Queanbeyan-Palerang Regional Council
PO Box 90
Queanbeyan
NSW 2620

J:\Jobs\115070_01\Admin\L13092016_Tralee_Review

15 September 2016

Attention: Beate Jansen

Dear Beate,

Re: Calibre Consulting – 2016 North Tralee Flood Study Review

In February 2016, WMAwater carried out a peer review of the North Tralee Flood Studies (Brown Consulting, 2010) on behalf of Queanbeyan City Council. This review concluded that the 100 year ARI flow estimate determined as part of the Brown Study (2010) was suitable for use in design flood modelling. However, the review suggested that hydraulic model should be reviewed and additional survey work be carried out to incorporate into the model. This work has now been carried out and an update has been provided by Calibre Consulting in July 2016. This letter details a review of the Calibre Study (2016), undertaken by WMAwater on behalf of Queanbeyan-Palerang Regional Council.

It is worth mentioning that the Calibre Study (2016) report contained insufficient information to undertake a detailed assessment which necessitated WMAwater to request available survey, models and model results to assist in the review. Whist this data was forthcoming, it was generally incomplete and difficult to assess due to the unusually large file sizes associated with the selection of a 1 m grid (see below for further details).

HYDROLOGY REVIEW

The hydrology was examined by WMAwater as part of the Brown Study (2010) review. The Calibre Study (2016) indicates that the same design flows have been applied and accordingly review of the hydrology has not been revisited.

HYDRAULIC MODEL REVIEW

The Brown Study (2010) investigation used the hydraulic modelling software package SOBEK whilst the Calibre Study (2016) used TUFLOW. Accordingly, the hydraulic models used for these studies have changed and a full review of the Calibre Study (2016) hydraulic model was required.

Model Domain and Grid Size

The Calibre Study (2016) used a 1 m grid for modelling of the 2D domain (5.3 million cells). This resulted in extraordinarily long model run times and large output files. Some of the check files and result files were so large that they could not be examined using WMAwater's GIS programs.

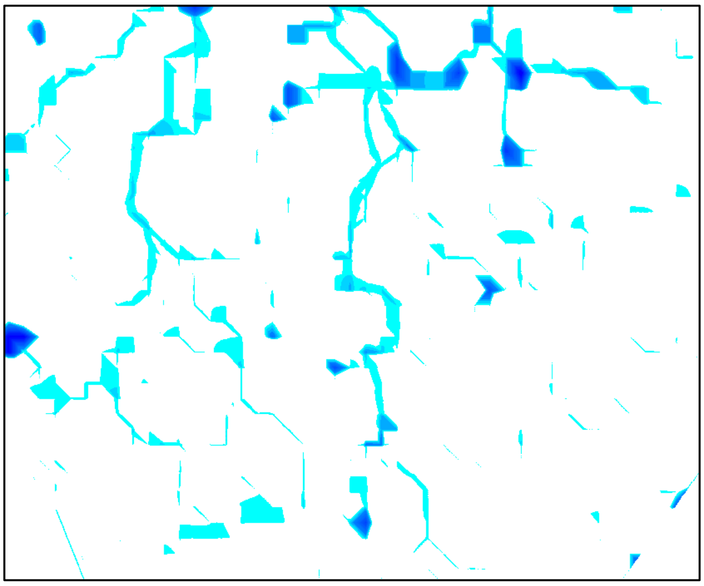
The selection of grid size for use in a hydraulic model is based on ensuring hydraulic features are adequately defined whilst not creating excessively long model run times. Of most importance is that sufficient detail of the creek channel is available. Typically, 3 to 4 cells is required to accurately model a creek channel.

TUFLOW calculates hydraulic flood behaviour based on Shallow Water Equations of which some of the assumptions that TUFLOW makes during calculation become ambiguous when the flood depth is many times greater than cell size. The Calibre Study (2016) frequently has flood depths four times greater than the selected cell size within the creek channel, with flood depths increasing to over five times the selected cell size near the Railway Bridge. TUFLOW notes that whilst this is typically not an issue, modelling of complex flow patterns (such as those experienced at the Railway Bridge) on very fine grids with deep water may lead to some issues (Reference 1).

Preliminary investigation by WMAwater indicates that a 3 - 5 m grid would be more suitable for use to determine the mainstream flood extent in the Calibre Study (2016).

