BMT WBM

Queensland Floods Commission of Inquiry Technical Review of Flood Frequency Analysis Report by WMAwater (12 October 2011) on Ipswich Flood Frequency Analysis

prepared for

Ipswich City Council

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October 2011

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Prepared For:	Ipswich City Council
Prepared By:	BMT WBM Pty Ltd (Member of the BMT group of companies)

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1 PURPOSE AND SCOPE OF THE REPORT

This Report has been prepared by Neil Collins. Neil's CV is included in Appendix A.

This Report documents a desktop review of a report prepared by Mark Babister of WMAwater dated 12 October 2011 (received 13 October 2011) for the Queensland Floods Commission of Inquiry, entitled 'Supplementary Report – Ipswich Flood Frequency Analysis – Final Report' (**Ipswich Frequency Report**).

In accordance with the timetable stipulated by the Queensland Floods Commission of Inquiry (**the Commission**) review reports of the Ipswich Frequency Report were required to be completed by 4 p.m. 20 October 2011, less than five full business days after receipt of the Ipswich Frequency Report. There has been insufficient time for a thorough review of the Report, to re-run models used or to construct independent models. We have therefore concentrated on three elements of the analysis that are critical to the conclusions drawn, being:

- The Savage's Crossing flood frequency analysis from which the ARI 100 year Brisbane River flow is derived.
- The 'conversion' of Warrill Creek / Brisbane River flow correlations to Bremer River / Brisbane River correlations.
- The derived flood levels at David Trumpy Bridge in Ipswich (Ipswich CBD) based on MIKE11 flood modelling.

The key conclusion drawn by WMAwater (at 78) is that the estimated 1% AEP flood level at Ipswich (David Trumpy Bridge/CBD) is RL20.6m. This conclusion is adopted despite the large uncertainty in predictions which are acknowledged in the Report (including at Section 4.5). We do not agree with either the inferred accuracy or the magnitude of this assessment, and this report details inaccuracies and uncertainties associated with the above three elements of analysis in this report which we consider make the key conclusion and other conclusions arrived at by WMWwater unreliable.

In summary, the analysis conducted by WMAwater:

(a) is likely to have introduced an overly conservative 'high bias' (Weinmann, October 2011) into the flood frequency analysis that would have led to an overestimation of flow for the 1% AEP event;

(b) is heavily reliant on a direct catchment area proportioning conversion of Warrill Creek / Brisbane River flow relationship to a Bremer River / Brisbane River, with the assumption that proportional flows would have occurred in the Bremer River to those that occurred in Warrill Creek. This was not the case in either the January 2011 floods or the 1974 floods;

(c) relies heavily on the use of the existing MIKE11 flood model to predict flood levels at Ipswich CBD when this model is known to be inaccurate as acknowledged in WMAwater's July 2011 report on 'Review of Hydraulic Modelling';

(d) does not use both the statistical flood frequency analysis and simulation modelling of design flood events as previously used and recommended by independent expert panel reviews [1]; and

(e) most importantly, the analysis has been prepared in isolation of the Wivenhoe and Somerset Dams Optimisation (WS DOS) study that is underway, and these works need to be completed before definitive conclusions of event frequency and the ARI 100 year flood line are reached.

The WS DOS study will carry out flood frequency analysis for several gauges, will update hydrologic and hydraulic models and will use these models to conduct simulation modelling of design flood events as a cross-check on the frequency analyses. In order to update the hydrologic and hydraulic models, new bathymetric survey is required of the Brisbane and Bremer river systems, as significant scour and siltation occurred during the January 2011 flood event. The Ipswich Frequency Report by WMAwater has relied on the existing MIKE11 hydraulic model to translate flood levels for the ARI 100 year event despite significant discrepancies between actual and predicted flood levels for the January 2011 event having already been identified (WMA Water's July 2011 'Review of Hydraulic Modelling' Report).

[1] Independent Review Panel 'Review of Brisbane River Flood Study, to Brisbane City Council' September 2003, and 'Joint Flood Taskforce Report', to Brisbane City Council, March 2011

2 GENERAL COMMENTS

The joint probability flood frequency analysis approach to Bremer and Brisbane River flooding is supported, though there are a variety of ways this can be carried out, including Monte Carlo simulation modelling as recommended in the 2003 Independent Review Panel Report to Brisbane City Council. That Report also recommended the use of both flood frequency analysis and simulation modelling.

WMAwater acknowledge the need for substantial revision to both hydrologic and hydraulic models (paragraph 72), which is needed to provide a critical cross-check of the flood frequency analysis.

