Appendix D AR&R 2016 Sensitivity Memorandum

Memorandum

1 February 2018

To	Sophia Findlay, Ku-ring-gai Council		
Copy to	John Wall, GHD		
From	GHD	Tel	0292397100
Subject	Blackbutt Creek FRMS&P TUFLOW Model Sensitivity Analysis	Job no.	21/25655

1. Introduction

Council requested GHD to undertake a sensitivity analysis on the original TUFLOW model developed for the Flood Study by updating the hydrology to represent the Australian Rainfall and Runoff (AR&R) 2016 rainfall conditions.

The original TUFLOW model adopted for the Blackbutt Creek Floodplain Risk Management Study and Plan (FRMS&P) included the 20%, 10%, 5%, 2% and 1% Annual Exceedance Probability (AEP) storm events. These were modelled using the design rainfall from AR&R 1987 storms in DRAINS.

Since the time of original model development, the release of AR&R 2016 has resulted in a different method for development of design rainfall and hydrological conditions.

This memorandum describes the updates made to the hydrologic and hydraulic models and summarises the results of the investigation.

2. Update of Model

2.1 Hydrological assessment using AR&R 2016 for 1% AEP

As agreed during consultation with Council, the DRAINS hydrologic model used to simulate the Blackbutt Creek catchment flows developed during the Lane Cove River Southern Region – Local Catchment Plan (URS, 2005) was utilised. This model was updated to reflect the same catchment parameters as the Blackbutt Creek Flood Study (SKM, 2014) DRAINS model.

The changes to sub-catchments' parameters, coupled with the AR&R 2016 rainfall inputs, were added to the model and simulated within the DRAINS model for the 1% AEP event for 6 different duration events, 15, 25, 60, 90, 120 and 180 minutes. The model was simulated for a range of temporal patterns as specified by AR&R 2016 guidelines. From these simulations, the peak flow resulting in the median compared to other temporal patterns were compared to the Regional Flood Frequency Estimation (RFFE) technique, as agreed with Council and in line with AR&R 2016 recommendations, which state hydrologic flows should be compared to an alternate estimation technique. These results are discussed further below.

Table 1 shows the ARR 2016 design rainfall pattern and Table 2 shows the estimated catchment outlet flows for a range of storm durations based on AR&R 2016. The 25 minute storm resulted in the peak outflow for the catchment of 105.1 m^3/s

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Table 1 Design Rainfalls for Identified Durations

Duration (minutes)	Depth (mm) (AR&R16)
15	43
25	54.2
60	74.4
90	85.5
120	94.8
180	151

Table 2 Areal Reduction Factors (ARFs)

Duration (minutes)	15	25	60	90	120	180
Areal Reduction Factor (ARF)	0.93	0.95	0.98	0.99	1	1

Table 3 DRAINS 1% AEP Peak Flow Rates at catchment outlet

Duration (minutes)	Flow (m^3/s) (AR&R16)	Flow (m3/s) (AR&R87)
15	79	123
25	99*	155
60	99	179*
90	84	176
120	91	170
180	61	135

* denotes peak flow rate

The ILSAX loss model was used in DRAINS involving depression storages and the Horton infiltration model for pervious areas. Key parameters are summarised in Table 4. Note the ARR 2016 storm loss parameters were determined for rural use only and are not for use in urban areas.

Table 4 DRAINS Hydrological Loss Parameters

Paved area depression storage	1 mm
Supplementary area depression storage	1 mm
Grassed area depression storage	5 mm
Soil type (infiltration rate)	3 (moderate to slow)

Temporal patterns have been provided by the AR&R 2016 data hub. The relevant temporal region for the Blackbutt Creek catchment is the East Coast South region according to AR&R 2016 Book 2 Figure 2.5.7.

Figure 1 and Figure 2 show the variation in the peak flows for the different temporal pattern storm events at the outlet of the catchment and at a randomly selected sub-catchment at the top of the catchment.