It was also noted that the Calibre Study (2016) modelled overland flow to the south of the Site. The overland flow results have not been reviewed extensively, however it is noted that on preliminary examination the results appear to be unusual, particularly in the upper reaches (see Image 1). It was noted that the flow paths appear to be gridded in a semi-linear/parallel fashion. This may indicate that there may be issues with the available DEM, presumably due to the employed tinning process. Whilst this is of only minimal issue with the current study's modelling of mainstream flood behaviour, for subsequent studies focusing on overland flow the DEM should be examined in detail and validated.

Image 1: Overland Flow Flood Modelling Results (Depth)



Breaklines

Flow paths, and rail and road embankments, are hydraulic features that can have a significant impact on flood behaviour. Such features should be represented in the model by breaklines with crest and invert heights determined by ground survey.

The Railway embankment is not overtopped and accordingly, a breakline is not required to define the crest level of this structure. Additionally, no breakline has been modelled for the creek invert, however this has meant higher flood levels and is therefore conservative.

Roughness Values

Roughness estimates impact on hydraulic characteristics such as peak flood level. The Manning's 'n' values for each grid cell should be based on vegetation and other obstructions at each location. The Calibre Study (2016) has used roughness values similar to those used in established references and other nearby studies. However, the spatial distribution of more dense vegetation types have not been modelled. In particular, riparian vegetation and vegetation close to the two railway underpasses (see Image 2) has not been considered. WMAwater have examined the vegetation density at these locations and estimate that a Manning's 'n' of 0.08 should be applied.

However, as the above mentioned vegetation is generally quite localised, it is expected that failing to model these features would not lead to widespread impacts on flood behaviour.

Image 2: Dense Vegetation

Bridges and Culverts

Three major bridges and culverts exist in the study area. These are:

1. Railway Bridge (at main creek channel);
2. Railway Culverts (160 m south-east of the main creek channel; and
3. Lanyon Drive Bridge.

A summary of how these bridges have been modelled is presented in the following sections.

Railway Bridge

The Railway Bridge is situated on the main creek channel. The bridge has been modelled in 2D using methods that are not considered best practise. The bridge piers have been modelled by nulling the cells to not allow flow to pass through the areas where the piers are situated. When using this approach care needs to be taken to ensure that the predicted afflux is representative. Modelling carried out using a variety of 2D software tends to show that blocking out cells/elements for bridge piers will overestimate the afflux (Reference 2). It is recommended that for modelling of bridges in 2D, TUFLOW's 2d_lfsch layer be used to model blockage due to piers and the associated form losses.

Additionally, the deck of the Railway Bridge has not been modelled. Liaison with Calibre Consulting indicates that survey obtained of the Bridge shows that the 100 year ARI flood level is below the level of the bridge obvert and therefore will not impact on the flood behaviour. If the flood level was at or above the level of the bridge deck obvert, this would lead to an increase in peak flood level. The 2d_lfsch layer mentioned above can also be used to model the bridge deck if required.

Assuming that the bridge deck obvert is above the level of the 100 year ARI flood as reported by Calibre Consulting, then the methodology used likely produces higher peak flood levels and is therefore conservative and suitable for use to determine the 100 year ARI flood level for the Site.

Railway Culverts

The Railway Culverts have been modelled as 1D features. The individual culvert details are reasonable and match available survey. However there are a number of issues with the application of these culverts as described below:

- The culvert dimensions are 4 x 2.6 m diameter culverts. Each of the four culverts are applied to a single 1 m cell which is not the best practise method of modelling the 1D/2D interface. It is recommended that each culvert is applied to three cells so that the culvert is modelled as the flow control, not the upstream and downstream cells.
- The stability and performance of these culverts has not been checked as insufficient information was available for this review.

Without having access to the complete model results (_PO.csv, _TS.mif etc.), WMAwater postulate that the conveyance of these structures are unlikely to be overestimated. Accordingly, upstream flood levels are likely to be conservative.

Lanyon Drive Bridge

The bridge on Lanyon Drive has been applied as a 2d_lfsch layer, however no form losses have been applied to this structure. Applying no form loss leads to lower flood levels upstream. The form losses recommended in the TUFLOW manual should be applied in the absence of calibration data.

It is considered unlikely that this bridge would impact on flood levels at the Site due to Lanyon Drive Bridge been situated 500 m downstream of the Railway Bridge. Additionally, the Railway forms a major control which would not likely be significantly affected by downstream flood behaviour.