WMAwater's recommendations regarding risk management (paragraph 22) and the need for consideration of evacuation routes and procedures on all events up to the Probable Maximum Flood (PMF) are fully endorsed.

Flooding in Ipswich City can be significantly influenced by Brisbane River flooding and this is acknowledged in paragraph 74. WMAwater have relied upon the conclusions reached in its Brisbane Frequency Report when conducting the joint probability analysis for the Bremer River. Hence, our report of 14 October 2011 in relation to Brisbane Frequency Report is relevant to the WMAwater's Ipswich Frequency Report. In our report of 14 October 2011 we conclude that it is premature for WMAwater to reach the conclusion that the 1% AEP flood flow of 9,500 $m^{3/}$s for the Brisbane River at the Port Office gauge be adopted. In our view that conclusion is unreliable for the reasons explained in our report of 14 October 2011 The Ipswich flood frequency analysis derives a flow at Savage's Crossing consistent with the WMAwater Port Office flow and uses this to determine the flood level in Ipswich City. Given the influence of Brisbane River flooding on Ipswich City, any inaccuracy in the Brisbane River flow directly affects the reliability of flood level predictions in Ipswich.

3 REVIEW OF FLOOD FREQUENCY ANALYSIS AT SAVAGE'S CROSSING

The Ipswich Frequency Report relies heavily on the methodology used in the WMAwater September 2011 Brisbane Frequency Report for the Brisbane River, which has been subject to expert review by a number of experts. Having reviewed those reports, we support the key findings as follows:

Erwin Weinmann (October 2011)

4 *The simplifying assumption used in WMA (2011) that the estimated attenuation effect for the January 2011 flood event is representative of typical conditions is considered to have introduced significant (high) bias into the estimated post-dam 1% AEP peak flow and corresponding flood level profile. Without confirmation from further analysis, the WMA (2011) peak flow estimate of 9500m^3/s can therefore not be considered to represent a 'best estimate' of the 1% AEP peak flow for the lower Brisbane River under post-dam conditions.*

5 *For a more defensible estimate of the 1% AEP post-dam flood characteristics in the lower Brisbane River, it will be necessary to use the combined results of a range of estimation methods based on all the relevant sources of flood data. The methods applied should include rainfall based design flood simulation for the pre and post-dam conditions.*

6 *Given the high degree of variability in Brisbane River flood characteristics that can result from widely varying storm rainfall characteristics and initial catchment/storage conditions, it would be desirable to examine to what extent the estimation uncertainty could be reduced by the adoption of a joint probability modelling framework (Monte Carlo simulation), as had been suggested in previous studies and reviews.*

7 *The large degree of uncertainty in the estimated 1% AEP peak flows for the post-dam conditions can be expected to be carried through into the determination of the flood level profile for this design flood event. Given the volume-sensitive nature of the lower Brisbane River system, it would be more appropriate to apply a hydrologic flood estimation method that produces complete flood hydrographs rather than just peak flows as inputs to the hydraulic flood level estimation model.*

Rory Nathan, Sinclair Knight Merz (28 September 2011)

55 *On the basis of the material presented by WMA Water, it is this author's opinion that:*

- *The broad approach used to undertake the frequency analysis using historical flood maxima is appropriate;*
- *There is reasonably strong justification for the Q100 estimate of 13000m^3/s under "no-dam" conditions as this analysis makes use of flood behaviour observed over a 170 year period;*
- *The method used to convert the estimation of "no-dam" Q100 to current conditions is overly simplistic and involves a somewhat circular argument that relies heavily on information contained in a single event;*
- *The estimate of Q100 for current conditions is accordingly not supported; and*

- *As a consequence the Q100 flood level estimates along the Brisbane River are also not supported.*

The estimate of the Q100 under current conditions is inherently more uncertain than the estimate of Q100 under "no-dam" conditions. It is considered that the only defensible way of estimating flood risk for current conditions is to analyse the joint probabilities in an explicit manner using such techniques as Monte-Carlo simulation.

Further to these comments by other experts on the methodology, we comment as follows.

Flood Frequency Analysis

The Flood Frequency Analysis (FFA) carried out by WMAwater on Savage's Crossing uses an appropriate methodology that is consistent with current best practice for a site flood frequency analysis in Australia. However, a number of subjective decisions have not been reported including:

- Choice of flood distribution
- Selection of censored data
- Use of historic data

Decisions made in these choices and selections will directly affect the results of the FFA.

Additionally, output from Flike has not been presented which would include parameters and model diagnostics. This output would assist reviewers. Different flood distributions produce different results, as does the adopted cut off flow in analysis.

