Memorandum

TO: Queensland Floods Commission of Inquiry
FROM: Mark Babister
DATE: 7 October 2011
SUBJECT: Response to Peer Reviews of WMAwater's *Brisbane River 2011 Flood Event - Flood Frequency Analysis* (Sept 2011)
PROJECT NUMBER: 111024

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1 This document addresses various comments and issues raised by the two independent reviews of our *Brisbane River 2011 Flood Event - Flood Frequency Analysis* (WMAwater, September 18th 2011, Reference 9) report:

- *Brisbane River 2011 Flood Event – Flood Frequency Analysis – Review of report by WMAwater*, Dr Rory Nathan, SKM, 28th September 2011
- *Review of Brisbane River 2011 Flood Frequency Analysis* – Dr Michael Leonard, Uni of Adelaide, 26th September 2011

Background

2 We thank both reviewers for their comments. We note that on most matters there is a commonality in opinion between the reviewers. However there are differences. This document does not attempt to address every minor issue raised by the reviewers, but instead addresses the main questions raised by the reviewers and adds clarification where our original explanation was not adequately understood. In preparing this response some discussion has been held with Dr Leonard.

3 Both reviewers have in broad terms endorsed the:
- methodology used to develop the high flow rating curve
- approach used in the flood frequency analysis, and
- pre dam Q100 estimate of 13,000 m^3/s (noting the uncertainty about the estimate).

4 The main issues raised by the reviewers are:

- Dr Nathan (Reference 11) has rejected the approach used to convert pre dam flows to post dam flows and hence the post dam flood levels.

- Dr Nathan has presented some additional observed debris marks for the 2011 event (Figure 3) that in some locations contradict the flood levels presented in the Joint Task Force 2011 report.
- Dr Nathan has raised questions, based on the debris marks, about the design flood profiles presented in our report.
- Dr Leonard (Reference 10) believes we have used implicit knowledge of the 2011 event to determine the post dam estimate.
- Both reviewers recommend the use of Monte Carlo (stochastic) analysis.

Monte Carlo Analysis

5 Both reviewers noted that our report (Reference 9) did not recommend Monte Carlo (Stochastic) Analysis to address the complex joint probability problem when determining flood levels under current conditions (post dam). It is our firm view that a Monte Carlo (Stochastic) would be the most appropriate method of addressing this problem as was recommended in our earlier report (May 2011, Reference 7) to the Commission and in The Commissions Interim Report. We did not reiterate this major recommendation because it had already been covered.

6 We understand that Dr Leonard was not aware of the recommendations in our May report when conducting his review but we find it curious that Dr Nathan who was well aware of this report and its associated expert testimony chose to ignore this fact. The two key quotes from our May 2011 report are set out below (we have used the term Stochastic instead of Monte Carlo).

> *"Substantial revision of the design hydrology methodology should be considered, preferably including a stochastic framework that can reproduce reasonable natural variability in the flood characteristics identified above, through the use of a suite of plausible temporal and spatial rainfall patterns." WMAwater, May 2011, Paragraph 123 (Reference 7).*

> *"The design modelling that was first developed in 1983 should be updated to take full advantage of new techniques for design hydrology and improvements in computing power. This should include an investigation of longer duration floods and larger inflow volumes, preferably using an ensemble or stochastic modelling process where a range of plausible temporal and spatial patterns are considered for a full range of flood events..." WMAwater, May 2011, Paragraph 173 (Reference 7).*

7 It is also part of the recommendations (2.10 to 2.13) of Queensland Floods Commission of Inquiry Interim Report that a "Stochastic or Monte Carlo or Probabilistic Approach" be used.

Pre Dam to Post Dam Conversion

8 While we thought that Figures 2 – 5 (Reference 9) and the associated text, on the pre to post dam relationship were largely self explanatory we accept the reviewer comment that more explanation was required.