Structure Blockage

Structure blockage can significantly affect peak flood levels both upstream and downstream of a structure. Blockage of hydraulic structures can occur with the transportation of materials by flood waters, which in the vicinity of Tralee is most likely vegetation such as logs and fallen trees but may also be sedimentation or urban debris such a wheelie bins.

It is recommended that a conservative approach to incorporate potential structure blockage in accordance with the ARR Blockage Guidelines (Reference 3) be incorporated into flood modelling of all design events for all culverts. Bridges with diagonal spans exceeding 6 m are not likely to block during a flood event (Reference 3) and therefore do not need to be blocked for design runs.

As the diagonal spans of both the Railway and Lanyon Drive Bridges exceed 6 m, modelling of structure blockage is not required for design events. However, the modelling of blockage for the Railway Culverts would be considered best practise.

The Railway Culverts convey a smaller portion of the total flow when compared to the Railway Bridge and accordingly have less of an impact on upstream flood levels. As mentioned previously, the flow in these culverts could potentially be restricted due to the culverts being linked to only one cell much smaller than the size of the culvert. This is therefore unlikely to be a major issue when considering design flood levels for the 100 year ARI flood event.

Boundary Conditions

The upstream boundary was modelled as a time varying hydrograph using TUFLOW's QT boundary. The downstream boundary was modelled using a HQ boundary. These methods of modelling boundaries are suitable for use in the current study.

Hydraulic Model Calibration

The Floodplain Development Manual requires that numerical models be calibrated and validated. The calibration process consists of adjusting appropriate parameter in the model to obtain agreement between recorded and simulated water levels during a major flood. No calibration/validation of the hydraulic model has been undertaken as part of the Calibre Study (2016).

As typical model parameters have been used in the Calibre Study (2016) a detailed calibration of the hydraulic model may not be required depending on what the model results are to be used for. The model is not suitable for determining finished flood levels for residential properties, however is likely suitable for undertaking a rezoning assessment for the reasons described below.

DISCUSSION

The Site is situated upstream of the Railway embankment which forms a major control for flows upstream. The 100 year ARI flood level is typically 0.2 – 0.3 m below the railway embankment crest height dependant on location. If the crest height of the embankment was to be overtopped by flow, any further increase in flow would lead to a comparatively minor increase in peak flood level compared to before the Railway embankment crest height is overtopped. This indicates that above the threshold created by the Railway embankment, peak flood levels are relatively insensitive to the assumptions made in the hydraulic model.

Furthermore, due to the steep terrain on either side of the creek floodplain, any increase in flood level leads to a relatively minor increase in flood extent. For example, assuming the 100 year ARI flood level estimate was to increase by 0.4 m, thus overtopping the Railway embankment, the average increase in flood extent at the Site would be approximately 10 m (maximum of ~15 m).

It is noted that a freeboard of 0.5 m is to be applied to the 100 year ARI flood level. This freeboard should sufficiently account for any error associated with the hydraulic modelling techniques.