While extensive work on the FFA at Savage's Crossing has been presented, no FFA on Amberley Gauge has been presented. While the Savage's Crossing gauge is the primary gauge in the analysis, presentation of FFA at the Amberley Gauge would be beneficial.

Uncertainty

While various aspects of the analysis undertaken in the report identify uncertainty, either quantitatively or qualitatively, these uncertainties have not been propagated through the analysis and no uncertainty bounds (or confidence intervals) are presented for the flood level at Ipswich. Given the identified uncertainties and the statistical nature of the analysis this should have been provided. The assumption at 79 that the 2% and 0.5% floods encapsulate uncertainty is not statistically based and is subjective.

Conditional model

One of the key steps in the methodology of Laurenson (1973) is the determination of a relationship between discharges at the two upstream stations. WMAwater have determined a relationship for flows at Amberley (Q_{Amb}) and conditional flows at Savage's Crossing (Q_{Sav}). Despite being one of the key steps only limited detail is presented in the Report.

This inclusion of this detail in the Report would allow reviewers to assess and comment on the determination of the Log-Normal relationship including a justification of the selection of this model. Further there is no information presented on the appropriateness of the determined model of (Q_{Amb})

conditional on (Q_{Sav}). Documentation and reporting of this step would also benefit from the presentation of model diagnostics and plots of results.

The Log-Normal distribution has been parameterised using the log-log relationship between (Q_{Amb}) and (Q_{Sav}) to determine the mean (μ) with the standard deviation (σ) determined from the binned residuals. WMAwater note that the variance of the residuals reduces with increasing bin ranges and conclude that there is a stronger dependence between gauges at high flows. However, depending on the bin ranges the determination of the standard deviation may have been based on a limited number of data points and therefore the estimate of standard deviation may be sensitive. This is particularly relevant to higher flows and may affect the degree of uncertainty of the analysis.

Joint Dependence

The premise of the Report is that there is joint dependence between discharges on the Brisbane and Bremer Rivers and only through consideration of this joint dependence can reliable estimates of flood levels at Ipswich be obtained. However, the strength of the joint dependence has not determined.

The strength of the joint dependence can be determined using bivariate or multivariate extreme value analysis. The theoretical background to this is presented in Coles (2001) and this method has recently been applied in Australia by Westra (2011) to investigate the joint dependence between rainfall and storm surge.

This should be completed for the site before a reliable conclusion can reached regarding joint dependence. It is important to recognise that the Savage's Crossing discharge is strongly influenced by dam operation, whereas Warrill Creek has no regulation. This must affect the reliability of correlation used.

Alternative Joint Probability Approaches

The use of the Laurenson model (1973) is a little surprising given that it is nearly 40 years old and there have been a number of significant developments in the assessment of joint probability predominately between surge tide and flooding in coastal catchments. A number of recent examples are presented below.

For instance, McInnes et al. (2009) notes that joint probability methods are commonly applied to evaluate storm tide return periods. This study uses Monte Carlo method to estimate the Joint Probability distribution between tide and surge distributions. While this example assumes that tide and surge distributions are independent, which differs to the Brisbane / Bremer River case, the method could be readily adapted using the conditional probability distribution derived from the Amberley Gauge (notwithstanding the comments above).

There are also frequentist approaches such as the χ measure approach of Svensson and Jones (2004) to investigate the dependence of surge on rainfall and river flow. The assessment of bivariate and multivariate extreme value analysis has been covered by Cole (2001) and this has been recently been applied in Australia by Westra (2011) as noted above. The work by Westra is currently being extended as part of the Australian Rainfall and Runoff update and will provide a methodology for estimating the exceedance probability of a flood event (or AEP) when it is caused by multiple factors. While this is currently being developed for surge and flood events it is likely it could be readily applied to the Brisbane / Bremer River case.

Further, Bayesian approaches provide a natural framework to investigate joint dependence. For instance, Coles and Tawn (2005) note that the Bayesian approach provides for the management of uncertainties as well as a framework for the construction of complex statistical model that would be intractable using frequentist approaches. A Bayesian joint probability approach has been applied by Wang et al. (2009) to estimate seasonal stream flow in south–eastern Australia.

In summary, I consider that the finding that the ARI 100 year flow at Savage's Crossing is 9,800m^3/s premature and subject to a large amount of uncertainty, with the potential for an overestimation of the ARI 100 year flow. This has a direct bearing on flood levels predicted in Ipswich City, given the influence of Brisbane River flows.

4 REVIEW OF CORRELATION OF WARRILL CREEK FLOWS TO BREMER RIVER FLOWS

WMAwater use a flow correlation between Warrill Creek flows at Amberley and Brisbane River flows at Savages Crossing, as part of a joint probability analysis for flows in the Bremer River in Ipswich City and in the Brisbane River at Moggill.

