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Dear Barnaby

Our ref: 4337-01L01v02

Amendment C109 to the Manningham Planning Scheme – Peer Review

In accordance with you letter of instruction of 11 February 2016 and subsequent correspondence I have undertaken a peer review of the methodology used to develop the flood mapping that forms the basis of the proposed Land Subject to Inundation (LSIO) and Special Building Overlays (SBO). This letter describes my review and opinion in relation to the proposed planning scheme amendment maps.

BACKGROUND

Purpose of the Amendment C109 is to make changes to the Manningham Planning Scheme to incorporate updated flood-related controls in the form of a Land Subject to Inundaiton overlay and 3 Special Building Overlays. The LSIO represents areas that may be subject to flooding from overbank flows associated with rural and urban waterways. SBO's define areas that are susceptible to flooding from urban runoff that exceeds tha capacity of the drainage system. Much of the municipality comprises development that is many decades old and does not have drainage infrastructure that meets current design standards. This means that drains do not have the capacity to convey nominal urban design flood flows (typically a minimum of the 5 year ARI design flood). Similarly, overland flow paths are either not available or do not have sufficient capacity to convey surface runoff without impacting private property.

Four overlays are proposed as follows:

- LSIO – relates to overland flooding along Melbourne Water waterway assets
- SBO1 – relates to overland flooding along Melbourne Water drainage assets
- SBO2 - relates to overland flooding along Council drainage assets
- SBO3 – relates to overland flooding along Council drainage assets, however the flood risk, impact and planning requirements are reduced compared to SBO2.

BASIS OF REVIEW

This review is based on the following documents and files.

- Manningham Planning Scheme Amendment C109 – Explanatory Report, 2015

- Manningham Planning Scheme Amendment C109 – Proposed Special Building Overlay Maps, Nos 1 - 4, 6 – 9 and 11.
- Development of the Special Building Overlay Technical Report, Cardno September 2015.
- Bulleen North Drain Catchment Mapping, Cardno November 2013.
- Final Study Report Flood Mapping of Koonung, Mullum Mullum and Andersons Creeks, Cardno March 2015.
- Ruffey Creek Flood Mapping, AECOM September 2013.
- Ruffey Creek – TUFLOW Model Review, WBM March 2012
- Ruffey Lake Flood Mapping Data Review, Cardno January 2015
- Bulleen North Flood Mapping Data Review – Technical Note, Cardno March 2015
- Ruffey Lake Flood Mapping – Technical Note, Cardno March 2015
- Managing Stormwater Flooding Risks in Melbourne, Auditor General Victoria July 2005
- ARR Project 15 Two-Dimensional Modelling in Urban and Rural Floodplains – Stage 1&2 Report, Engineers Australia November 2012.

BASIS OF LSIO AND SBO FLOOD OVERLAYS

The new overlays are based on flood mapping for 5 catchments within the Manningham City Council area. The approximate locations of these main drainage lines are shown in Figure 1. A brief description of each of the catchments is provided below.

- **Bulleen North Drain** – This catchment is located entirely within the western end of the municipality and flows broadly in a north-west before discharging into the Yarra River. It is mostly urbanised and has an area of approximately 225 ha. This catchment was modelled and mapped by Cardno between approximately 2008 and 2013.
- **Ruffey Creek** – Is situated north and east of Bulleen North Drain. It also flows in a north-west direction and discharges into the Yarra River. It is entirely within the municipality and has a catchment area of just over 1,000 ha. This catchment was modelled and mapped by AECOM between approximately 2009 and 2013.
- **Mullum Mullum Creek** – This waterway originates to the east of Manningham City and flows west, crossing the south-east municipal boundary. It then flows in a north-west direction before joining with the Yarra River. It is located to the north of Ruffey Creek and has a catchment area of approximately 2,700 ha within the municipality. This catchment was modelled and mapped by Cardno in 2014/2015.
- **Koonung Creek** – Essentially forms the southern boundary of the Municipality. It flows from east to west with the northern part of the catchment in the Manningham City area and the area south of the main channel in another local government area. The catchment has an area of approximately 1,500 ha within the Municipality. This catchment was modelled and mapped in parallel with Mullum Mullum Creek and Andersons Creek by Cardno in 2014/2015.
- **Andersons Creek** - This catchment is located on the eastern side of the municipality and has an area within the council boundary of approximately 1,800 ha. This is a small part of the catchment to the east. It flows in a northerly direction to the Yarra River. It was modelled and mapped by Cardno in 2014/2015.