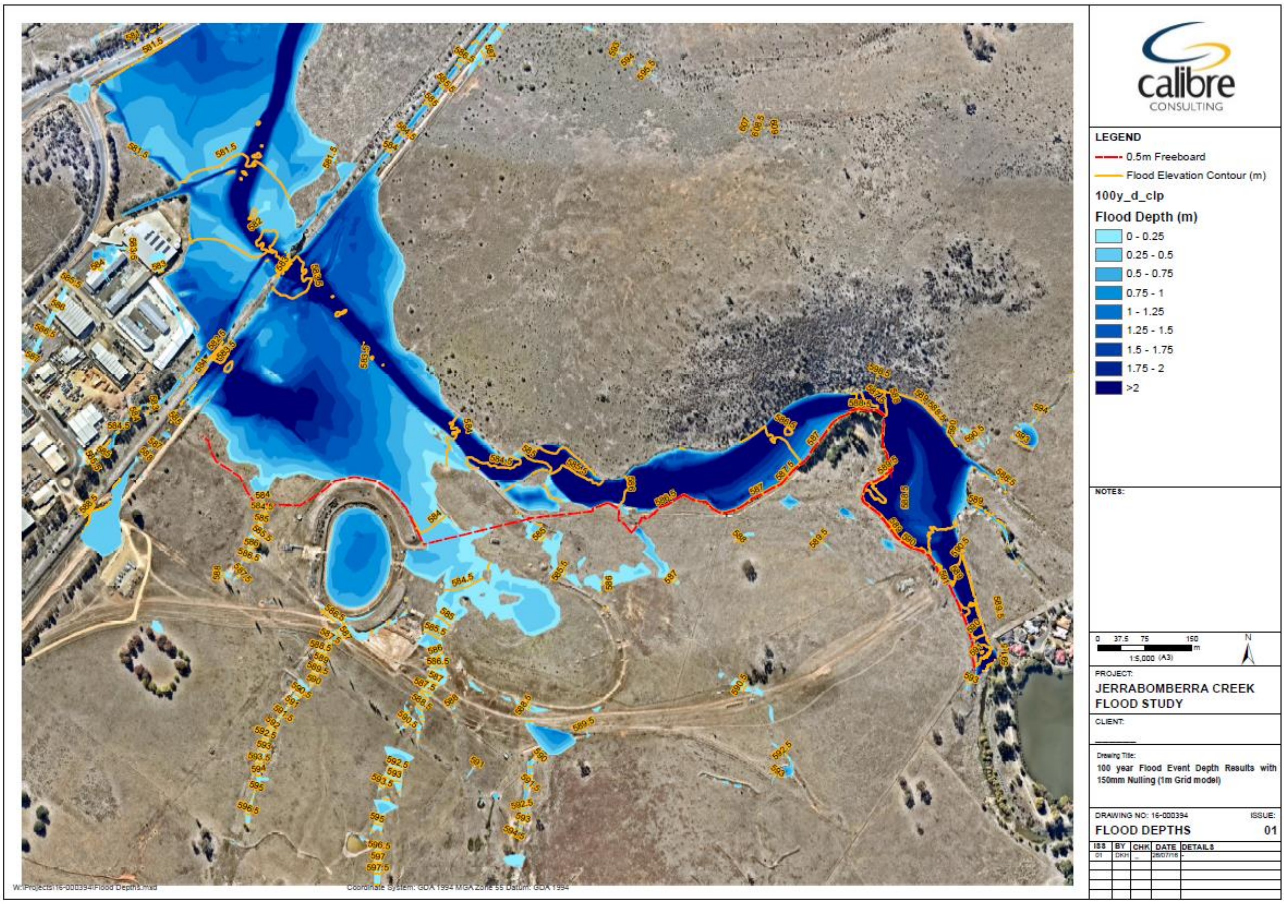
CONCLUSIONS AND RECOMMENDATIONS

The Calibre Study (2016) hydraulic model was found to have a number of issues making it unsuitable for determining finished floor levels for residential properties and other outputs that are required as part of a Flood Study performed under the NSW Floodplain Management Program.

However, the assumptions and modelling methods applied have been determined to be generally conservative. This coupled with the characteristics of the control formed by the Railway embankment and the steep terrain on the surrounding floodplain, indicates that the model results are suitable for rezoning assessment purposes when used in conjunction with a 0.5 m freeboard.

Council have requested that the Calibre Study (2016) FPA (as derived using the 100 year ARI event + 0.5 m freeboard) be examined to investigate the suitability for incorporation of this information into the draft plan for Council's LEP. The FPA extent as presented as the red line on the final page of the Calibre Study (2016) and recreated herein as Image 3, has been determined as representative of the 100 year ARI event + 0.5 m freeboard. However it should be noted that the FPA extent may need to be extended further to the north-west until the Railway embankment is met, depending on the proposed rezoning area. Additionally, it should be noted that the FPA extent has not been determined for the northern floodplain which may be a requirement of Council.

Image 3: Calibre Study (2016) FPA – 100 year ARI Event plus 0.5 m



It is recommended that for future studies, a more detailed hydraulic model be derived that addresses the issues highlighted throughout this letter. The model should also be calibrated if possible.

No comment is made as part of this letter as to the accuracy of the overland flow results to the south of the Site.

REFERENCES

TUFLOW

1. **TUFLOW Forum**
   http://www.tuflow.com/forum/index.php?/topic/785-purely-2d-river-model-is-this-suitable/

TUFLOW

2. **Modelling Bridge Piers and Afflux in TUFLOW**
   http://www.tuflow.com/Download/Technical_Memos/Modelling%20Bridge%20Piers%20in%202D%20using%20TUFLOW.pdf

Engineers Australia

3. **Australia Rainfall and Runoff, Project 11: Blockage Guidelines for Culverts and Small Bridge**
   February 2015

Yours Sincerely,

WMAwater

Zac Richards

Associate