This process is described in Appendix B of the WMAwater Ipswich Frequency Report.

A key step in this analysis is the translation of the Warrill Creek / Brisbane River flow relationship to a Bremer River / Brisbane River flow relationship.

Paragraph B12 states: "Each value of Q_{Ips} was factored to a corresponding flow at Amberley based on a simple relative catchment area relationship (assumed $Q_{Amb} = 0.6*Q_{Ips}$)". Based on the 0.6 factor, we assume WMAwater has proportioned catchment areas for Bremer River at Walloon to Warrill Creek at Amberley, as demonstrated below. Table 4-1 below summarises the catchment areas and proportion of the total contributing catchment upstream of Ipswich.

Table 4-1 - Contributing Catchment Areas

Catchment	Catchment Area (km^2)	Fraction of total area (no Purga Creek)	Fraction of total area (with Purga Creek)
Bremer River @ Walloon	638.6	0.41	0.36
Warrill Creek @ Amberley	913.3	0.59	0.52
Total area (no Purga Creek)	1551.9	-	-
Purga Creek @ Loamside	210.4	-	0.12
Total area (with Purga Creek)	1762.3	-	-

These figures show that the WMAwater catchment area relationship is true when Purga Creek is not considered. However, if Purga Creek is also included in the catchment area relationship, the proportion of contributing catchment for Warrill Creek drops to 0.52.

Using gauging station data extracted from the DERM website, Table 4-2 below gives the peak flows for a range of historic flood events for the major contributing catchments upstream of Ipswich.

Table 4-2 - Peak Flows Upstream of Ipswich for Historic Flood Events

Event date	Total combined flow (m^3/s)	Recorded Peak Flow (m^3/s)			Proportion of Total Flow		
		Bremer River @ Walloon	Warrill Creek @ Amberley	Purga Creek @ Loamside	Bremer River @ Walloon	Warrill Creek @ Amberley	PurgaCreek @ Loamside
Jan 1968	887	484	403	-	0.55	0.45	-
Jan 1974	4179	1660#	2108	411	0.40	0.50	0.10
June 1983	1182	602	437	143	0.51	0.37	0.12
Apr 1989	658	389	158	111	0.59	0.24	0.17
May 1996	1058	630	307	121	0.60	0.29	0.11
Feb 1999	706	451	195	60	0.64	0.28	0.08
Jan 2011	2501	1645*	706	150	0.66	0.28	0.06

Gauging records does not have data at the Walloon gauge for this event. Magnitude of flow has been taken from SEQWater data

* Gauging record indicates quality for this value as 'suspect'; value taken from URBS model data supplied by SEQWater

Paragraph 52 within the main body of the WMAwater Ipswich Frequency Report states that the Amberley gauge on Warrill Creek was considered more suitable for the FFA than the Walloon gauge on the Bremer River as it captures a larger proportion of the Bremer River catchment. Whilst this is true, based solely on catchment area, historical flow records from the gauging stations indicate that during flood events, flows at Walloon generally exceed the flows at Amberley, as given in the tables shown in Appendix B of this report.

Therefore, the following can be determined:

- The assumed catchment area relationship ($Q_{Amb} = 0.6*Q_{Ips}$) does not correlate with the flow data for the various gauging stations upstream of Ipswich.
- The historical data suggests that (on average) flows are greater in the Bremer River catchment to Walloon than the Warrill Creek catchment to Amberley, despite having a smaller catchment area.
- Purga Creek has an average contribution of 10%-11% to the total flow upstream of Ipswich.

5 IMPACT OF THE USE OF THE MIKE11 MODEL

WMAwater in their July 2011 'Review of Hydraulic Modelling' describe in detail the shortcomings of the SKM Version 2 MIKE11 model which is used in the Ipswich Frequency Analysis (Chapter 4). In particular, in paragraph 56 of WMAwater's July 2011 report, they state:

- *Reliability of Brisbane River model upstream of Mt Crosby is unproven by calibration.*
- *Bremer River model is not successfully calibrated and results must be used with caution as being indicative only; and*
- *Given the model has been calibrated to the January 2011 event model but not validated against other historic floods, the accuracy for other events is not established.*

In Appendix B to our October 2011 report on WMWwater's Brisbane Frequency Report, we comment (in Chapter 4) on the SKM MIKE11 model and conclude that there is considerable uncertainty over the accuracy of flood wave timing and magnitude in the Ipswich area.