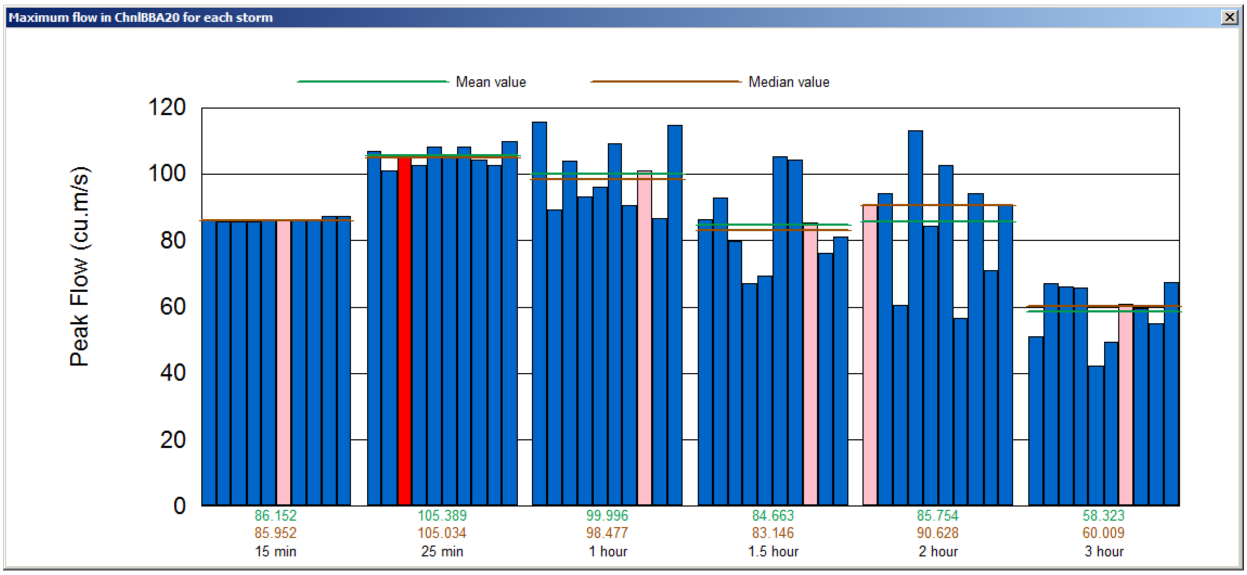


Figure 1 Peak Flow Results for Individual Storm Events (Catchment Outlet)