9 The intent of these figures was to demonstrate the variability of pre dam to post dam flows and that there is no fixed ratio as this will vary from one event to the next. It was for this reason that the approximate zone of influence (solid orange line) was drawn around these values. The key aspect of Figures 2 – 5 (Reference 9) is that they include the best estimates of 1893, 1974 and 2011 events, as well as a number of synthetic (design) events. An updated version of Figure 3 is attached which includes a range of plausible adjustments for the impact of Somerset dam. It also shows the most likely zone of influence based on the scatter of the data points.

10 Figure 2 mainly contains Seqwater (Reference 12) and DNR data, while nearly all the points on Figures 3 - 5 were extracted from modelling work carried out by SKM (Reference 6). Even though Figure 2 is derived from different data sets it has a very similar shape to Figures 3 - 5.

11 It is important to understand that for all actual historical flood events either the pre or post dam value has to be estimated using complex modelling that adjusts for the presence or otherwise of the dam. For example the 1893 flood would have been modelled for post dam impacts. For synthetic events both pre and post dam flows are estimated using modelling. All of these events (historical or synthetic) represent the impact of a hydrologic loading on the catchment with and without dams. The historical events are important as while they do not represent the full complexity of the individual historical events they do embody the core characteristics (temporal and spatial patterns) and therefore are a good predictor of real catchments response. Of these the 2011 event is the most important as there is no uncertainty on how the operating procedures would have been carried out. The actual probability of the synthetic events are not that important in this application as they are only considered as hydrologic loadings, it is however important that they have plausible characteristics.

12 Using models it would be possible to add additional data points to these graphs. This would be best done by using a range of design rainfalls with observed temporal patterns and appropriately scaled spatial distributions. If the graph were sufficiently populated it could be used as part of a joint probability exercise to determine post dam flows from pre dam flows. The variability seen on these graphs represents the influence of many of the factors discussed by Dr Nathan in Paragraph 37 Reference 11. When the data points on these graphs are considered as hydrologic loadings there is no "circular" argument as suggested by Dr Nathan (Reference 11, paragraph 19, 55).

13 The 3 historical events (1893, 1974 and 2011) on Figure 3 are described by Dr Nathan as a "miserably small" dataset, they show a dam performance which is very different from the 2003 Review Panels 12 000 m^3/s pre dam to 6000 m^3/s post dam (Reference 5) and SKM (2003) 12 000 m^3/s pre dam to 6500 m^3/s post dam and all 3 events are larger than 6500 m^3/s. This raises serious concerns about the 2003 pre to post dam conversion as not one historical event supports it and it is hard to accept all 3 events are outliers.

14 While we still recommend a full Monte Carlo approach the advantage of this approach would be it doesn't need to make assumptions about the probability of design rainfall or design losses and can be used as a check.

15 Dr Leonard (Reference 10) has suggested that we have used implicit knowledge of the 2011 event to estimate post dam Q100 flow. While we were clearly aware of the dams impact on the 2011 event we believe that the estimate is valid without being aware of this event and makes best use of

the behaviour of large events that were known prior to 2011 (orange dashed line (estimation line) on Figure 3).

Comments of the SKM 2003 Models and Estimates

16 Dr Nathan (Reference 11) suggests that the SKM (2003) study (Reference 6) is the best available information and that *"the findings of the study were independently reviewed and endorsed by an independent panel."* The flood frequency analysis conducted by SKM at Savages Crossing represents best practice. The following commentary raises a number of issues have been documented by others in relation to the data and models used by SKM.

Rainfall

17 One of the concerns of the 2003 Review Panel (Reference 5) was a major misclosure between the Flood Frequency Analysis and the design rainfall method. The implications of this were that the modelling may have substantially underestimated the volume. Sargent (2006a, Reference 13) found a number of issues with the SKM (2003) work when conducting an analysis for Ipswich. Sargent (2006a, Reference 13) found that the CRC FORGE rainfall had been incorrectly input into the RAFTS model for the 24, 30, 36 and 48hr durations.