Our review of the Brisbane Frequency Report also provides comment on the URBS model used by SKM and prepared by SEQ Water. We conclude in that report that the URBS model represents the most reliable tool currently available for Ipswich City, as it matched very closely the recorded flood levels in Ipswich for the January 2011 event.

Therefore, in order to check the results by WMAwater in terms of levels in Ipswich City, for the Brisbane River and Bremer River flows assumed, we have utilised SEQ Water's URBS model. Appendix C provides details of the key rating curves of flow in the Bremer River versus gauge height at Ipswich City (the David Trumpy Bridge gauge). Each curve relates to a different Brisbane River tailwater level at Moggill.

Using WMAwater's published Brisbane River flood level at Moggill from their September 2011 Brisbane Frequency Report (Figure 13), the 100 year flow for the Brisbane River (9800m^3/s), and the corresponding flow in the Bremer River at Ipswich City (1900m^3/s) based on WMAwater's 12 October 2011 Ipswich Frequency Report, the URBS model produces a Q100 flood level at Ipswich City of RL18.3m, 2.3 metres lower than that predicted by the MIKE11 model. Had the 2003 Independent Review Panel design flow of 6,000m^3/s been used, flood levels predicted in Ipswich using the WMAwater methodology would have been between RL16 and 17m.

It is important to note that there is inadequate information provided by WMAwater to exactly define the assumed river flows or Moggill tailwater level, hence, we have had to rely upon interpolation.

The SEQ Water URBS model was not designed as a flood prediction tool, but rather as part of an overall rainfall / runoff and flood management system for the entire rivers system catchment. As such, whilst it performs a very useful cross-check of flood levels in Ipswich, we do not recommend its results be relied upon in isolation of alternate analysis. Such alternative analysis requires new river survey, re-building and recalibrating of the hydrodynamic model and flood frequency analysis, including Monte Carlo simulation and we again note that this work is all within the scope of the current WSDOS study.

6 CONCLUSIONS

I conclude that:

1 The conclusions reported by WMAwater at Section 5.2 of the Ipswich Frequency Report, and particularly the estimate that 1% AEP flood level at Ipswich (David Trumpy Bridge) of 20.6 mAHD (at paragraph 78), cannot be justified.

2 The methodology to convert the estimate of 'no-dam' ARI 100 year flows at Savage's Crossing to current conditions is simplistic and may have produced an overly conservative outcome, with over-estimation of the ARI 100 year flow.

3 The extent of uncertainty in the Savage's Crossing flow estimate should be reduced by alternative joint probability analyses, such as Monte Carlo simulation, as recommended by previous studies and reviews, including WSDOS.

4 The translation of the relationship developed between Warrill Creek and Brisbane River flows, to Bremer River and Brisbane River flows using catchment area alone ignores the effect of Purga Creek, leading to an incorrect estimation of Bremer River flows. In any case, the assumed relationship of flow at Amberley being 0.6 times flow at Ipswich does not correlate with any historic flow data. For example, a factor of 0.28 has been derived for the January 2011 event, and none of the 7 significant historic events exceed 0.5 and were generally lower. This translation method is not appropriate and is inaccurate and an alternate method taking account of spacial variability is required.

5 SEQ Water's URBS model is considered more accurate than the MIKE11 model used by WMAwater in predicting flood levels in Ipswich City for given combinations of Bremer River and Brisbane River flows, and the current MIKE11 model is considered unreliable for Ipswich City predictions.

6 Using the URBS model, I estimate that for the Brisbane and Bremer River flows assumed by WMAwater in their analysis (and I question WMAwater's assessment of the Brisbane River flows for the reason outlined report on the Brisbane Frequency Report), the peak flood level in Ipswich is RL18.3m AHD, some 2.3m lower than that predicted by the MIKE11 model. This analysis is not intended to suggest that RL18.m AHD is the correct flood level (given my views on the Brisbane River flows adopted by WMAwater) but it demonstrates the unreliability of the estimate at 78 of WMAwater's report. Given the very close match of the URBS model to the recorded January 2011 flood levels, the URBS model is a more reliable tool at present for assessments of flood levels in Ipswich City. Had the 2003 Independent Review Panel design flow of 6000m^3/s been used, flood levels predicted in Ipswich using the WMAwater methodology would be between RL16 and 17m.

7 Because of the very large uncertainty range inherent in the analysis, and because of a number of apparent overly conservative assumptions on which the WMAwater analysis for Ipswich has been based, it is not appropriate to rely on the reported findings in terms of ARI 100 year flood levels for Ipswich City.

8 The analysis by WMAwater has been carried out in a short period of time in isolation of the WSDOS study that is underway, and these works should be completed before any conclusions of event frequency and the ARI 100 year flood line can be determined.