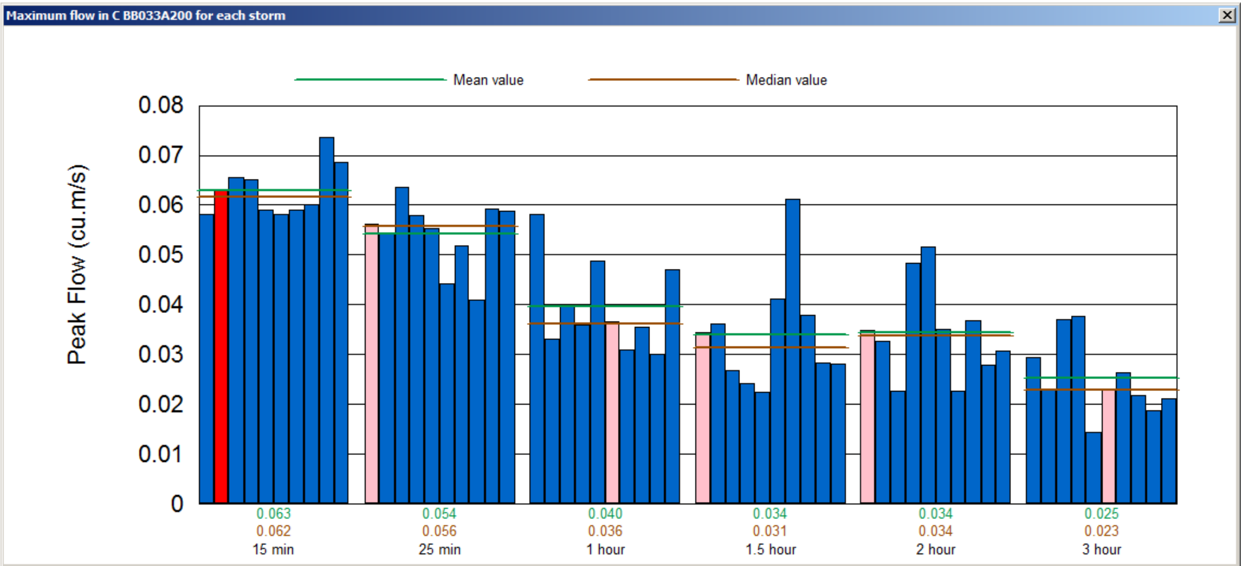


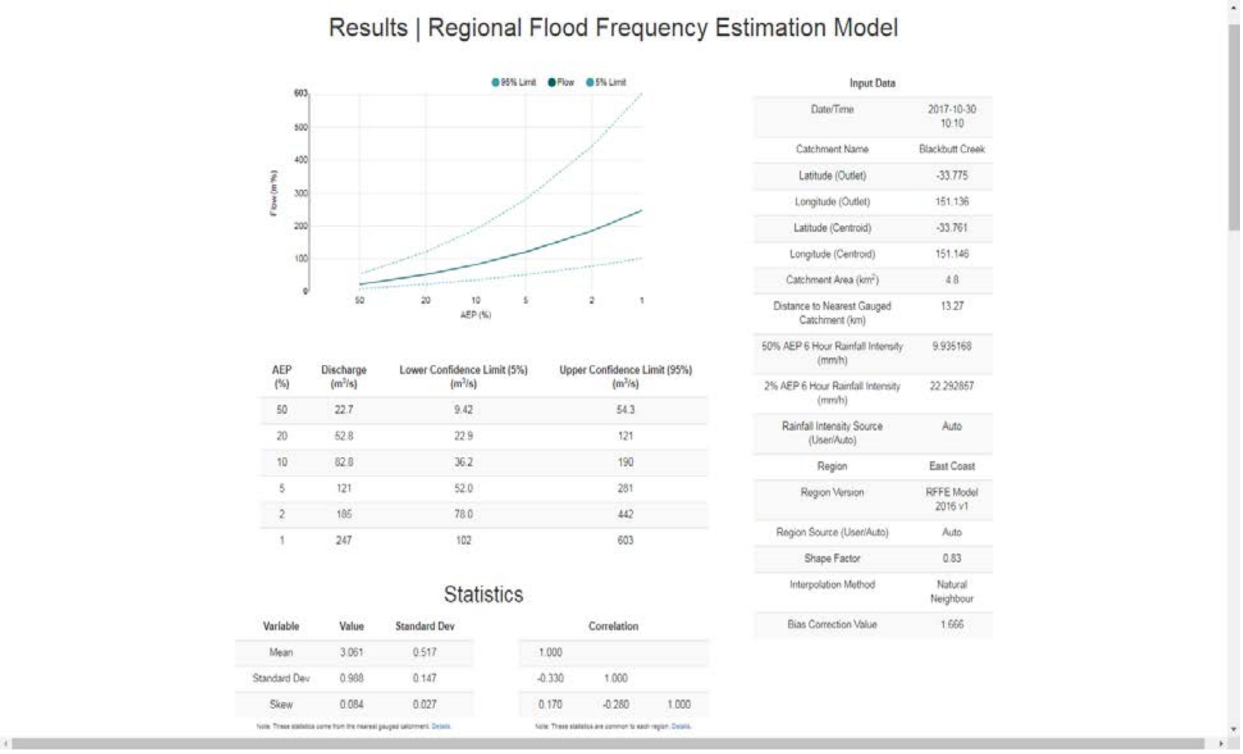
Figure 2 Peak Flow Results for Individual Storm Events (Top of Catchment)

2.2 Regional Flood Frequency Estimation (RFFE)

The RFFE method utilises a purpose built tool developed as part of the AR&R 2016 project by a number of different contributors. The method looks at estimating flows in regional catchment where no historical flow data exists by utilising a wide database of gauged catchments across Australia to estimate the flows for the catchment of interest. The tool requires the input of the coordinates for the centre of the catchment, the outlet of the catchment and the catchment area.