18 Sargent notes that of the SKM study that:

> *"… the effective rainfalls on the sub areas (i.e. input rainfall minus losses) were consistently lower than those applied in the current study. It was also confirmed that the applied losses were identical, so it was concluded that the input rainfalls were less than those provided in the CRC-FORGE spreadsheet." Sargent 2006a Section 5.1 , Page 11, para 2 (Reference 13)*

19 Once Sargent corrected the rainfalls the misclosure between the FFA and the design rainfall method was removed (refer to Table 1). The corrected pre dam RAFTS estimate is within 3% of the WMAwater estimate of 13 000 m^3/s (Reference 9).

Table 1: Comparison of RAFTS Model Peak Flow Estimates (Reproduced from: Sargent, 2006a, Reference 13). Note Current Study refers to Sargent 2006a.

Location	***Peak Flows (m³/s) for Storm Durations of***				
	24 Hrs	***30 Hrs***	***36 Hrs***	***48 Hrs***	***72 Hrs***
a) Values from SKM (2003) Table 4-2					
Savages Crossing	*8,387*	***9,607***	*8,379*	*8,626*	*9,192*
Moggill	*7,607*	*9,015*	*7,588*	*8,004*	***10,101***
Brisbane Port Office	*7,608*	*9,015*	*7,589*	*8,005*	***10,106***
b) Current Study					
Savages Crossing	*9,700*	***13,140***	*11,400*	*9,700*	*9,100*
Moggill	*8,600*	***12,600***	*11,800*	*10,000*	*10,200*
Brisbane Port Office	*8,600*	***12,600***	*11,800*	*10,000*	*10,200*
Difference between b) and a) %					
Savages Crossing	*+16%*	*+37%*	*+36%*	*+12%*	*+9%*
Moggill	*+13%*	*+40%*	*+56%*	*+25%*	*+1%*
Brisbane Port Office	*+13%*	*+40%*	*+56%*	*+25%*	*+1%*
NOTE: Critical duration values shown in bold type					

RAFTS Modelling

20 Further, Sargent (2006a, Reference 13) also found the SKM (2003) RAFTS model has been set up in a very unorthodox way. Typically for a large rural catchment flow is routed through the each subcatchment or river reach. However, an approach often used for an urban situation has been used, where flow in each reach has been simply lagged without attenuation. Most of the attenuation takes place in a small number of large conceptual storages including the:

- Confluence of the Brisbane River and the Bremer River, and
- Confluence of the Brisbane River and Lockyer Creek.

21 Given these two large conceptual storages are just above two major calibration points, Moggill and Savages Crossing, there is serious concern that these storages are the only locations where the model estimates are reliable. Sargent (2006a, Reference 13) also found that these conceptual storages produced very different routing behaviour for different storm durations.

Hydraulic Model

22 KBR (2002, Reference 14) found that the use of the resistance radius method in the Mike 11 model developed by SKM was having major effects on the models behaviour for events that were not a similar order of magnitude to the calibration event. KBR (2002, Reference 14) recommended switching to the total area hydraulic radius procedure.

> *"In general, the conveyance value calculated in the previous study has been overestimated using the Resistance Radius procedure. The adoption of the new procedure for calculating hydraulic radius has increased water levels in some locations despite the significant reductions in Manning's n roughness". KBR, 2002, page 2* (Reference 14)

23 This finding regarding resistance radius is similar to the findings of the WMAwater 2011 Hydraulic Modelling Report (Reference 8) which also identified issues with the use of the resistance radius method in this catchment.

Observed peak flood level data for the January 2011 flood event

24 At the time of issuing WMAwater's Flood Frequency Analysis report (Reference 9), the only datasets available that contained information on peak flood levels for the January 2011 floods were the peak flood level marks indicated in Table 3 of the Joint Task Force March 2011 report (Reference 15) and stream gauge station observations along the Brisbane River.

25 In his response Dr Nathan (Reference 11, Figure 3) refers to observed data points for the 2011 event collected by Brisbane City Council that are different to those listed in the Joint Task Force March 2011 Report. The Joint Task Force (2011, Reference 15) did note that the observed levels contained within the report were draft and subject to verification.