7 LIMITATIONS

This review is based solely on the published report and we have not had the opportunity to review the data relied upon.

Due to the extremely short timetable for review, this report concentrates on three specific areas of uncertainty to demonstrate that the conclusions drawn are premature and that much more work is required before any firm conclusions can be reached.

8 REFERENCES

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WMAwater, October 2011, Queensland Floods Commission of Inquiry, Supplementary Report, Ipswich Frequency Analysis, Final Report

APPENDIX A: CURRICULUM VITAE OF NEIL IAN COLLINS

A part of BMT in Energy and Environment

Neil Ian Collins

Position	Principal Hydraulic Engineer – Expert Services
Years of Experience	32
Professional Affiliations	PIANC NPER-3 RPEQ
Qualifications	Master of Science Engineering, University of Queensland Bachelor of Engineering (Civil) University of Queensland
Recent Employment Profile	2010 to Present BMT WBM Pty Ltd – *Principal Hydraulic Engineer - Expert Services* 2007 to 2010 Gilbert & Sutherland Pty Ltd – *Principal Hydraulic and Water Resources Engineer* 2004 to 2007 Cardno Lawson Treloar – *Director*, *Queensland Manager* 1993 to 2004 Lawson Treloar - *Director*

Areas of Expertise

Hydraulics, Hydrology and Water Resources

Provision of Expert Witness Services in Flooding, Stormwater, Quality Control and Coastal Engineering

Career Overview

Neil is BMT WBM's Principal Hydraulic Engineer; part of the Expert Services team, based in the Brisbane office. He has 31 years experience and is an acknowledged expert in the P+E, Land Court and Supreme Court of Queensland in flooding, water quality and coastal processes. He was also the independent hydraulic expert to the Queensland Government for the North Bank project. Neil has worked on major infrastructure projects as an Hydraulic Specialist including Sydney Third Runway, Sydney Harbour Tunnel, Gateway Bridge and Arterial and several coal ports in Queensland and in Indonesia, power stations in Queensland and Thailand, hydro-electric schemes in PNG and port dredging management at Cairns, Townsville, Weipa and Mackay.

Summary of Major Projects

- Lauderdale Quay, Hobart – Coastal Hydraulics, Water Sediment Quality for IIS on a Major Marina Residential Reclamation Project.
- Brisbane Airport - International Terminal Drainage Design.
- Sydney Harbour Tunnel - Hydraulics Engineer for Immersed Tube Tow and Placement.
- Sydney Third Runway - Hydraulic Model Testing, Sea Wall Design and Environmental Management.
- Gateway Arterial - South East Freeway to Lytton Road - Civil and Hydraulic Design Manager.
- Gateway Bridge - Hydraulics and Approaches Services Relocations.
- Trade Coast Central - Flooding Review for BCC.
- Oak Flats to Yallah RTA Freeway Hydraulics.
- Kedron Brook Flood Impacts due to Airtrain.
- Tully and Murray River Floodplains Hydraulic Analysis and Modelling, for Drainage Scheme Design includes Large MIKE11 Modelling, with over 40 Bridges and 200 Channels.
- Expert Review - Mossman Daintree Road, Saltwater Creek Crossing: Independent Review of the Hydraulic Design of two Large Bridges.
- Hydraulic Design of Rock Armouring Works for the Barron River Bend at Cairns Airport.
- Eastern Corridor Study - Hydraulics and Hydrology investigation for Department of Transport.
- Relief Drainage Scheme Design for Albion Windsor Area Brisbane (Capital cost $2 million).
- Tarong Power Station - Design of Earthfill Dam (max. 23m height), Ash trench, Stormwater Diversion Channels.

Professional History

BMT WBM Pty Ltd

Principal Hydraulic Engineer providing expert witness services in flooding, stormwater, quality control and coastal engineering.
2010-2011: Over 25 appeals completed or still in progress
2010-2011: Flooding Commission of Inquiry – Technical expert for LGAQ and Ipswich City Council
2010-2011: Cairns Airport – Review of Airport Flood Immunity and Risk

Gilbert & Sutherland Pty Ltd

Wet 'n' Wild, Sunshine Coast – site and soil assessments, input to and review of AGE groundwater assessment, conceptual stormwater quality assessment, hydraulic and flooding assessments including yield, medli modelling for onsite and input to S&B water balance, contamination investigation.