From this data, the tool calculates an estimate of the catchment flow for a number of AEP events. These estimates are given, along with estimates to 5% and 95% Confidence Limits.

Figure 3 shows the results derived from the RFFE tool.



AEP (%)	Discharge (m^3/s)	Lower Confidence Limit (5%) (m^3/s)	Upper Confidence Limit (95%) (m^3/s)
50	22.7	9.42	54.3
20	52.8	22.9	121
10	82.8	36.2	190
5	121	52.0	281
2	185	78.0	442
1	247	102	603

Statistics

Variable	Value	Standard Dev	Correlation		
Mean	3.061	0.517	1.000		
Standard Dev	0.988	0.147	-0.330	1.000	
Skew	0.084	0.027	0.170	-0.280	1.000

Input Data

Date/Time	2017-10-30 10:10
Catchment Name	Blackbutt Creek
Latitude (Outlet)	-33.775
Longitude (Outlet)	151.136
Latitude (Centroid)	-33.761
Longitude (Centroid)	151.146
Catchment Area (km^2)	4.8
Distance to Nearest Gauged Catchment (km)	13.27
50% AEP 6 Hour Rainfall Intensity (mm/h)	9.935168
2% AEP 6 Hour Rainfall Intensity (mm/h)	22.292857
Rainfall Intensity Source (User/Auto)	Auto
Region	East Coast
Region Version	RFFE Model 2016 v1
Region Source (User/Auto)	Auto
Shape Factor	0.83
Interpolation Method	Natural Neighbour
Bias Correction Value	1.666

Figure 3 - RFFE Results

From the result shown above, the predicted peak discharge for the 1% AEP event is 247 m^3/s, which is much larger than the DRAINS model predicts (105 m^3/s). The results also show the Lower Confidence Limit (5%) value is 102 m^3/s, which compares more favourably to the DRAINS model prediction of 105 m^3/s. The graph also shows that there is a large amount of uncertainty at the 1% AEP event level, this being evident in the wide range of the peak flow that is predicted. The upper bound is 603 m^3/s, which is almost 2.5 times greater than the predicted peak discharge, with the lower bound of 102 m^3/s being less than half the predicted peak discharge.

The large differences between the DRAINS and the RFFE results can be attributed to a number factors, most notable the fact that the RFFE method is recommended for use on ungauged and generally undeveloped catchments. Blackbutt Creek is ungauged but is definitely not undeveloped. Secondly, the method is dependent on the proximity of the gauges used in the estimation to the area of interest (in this case the Blackbutt Creek catchment). The nearest gauged catchment sourced for this estimate is around 14 km from the Blackbutt Creek catchment, but the furthest is over 100 km away. Also, the size of the catchments used to derive the estimate is quite different, with the smallest being 35 km^2 and the largest over 1,000 km^2 compared to the Blackbutt Creek catchment which is 4.8 km^2.

Also of note, the comparison peak flow rate from DRAINS (105 m^3/s), is the peak flow rate for the median temporal pattern. Statistically, there are other temporal patterns applied within the DRAINS hydrology that produce a higher peak flow. Hence, another DRAINS flow estimate may be closer to the RFFE estimate but is not used in the comparison, in this instance.

2.3 Hydraulic assessment using updated hydrologic model results.

Following completion of the revised hydrologic assessment, the hydrographs generated from DRAINS were input into the TUFLOW model by updating the boundary conditions. A suite of hydrographs was developed for several durations in the 1% AEP event, including the 15, 25, 60, 90, 120 and 180 minute design storm durations.

The updated TUFLOW model was then run for each of these durations, and critical flow conditions (including depth and velocity) were determined throughout the catchment area.

3. Existing Flooding

The existing TUFLOW flood model for the Blackbutt Creek catchment area was provided to GHD by Council. This included detailed modelling results, which were processed to carry out the comparison with the results from the updated TUFLOW model. The 1% AEP event results from the original flood study were utilised for purposes of direct comparison with the updated model.

4. Change in Flood Behaviour

Utilising the updates described above, difference plots were created for the maximum velocities and water levels of the 1% AEP storm using the “no blockage” scenario (All Clear).