26 The data points used by Dr Nathan were not made available to WMAwater and no source is included in Dr Nathan's review. As a result further assessment was not possible as the data points have not been tabulated. However, if these data points prove to be more reliable than the Joint Task Force March 2011 levels then these data points would suggest that the calibration of the Mike 11 model was not as poor as originally thought. Figure 3 would suggest that within 10km up and downstream of Jindalee the Mike 11 model fits the observed data reasonably well. There are still some issues with the calibration between Oxley Creek and the Port Office.

Clarification of method used to derive flood profiles

27 Dr Leonard (Reference 10) has wrongly interpreted that WMAwater calibrated the Mike 11 model to fit the 2011 Joint Taskforce data (Reference 15) and used this revised model to determine the 1% AEP levels.

28 WMAwater did not use the Mike 11 model to determine the 1% AEP levels because it was not practical to recalibrate the model in the time available. An alternative approach was undertaken by WMAwater to obtain a reasonable estimate of the Q100 levels along the Brisbane River (from Moggill to Brisbane Port Office). The basis of this approach was to utilise the observed peak flood level marks along Brisbane River (Reference 15), to derive the January 2011 peak flood profile. The Mike 11 model was used to estimate how far flood levels for design flows of 9500 m^3/s and 9000 m^3/s were below the January 2011 flood of approximately 9850 m^3/s.. Because the Joint Task Force flood levels were a fair distance apart a straight linear interpolation between the points was not considered appropriate. The shape of the flood profile between the observed flood levels was guided by the shape of the Mike 11 profile for the 2011 event.

29 While it would be better to recalibrate the model this approach is can be readily applied to the new dataset reported by Dr Nathan or any subsequent dataset. The flood levels for post dam design flows of 9500 and 9000 m^3/s can be presented relative to the 2011 observed flood levels. Table 2 shows the height of the revised Q100 lines relative to the 2011 flood levels. The values in the table

can be easily interpolated to determine design levels at any location where there is a reliable measurement of the 2011 level.

Table 2: Height of the Q100 below the 2011 flood level

Location	Height of the WMA Q100 (9500 m^3/s) below the 2011 level (mm)	Height of the WMA Q100 (9000 m^3/s) below the 2011 level (mm)
13 Bridge St., Redbank (off-bank)	400	980
Cnr. Ryan St. and Woogaroo St., Goodna	410	980
Cnr. Moggill Rd. and Birkin Rd., Bellbowrie (off-bank)	410	960
Cnr. Thiesfield St. and Sandringham Pl., Fig Tree Pocket	360	800
312 Long St. East, Graceville	340	730
Brisbane Markets, Rocklea	330	710
Softstone St., Tennyson (Tennyson Reach Apartments)	320	700
15 Cansdale St., Yeronga (off-bank)	270	610
42 Ferry Rd., West End	200	490
81 Baroona Rd., Paddington (off-bank)	180	460
Brisbane City Gauge	140	390

Flood Frequency Analysis - Data

30 While both reviewers have endorsed the pre dam flood frequency estimate as reasonable, the following issues raised by the reviewers are addressed.

31 Dr Nathan (Reference 11 Paragraph 33) writes that "*It is not clear why WMAwater did not critically review the extensive flood frequency analysis undertaken by SKM (2003).*". The main reason was that it was not undertaken at the Port office and could not be considered an "at site analysis" as Savage's Crossing, is considerable distance upstream (in the order of 100km) of the Port Office Gauge. While flood frequency estimates at Savages Crossing can be translated downstream it is necessary to assume that the attenuation over this long reach is exactly balanced by the Bremer inflows. For this reason the SKM (2003) (Reference 6) estimate was not included in the list of similar estimates in Paragraph 131 (Reference 9). It should be noted that the two estimates referenced were within approximately 5-6% of our estimate which is very different to the 30% bounds discussed by Dr Nathan.

32 Dr Nathan also questions why the 1999 December City Design (Reference 4) Q100 estimate was not included in the list of similar estimates. The Q100 pre dam in the version of the City Design December 1999 report provided to WMAwater contains no text regarding how this estimate (which is contained in a figure in the partial Appendix A provided) was derived.