- Stockland, Twin Waters – Flooding Assessment
- Mackay Boat Harbour – Wave Investigation
- Bourton Road, Alkira – Flooding and Stormwater Management Plan
- The Glades, Robina – Water Quality Compliance and Inspection Report

Expert Services:
2007: Truloff Pty Ltd -v- Gold Coast City Council
2008: Jimboomba Turf Co Pty Ltd -v- Logan City Council
2008: Lechaim -v- Gold Coast City Council
2008: Sunnygold International Pty Ltd -v- Brisbane City Council
2008: Bon Accord -v- Brisbane City Council
2008: Blue Eagle -v- Beaudesert Shire Council
2008: Brian Paddison -v- Redland Bay Shire Council
2008: Monarch Nominees -v- Brisbane City Council
2008: Kunda Park Pty Ltd -v- Maroochy Shire Council
2008: Owl Projects & Hyder -v- Gold Coast City Council
2008: Port Pacific Estates Pty Ltd -v- Cairns Regional Council
2008: Joanne Shepherd & Ors -v- Brisbane City Council
2009: Lenthalls Dam, Hervey Bay
2009: Testarossa -v- Brisbane City Council
2009: Heritage Properties & Ausbuild -v- Redland City Council
2009: Samantha Skippen -v- Miriam Vale Shire Council
2009: Anthony Wan Pty Ltd -v- Brisbane City Council
2010: Over 25 appeals in progress this year

Professional History (cont)

Cardno Lawson Treloar
Sovereign Waters, Wellington Point - flooding, tidal exchange and water quality management.

EMP Water Quality Management Plan preparation and site stormwater management, including hydrodynamic, advection/ dispersion and catchment pollutant yield modelling for:
- Emerald Lakes Project, Carrara
- Glenwood Estate, Mudgeeraba
- 'The Glades' (Greg Norman Design Course), at Robina
- Sovereign Waters, Wellington Point
- Pacific Palisades, Gavin
- Freshwater Valley Estate, Cairns
- Carrara Golf Course Re-development, Carrara
- The Broadwater Development, Mudgeeraba
- Over a Dozen Major Residential Development Projects.

- Full Two-dimensional (MIKE 21) Floodplain Modelling for Cairns Airport Inundation, Nerang River Floodplain and Martins Creek, Maroochydore.
- Noosa River System Flood Study: Includes full G.I.S. Interfacing, Colour Inundation Plan Production and MIKE11 Modelling.
- Detention Basin Design for Development Consulting, Calamvale, Brisbane: Hydrologic and Hydraulic Design using RAFTS.
- Hydraulic and Water Quality Design, Lucinda Drive Main Drain, Port of Brisbane, including Catchment Pollutant Runoff Management.
- Moreton Bay College Flood Investigation: MIKE11 Analysis of Flooding, Including Culvert and Channel Diversion Options.
- Input on EIS Report on Water Quality for Freshwater Valley Development, including EMP.
- Townsville Port Road and Rail Access Study - Hydraulics.
- Freshwater Creek Flooding, for Main Roads, included Bridge and Culvert Sizing and Positioning of Channel Training Works. (RORB/RUBICON).
- Mountain Creek Flooding Investigation Examination of 1992 Floods using detailed Hydrologic/Hydraulic Modelling and Design of Mitigation Works.

Expert Services:
2004: T.M. Burke Appeal
2004: East Point Mackay
2004: Dore Appeal
2004: 900 Hamilton Road, McDowall
2004: Milton Tennis Centre
2005: P&E Appeal Mount Samonsvale
2005: BCC & George Pasucci
2005: P&E Appeal 48 Comley Street Sunnybank
2005: P&E Appeal 398 Wondall Road, Tingalpa
2005: Cabbage Tree Creek Appeal
2006: 35 Suscatand Street, Rocklea Appeal
2006: Leong - v- Redland Shire Council Appeal
2006: Barry Hilson & Bach Pty Ltd - v- GCCC Appeal
2006: 57 Longhill Road Appeal
2006: 699 Bargara Road Appeal
2006: Chevellum Road Appeal
2006: 10 Karridawn Street, Nudgee Appeal
2006: Australian Hardboards Limited Appeal
2006: Dell Road and Hawkin Drive, St Lucia Appeal
2006: 106 Munro Street, Auchenflower Appeal
2006: 10 Adsett Road, P&E Appeal
2006: Saunders Creek Appeal
2006: 64, 70 & 74 Washington Avenue, Tingalpa

Professional History (cont)

Lawson Treloar

- Coastal Data Gathering and Analysis for Projects in Bali, Lombok and Malaysia.

- Pandorah Gas Project, Gulf of Papua. Neil was Responsible for Project Management of all Coastal and Oceanographic Aspects of this Project, including Preparation of the Relevant Components of EIS. This included Extreme Climate, Wind/Wave and Current Modelling.