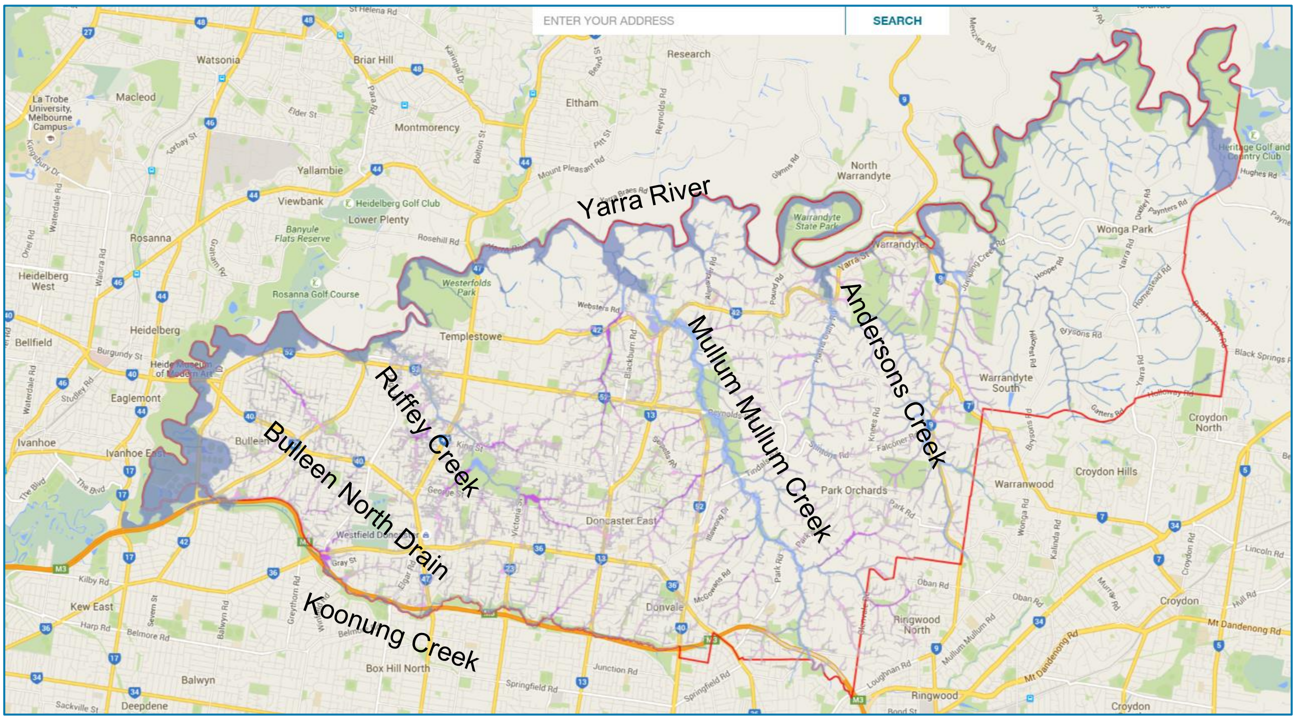

Figure 1- Location of study area catchments

FLOOD MODELLING METHODS

The 5 catchments were modelled in 3 separate studies with the Bulleen North Drain and Ruffey Creek being undertaken by Cardno and AECOM respectively between 2008 and 2013. The Koonung Creek, Mullum Mullum Creek and Andersons's creek catchments were modelled together by Cardno in 2014/15. Each modelling study used similar but slightly different flood modelling methods, however the use of LiDAR aerial survey to inform the models and mapping was common across all the studies.

A summary of the method for each study is provided below:

Bulleen North Drain

This catchment was modelled using a two-dimensional Rain on Grid (RoG) or Direct Rainfall Method (DRM) approach to generate overland flow distributions, depths and velocities. The SOBEK software package by Deltares was used for the modelling. The model utilised a grid resolution of 2 m which is in the range of appropriate values for detailed urban flood modelling.