33 Footnote 2 of Dr Nathan's review (Reference 11) suggests the flood level data used in Appendix B of our report was incorrectly attributed to SKM and should be City Design June 1999. WMAwater have been provided with 2 separate versions of the June 1999 Brisbane River Flood Study, neither of which are complete and one of which has an SKM logo on the front cover. Dr Nathan will no doubt understand the confusion with so many versions of reports floating around as he has himself mistakenly referenced the December 1999 City Design Report as the June 1999 report (Table 1, Reference 11).

34 Dr Nathan raised several questions about the assumptions behind some of the data used in the flood frequency analysis.

35 Two inconsistent flow values are given in Table 1 of City Design June 1999 (Reference 3) for the 1931 flood event: 7000 m^3/s and 6245 m^3/s. The table suggests that the removal of the dams reduce the flow. This makes no sense as even Somerset dam wasn't in place in 1931 and its removal would make flows go up. The flow value of 7000 m^3/s was used as it was more compatible with the other data.

36 The 1974 pre dam flow of was based on a consideration of estimates with Somerset dam (described in Paragraph 101 of Reference 9). These estimates range from 9800 to 10 900 m^3/s. Greater emphasis was put on the upper end of the range which is more consistent with the adopted rating curve. City Design (June 1999, Reference 3) suggests at the Port Office the adjustment to pre Somserset dam is 490m^3/s. While other sources suggest this adjustment may be higher. A pre dam estimate of 11 300 m^3/s was adopted.

37 The 2011 pre dam estimate was developed using the SKM pre dams 2011 flood level of 6.4mAHD (Reference 16, Table 7-2 Case 5) and the adopted rating curve.

References

1. SKM
   Brisbane River Flood Study
   Brisbane City Council, June 1998.

2. Mein, R.
   Brisbane River Flood Study Review of Hydrological Aspects
   Monash University December 1998.

3. City Design
   Brisbane River Flood Study
   Brisbane City Council, June 1999.

4. City Design
   Further investigations into the Brisbane River Flood Study
   Brisbane City Council, December 1999.

5. Mein, R., Apelt, C., Macintosh, J., Weinmann, E.
   Review of Brisbane River Flood Study
   Independent Review Panel, 3 September 2003.

6. SKM
   Brisbane River Flood Study - Further Investigation of Flood Frequency Analysis Incorporating Dam Operations and CRC-Forge Rainfall Estimates - Brisbane River
   December 2003.

7. WMAwater
   Report to the Queensland Floods Commission of Inquiry
   May 2011

8. WMAwater
   Review of Hydraulic Modelling – Queensland Floods Commission of Inquiry
   July 2011

9. WMAwater
   Brisbane River 2011 Flood Event – Flood Frequency Analysis
   September 2011

10. Dr Michael Leonard, Uni of Adelaide
    Review of Brisbane River 2011 Flood Frequency Analysis
    26th September 2011

11. Dr Rory Nathan, SKM,

Brisbane River 2011 Flood event – Flood Frequency Analysis – Review of report by WMAwater,
28th September 2011

12. SEQ Water
Report on the Operation of Somerset Dam and Wivenhoe Dam
March 2011.

13. Sargent Consulting
Ipswich Rivers Flood Study Rationalisation Project Phase 3 – "Monte Carlo" Analysis of Design Flows
January 2006

14. Haliburton KBR
Ipswich Rivers Flood Studies – Lower Bremer River Flooding Report
8 May 2002

15. Joint Flood Taskforce
Independent Review: Joint Flood Taskforce Report
8 March 2011.

16. SKM
Joint Calibration of a Hydrologic and Hydrodynamic Model of the Lower Brisbane River –Technical Report
Seqwater, 24 June 2011

17. SKM
Joint Calibration of a Hydrologic and Hydrodynamic Model of the Lower Brisbane River –Technical Report
Seqwater, 5 Aug 2011

Port Office - Pre and Post Dam (Updated Figure 3)