obtained from the NIWA method HIRDS (version 4). Depths with storm durations ranging from 10 minutes to 12 hours have been nested within one another, to create what is sometimes known as a Chicago-style hyetograph.

The SCS method (US Soil Conservation Service) has been applied for the rainfall-to-runoff computations. In applying the SCS method, a guideline prepared for Wellington Water Ltd was followed where considered applicable: “Reference Guide for Design Storm Hydrology“, Cardno N.Z. Ltd, 2019.

All these choices are common practice in New Zealand, if not universally adopted. This approach was chosen for the Auckland region by the Auckland Regional Council, in its guideline TP108, for application to assess the hydrological effects of urban development. The Cardno report bears many similarities with TP108.

A universal increase in rainfall of 16% has been allowed for future Climate Change. This particular increase should be referenced, or its derivation described, but is consistent with present practice and present scientific understanding.

The contributing areas with different estimated Curve Numbers appear to have been correctly calculated and used to obtain a single weighted Curve Number. The resulting runoff hydrographs produced by Mr Hall (his Table 3 and 4) are in each case just from the area to be developed.

Choice of modelling parameters

The SCS method is largely prescriptive except for the choice of a Curve Number for each area of land, the Curve Number being largely a measure of losses of rainfall to ground. Both the Cardno (2019) report and Auckland Council’s TP108 provide guidance in choosing Curve Numbers based on soil type and land use.

Curve Numbers

A single representative Curve Number is chosen for each modelled scenario, being an area-weighted average of the Curve Numbers chosen for parts of the catchment. This is common practice and is in fact the method specified in Cardno (2019).

Where there are two or more disparate soil types and/or land uses within a catchment, an alternative approach preferred by some is to separately calculate the runoff from each area and add them to obtain a combined hydrograph. Hydrographs derived this way will differ slightly from those obtained with the averaged Curve Number, but the difference is fairly minor.

Mr Hall's Curve Numbers

The Curve Numbers chosen by Mr Hall are low, consistent with sandy and silty loam soils.

These Curve Numbers are also consistent with the infiltration tests carried out by Mr Ross which show high infiltration rates at and near the areas to be developed. Mr Hall has referred to published New Zealand research in associating Mr Ross's infiltration rates with SCS Curve Numbers

Guidance from the Waikato Regional Council procedure TR2018/02 has been taken in assuming that areas that are earthworked and then left unpaved, i.e. pervious, are made less permeable. This is a well-known consequence of earthworking, and it is reasonable to increase the Curve Number of those areas, as has been done in these calculations.

Cardno Curve Numbers

In contrast, the map provided by Cardno (2019) specifies quite high Curve Numbers for parts of the area proposed for development.

Cardno (2019) explains that the curve numbers have been derived from soil drainage characteristics and land cover. The soil drainage characteristics are those made available by Landcare Research: the Land Environments NZ (LENZ) data set and the Fundamental Soils Layers (FSL). Land cover is derived from the Land Cover Database (LCDB v4.1) also available by Landcare Research.

Commentary

It is not immediately possible to resolve the discrepancy between these two sources of Curve Numbers. In the steep terrain of Catchment B, high measured infiltration rates might or might not result in high loss of water from the flood flow, as water might soon emerge further down the catchment.

The choice of Curve Numbers is therefore not obvious. In my opinion, given the measured infiltration rates, prudent engineering practice would be to seek corroboration from other evidence before adopting the Cardno curve numbers. Two possibilities come to mind which could help resolve the issue:

1. It might be possible to estimate the channel-forming flow from the natural stream bed upstream of the Pinehaven residential properties. This flow would be assigned an Average Recurrence Interval of about 2.4 years, allowing an approximate estimate of the 100-year ARI event.
2. However, the best way to resolve the uncertainty about Curve Numbers would be to analyse coincident rainfall and runoff records. It is understood that a flow record of about five years' duration has been obtained from the larger Pinehaven catchment that includes Catchment B. If that record can be analysed along with suitable rainfall data, it should be possible to determine typical losses from quickflow and to then reassess the Curve Numbers; it would not matter if the record did not include any particularly large event.

Curve Numbers for Jacobs' calculations

Mr Hall has carried out calculations to determine the Curve Numbers needed to produce the runoff volumes computed by Jacobs (their Table 1, included in Mr Hall's report as Figure 8). I have carried out calculations to check his results. Mr Hall has analysed a 2-hour rainfall event, and it is understood that Jacobs did the same.

I concur with Mr Hall's conclusions that Jacobs' runoff volumes are consistent with a Curve Number of 96 for the undeveloped catchment, and average Curve Numbers of 97.5 and 97 for development scenarios DS1 and DS2 respectively.

These Curve Numbers are higher than any recommended values for natural ground surfaces, and are close to the Curve Number specified by TP108 for sealed roads and roofs. It therefore seems likely that Jacobs applied a different hydrological model rather than the SCS method, and assumed an exceptionally impervious catchment.

Time of concentration

The method specifies the methods for calculating of the catchment's time of concentration. This review has not included a review of "Sub-catchment B - Time of Concentration calculations" per se. However, the times of concentration (typically about 15 minutes) that Mr Hall has adopted from that report appear very credible.

The calculated difference between pre-development and post-development times of concentration also appears very credible. This difference contributes to the increase in peak runoff with development.

Assessing the effect of development

Areas of the catchment have been modelled as impervious, virgin pervious and earthworked pervious. The respective areas appear to have been assigned correctly.

Two pre-development scenarios were modelled: the present /historical climate scenario and a future Climate Change scenario. Several alternative development scenarios were modelled; this brief review does not address whether the impervious areas claimed by the developers or assumed for the modelling accurately reflect the most likely development.

The report notes that the Waikato Regional Council guideline, Technical Report 2018/02, provides that "pre-development rainfall data should not be adjusted for climate change while post-development rainfall data should be adjusted for climate change". This appears suitable for an assessment of upgrades to existing infrastructure changes that might be needed. However, it is not the right test for assessing the effect of the urban development. Given the present available modelling results, the comparison should be between the pre-development and post-development scenarios both with Climate Change allowed for.

Those runs using Mr Hall's Curve Numbers (his Fig 14) show an increase in peak runoff with development of about 5 times, whereas those runs (e.g. Fig A14) using the Cardno (2019) Curve Numbers produce a doubling of the runoff peak with development. In my opinion, therefore, the Cardno Curve Numbers should be corroborated as discussed above before using them to design any flow detention storage.

Conclusions

The general hydrological method adopted in Mr Hall's report is sound, and is now long-established good practice.

Mr Hall’s choice of Curve Numbers for Catchment B is consistent with the infiltration tests described by Mr Ross in his report, but is inconsistent with the map provided by Cardno (2019). Particularly given the general geology and the steep terrain of Catchment B, this inconsistency is difficult to resolve in favour of one set of curve numbers or the other.

In this context, the two sets of model output, using alternative Curve Numbers, are helpful. Regardless of which model results are preferred, the increase in runoff is significant, and mitigation would require detention storage at the development site.

Mr Hall’s modelling demonstrates the well-known hydrological consequences of urban development: less water is lost to ground, and runoff is quicker, resulting in increased peak flows.

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