Standard design rainfalls and losses were applied to the model, along with typical values of hydraulic roughness to characterise the impact of different land-uses on flooding. Appropriate Yarra River tailwater levels were applied for boundary conditions.

The full council pipe network was incorporated into the hydrodynamic model.

As part of this study a sensitivity analysis of the model results was undertaken to assess the potential variability of the model results under a range of conditions. This included; testing of the RoG method against alternative hydrologic approaches, testing the impact of changes to hydraulic roughness and the potential impact of removing part of the council pipe network from the model.

Ruffey Creek

The Ruffey Creek catchment was modelled using a rainfall-runoff approach to develop the design hydrology and a TUFLOW hydrodynamic model for the overland flow routing. The hydrodynamic model used a 4 m grid resolution to define the topography which is within the range of appropriate values for this type of urban flood mapping study.

Standard design rainfalls and losses were applied to the model, along with typical values of hydraulic roughness to characterise the impact of different land-uses on flooding. Appropriate Yarra River tailwater levels were applied for boundary conditions.

The full council pipe network was incorporated into the hydrodynamic model with sub-catchment flows evenly distributed to nearby manholes.

As part of this study a validation of the hydrology and overland routing was undertaken.

Koonung, Mullum Mullum and Andersons Creek

This catchment was modelled using a two-dimensional Rain on Grid (RoG) or Direct Rainfall Method (DRM) approach to generate overland flow distributions, depths and velocities. The TUFLOW software package was used for the modelling, which is a standard requirement of Melbourne Water. The model utilised a grid resolution of 3 m which is in the range of appropriate values for detailed urban flood modelling. The study area was split into a number of sub-areas in order to ensure each model was of a manageable size for simulation and processing purposes.

Standard design rainfalls and losses were applied to the model, along with typical values of hydraulic roughness to characterise the impact of different land-uses on flooding. Appropriate Yarra River tailwater levels were applied for boundary conditions.

The full council pipe network was incorporated into the hydrodynamic model.

As part of this study a detailed reconciliation and validation analysis was undertaken to test the RoG method against alternative hydrologic approaches. This was performed for both the 100 year ARI and 5 year ARI design floods. This resulted in the adoption of higher pervious area runoff coefficients to compensate for the mitigating impact of surface storage on design flow peaks on RoG model.

Discussion

The modelling techniques applied for the different catchment are all considered appropriate for mapping urban flood extents. Discussion on key aspects of the modelling approach for the different areas is provided below.

Model Grid Resolution

It is noted that different hydrodynamic model grid resolutions have been applied in the different catchments; 2 m resolution for Bulleen North Drain, 4 m in Ruffey Creek and 3 m in the Koonung, Mullum Mullum and Anderson Creek catchments. I consider these are all in the range of appropriate resolutions for detailed urban flood mapping studies. There is no single, ideal model resolution that should be applied to these type of studies. The selection of a model set-up for a particular study will typically be based on a number of factors including topographic characteristics of the area, the size of the model domain and expected simulation times. Over the years, model resolutions have generally become finer as computing power has increased, allowing larger grids to be computed in a reasonable time. Through previous investigations and sensitivity testing it has been demonstrated that, in general, a 5 m grid resolution is sufficient to characterise urban flood behaviour. Whilst finer grids may provide a better visual presentation and represent some local topographic features more clearly, it has been found that peak flood depths and extents do not vary greatly with increased model resolution.

For the resolutions utilised in these studies I do not believe there is likely to be any discernible difference, between the areas, in the level of accuracy or reliability in the model outputs, such as flood depth and extent.

Modelling Method

As described in the previous section, 4 of the 5 catchments used the ROG hydrology method whilst the 5th catchment, Ruffey Creek, used a more traditional lumped rainfall-runoff method. The reasoning for the difference in approach is primarily one of timing, although user or authority preference may have played a role in this as well. Until fairly recently (within the last 5 years) the ROG approach to urban flood modelling was not widely accepted by drainage authorities in Australia. There has been caution in adopting the method as many people were not familiar with it and industry standards had not necessarily been updated to incorporate it. This may explain why the Ruffey Creek modelling project, which started around 2008, adopted a more traditional approach that was the accepted practice at the time. Whilst the Bulleen North Drain study occurred at a similar time, it was by a different consultant that may have been more familiar and confident with the use of the ROG method.