Mapping of the modelling results is provided in Figure 4 and Figure 5. The flood level afflux is illustrated in coloured shading and areas either “Extent Now Dry” or “Extent Increase” are shown as red and black shading.

4.1 Flood Level Impact

Changes in Flood Level are shown in Figure 4. These reflect the difference in flood levels when comparing results from the original Flood Study model using AR&R 1987 rainfall conditions, and the updated scenario run with AR&R 2016. The changes in flood levels have been chosen for comparative purposes as they are important for determining flood planning extents, as well as influencing risks to adjacent and surrounding developments.

Review of the flood level differences in Figure 4 shows a general trend towards reduction in flood levels across the catchment area. The largest reduction in levels are primarily in the main channel of Blackbutt Creek, with typical reductions of 0.3 m – 0.5 m. These areas are mainly located in areas not occupied by residences and hence, will likely have little impact on the community. Flood differences of between -0.01 m and +0.01 m were filtered from the flood maps as these were considered within the TUFLOW model’s margin of computational error. Typical reductions of 0.01 m to 0.1 m were observed where overland flow paths converge, though most of these differences were also within channelized flow sections adjacent to properties. Most of the level changes in areas, which affect the community, were less than 0.01 m and within the TUFLOW model’s normal margins of computational error, although areas of notable concern, namely Vale and Dumaresq Streets, as well as, St John’s Avenue, show larger differences (reductions), generally around 0.12 m and 0.05 m, respectively.

Some larger changes in flood levels were observed in specific locations through the catchment area. Reductions in flood levels of up to 0.3 m were observed at properties on Calvert Avenue, Gleneagles Avenue and Bowes Avenue. Another area of note is just upstream of the Blackbutt Creek crossing at Ryde Road, where reductions of up to 0.5 m were observed. Reductions of up to 0.3 m were also observed at the downstream end of the dam at Killara Golf Club.

Figure 4 also highlights areas, which were shown to be flooded in the Flood Study and are now dry (Extent Now Dry), as well as previously dry areas now shown to be wet (Extent Increase). These areas are of low depth and also low velocity and, as such, were removed from the Flood Study mapped results. The same ‘cleaning up’ process has not been undertaken for the mapping of the results for this sensitivity check, although the depths were checked and are generally less than 0.05 m and velocities less than 0.1 m/s, and hence, will have little influence on outcomes of the FRMS&P.

4.2 Flood Velocity Impact

Changes in Flood Velocity are shown in Figure 5. Flood velocities are critical to understanding the hazard level and scour potential throughout the catchment area.

Review of the existing flood velocity data shows typical velocities of approximately 0.0 to 1.0 m/s present in residential sections for the existing scenario. Channelized sections further downstream indicate velocities of between 1.0 m/s and 8.0 m/s at the downstream end of Blackbutt Creek.

A comparison of results shows that typical reductions in velocities of approximately 0.1 to 0.2 m/s were present in some residential areas, and typical velocity reductions of up to 0.8 m/s in the main channel of Blackbutt Creek.

Some localised decreases in velocity were present just west of Golf Links Road, which is also where a reduction in flood levels of up to 0.3 m was identified. Significant reduction in flood velocities were also identified just downstream of the Blackbutt Creek crossing at Ryde Road. Also, a review of flood levels at this location shows a reduction of 0.5 – 0.6 m, which would likely contribute to the localised reduction in velocities.

5. Conclusion

The results shown in the mapping compare the updated flooding results (AR&R16) to the Flood Study results. The differences are generally minor throughout areas that are developed, with differences of around –0.05 m and +0.05 m. The extent of flooding through the floodplain largely remain unchanged, with some areas of low level flooding in the Flood Study results, having zero flooding (a reduction in extent) in this sensitivity study.

Velocity results show some areas of localised changes. Through developed areas of the catchment, velocity changes were only relatively small (0.1 to 0.2 m/s).

Based on the sensitivity analysis using the AR&R16 hydrology, it is recommended that Council continues to adopt the flood mapping undertaken for the Flood Study for its floodplain risk management activities.

Regards,

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