Experience over recent years suggests that a RoG approach is better suited to detailed council mapping studies where it is desirable to define flood impact down to the local scale. As described above, it is recognised that the Ruffey Creek study was undertaken some years ago and hence employed a different method to the other studies. The way in which storm flows interact between the pipe network and the surface is considered less “realistic” when a lumped hydrologic model is used and sub-catchment flows are split between manholes in a somewhat arbitrary way. Despite this, the accumulation of excess stormwater flow in low points within the topography, which is where local flooding typically manifests, will generally still be well represented using this method.

The lumped hydrology method assumes a high degree of efficiency in the drainage network and effectively unlimited inlet capacity at manholes as runoff is entered directly into the drainage system. Through this approach shallow surface storage in the upper catchment may be slightly underestimated and local surcharging of pipes overestimated. Subsequently, the Ruffey Creek model could be considered to be slightly conservative in areas where flows have been assumed to enter the pipe system by being evenly distributed to pits within a sub-area. This would typically be in parts of the upper catchment and be represented by slightly greater flood extents in some areas. However, the overall impact on flood depths, velocities and mapped extents is expected to be small.

Model Validation

Each model used some form of validation to reconcile or check design flows against a Rational Method and in some instances, against a RORB model for peak flows. This provides confidence in the flood mapping outputs. Sensitivity testing indicated that peak design flows though the catchments were higher for the RoG models when using standard parameters. This is consistent with literature and suggests that the RoG models explicitly take account of surface ponding that would otherwise flow directly to a catchment outlet in a lumped hydrologic model such as RORB.

Overall, there are sufficient checks on each model to provide confidence that the models developed and results obtained are of an appropriate standard for the planning amendment.

FLOOD MAPPING AND OVERLAY DEVELOPMENT

The development of flood mapping outputs has been consistently applied by Cardno for all 5 catchment areas. This mapping process has used an industry standard approach to filter out unnecessary flood data including areas with very shallow depths and low velocity x depth. Once this filtering is done, it is often common practice to further "thin" the data based on a minimum "puddle" area. That is an area that becomes isolated from the rest of the flood extent because the connecting flow path is too shallow and becomes removed. It is understood that thinning of "puddles" has been undertaken for the proposed flood mapping and overlays based on standard Melbourne Water criteria.

One issue that I have observed in the mapping outputs is the existence of multiple areas of isolated flood extent, particularly in the SBO3 layer. Figure 2 below shows an example section of the online flood overlay map from the Council website. This illustrates there are small sections of SBO3 that are mostly, if not entirely, within the road reserve. It could be argued that these areas do not serve a strong purpose compared to other areas connected to the main flow paths or ponding areas. In many of these places depths are very shallow, no property is directly affected and planning controls or conditions are unlikely to be required. It appears that these areas of shallow depth within the road reserve are unlikely to restrict access or impose any safety risk for evacuation or emergency service access. In my experience this information can be very useful to council officers for understanding nuisance flooding and planning maintenance or mitigation works. However, it is not necessary to include all flood information into an overlay and some manual thinning or cleaning up of the SBO3 layer may be beneficial. Such flood mapping extents may cause unnecessary anxiety within the community and additional work for council planning officers.

Figure 2- Bulleen North Drain – example isolated areas of SBO3

CONCLUSIONS

It can be concluded that:

- The methods and outputs for the 5 catchment areas comprising the Amendment are appropriate for urban flood mapping and the development of flood-related planning overlays.
- Appropriate checks and validation have been made in each study such that the design flow estimates are considered robust.
- A consistent and appropriate method has been applied to the processing of model results to produce mapping outputs and overlays that are relatively consistent across the Municipality.
- It is considered that a number of small, isolated areas of inundation that are not expected to represent any significant threat to life or property could be removed from the SBO3 layer without compromising the appropriate management of flood risk within the area.

Please let me know if you have any questions regarding this information.

Yours sincerely

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WATER TECHNOLOGY