Chevron PNG to Cape York Gas Pipeline Project, Gulf of Papua
Neil Carried out Project Management for all Coastal/Oceanographic Components of this Project, including:

- Wind/Wave Modelling
- Extremal Climate
- Bed Current Prediction
- Kumul Platform Berthing
- Endeavor Passage Landfall
- Wave, Current and Wind Data Gathering.

- Tidal Lagoon, Breakwater/Groynes, Water Quality and Quantity Management at Pecatu Indah Resort, Lombok.
- Marina and Reclamation, S-W Bali, (Putri Nyale) including Coastal Investigations and Hydraulic Design of Breakwaters and Revetments.
- Sediment Sampling and Monitoring Program for the Albatross Bay Dumpsite, Weipa, for Dept. of Transport. Job Manager for this Investigation which includes Monitoring of Movement of Material Following Dumping, and its Impact on Water Quality and Benthic Communities.
- Wellington Point Canal Estate - Coastal Hydraulic Investigation of Proposed Marina and Dredged Channel.
- Weipa, Embley Inlet Environmental Monitoring: Review and Planning for Long Term Monitoring and Assessment of Water Quality (for Comalco).
- Full 2D flooding assessments for Dept of Main Roads using MIKE 21 on Yarrabah, Cairns and Warrego Highway at Marburg.
- Current Profiling, Warrego River (1994).
- Sovereign Waters, Wellington Point - Flooding, Tidal Exchange and Water Quality Management.
- Responsible for all Flood and Water Quality aspects for several Gold Coast Projects, including Emerald Lakes, Nifsan's Glenwood and Broadlakes, including Lake, Wetland and EMP Design.
- Stream Diversion, including Sloping Drop Structure, Hydraulic Design, at 'Coops' Development, Brisbane (1993).
- Northumbria Lakes Estate, Flooding, Drainage, Gross Pollutant Trap and Trash Rack Modelling and Design (1994).
- Barron River Delta Prawn Farm I.A.S., including Flooding and Water Quality Monitoring and Modelling, using MIKE11 (1995).
- Hydraulic Manager for Cairns Airport Master Drainage Study, 1995, including Complex Hydrodynamic Flow and Catchment Management Analysis.

Expert Services:

1993: for Mulgrave Shire Council; Land Resumption Compensation Case in Land Court. (Flooding)
1993: for Mulgrave Shire Council; Development Appeal (Kamerunga Villas) in Planning and Environmental Court. (Flooding)
1994: for Pullenvale Residents Action Group, on Rezoning Appeal. (Flooding and Water Quality)
1994: for Development Consulting, on Rezoning Appeal for a Development with a Large Detention Basin at Calamvale. (Flooding and Drainage)
1994: for an Earthworks Contractor Regarding a Disputed Claim Over Levee Bank Construction at Mungindi. (Flooding)
1995: for a Developer on Bohle River Works. (Flooding and Water Quality)
1995: for Residents on Flooding, Murrumba Downs. (Flooding)
1995: for Residents on Flooding, Dayboro. (Flooding)

Connell Wagner

- Current Profiling, Warrego River (1994).
- Sovereign Waters, Wellington Point - Flooding, Tidal Exchange and Water Quality Management.
- Responsible for all Flood and Water Quality Aspects for several Gold Coast Projects, including Emerald Lakes, Nifsan's Glenwood and Broadlakes, including Lake, Wetland and EMP Design.
- Stream Diversion, including Sloping Drop Structure, Hydraulic Design, at 'Coops' Development, Brisbane (1993).
- Northumbria Lakes Estate, Flooding, Drainage, Gross Pollutant Trap and Trash Rack Modelling and Design (1994).
- Barron River Delta Prawn Farm I.A.S., including Flooding and Water Quality Monitoring and Modelling, using MIKE11 (1995).
- Hydraulic Manager for Cairns Airport Master Drainage Study, 1995, including Complex Hydrodynamic Flow and Catchment Management Analysis.
- Tarong Power Station. Design of earthfill dam (max. 23m height), Ash trench, Stormwater Diversion Channels.
- Callide B Power Station. Evaporation Ponds Simulation; Hydraulic Design and Stormwater Bypass Channel. Design of (25m) Ash Dam.
- Hay Point Multi-User Coal Export Facility. Design of Dams, Stormwater Drainage, Water Supply and General Civil.
- Townsville Container Terminal. Design of Stormwater Drainage and General Civil.
- Abbot Point Coal Terminal. Design of an Offshore Causeway.
- Subdivisional Design and Supervision, on over a dozen Projects.
- Bulk Sugar Terminal - Brisbane. Feasibility Studies, including Flooding.
- Gladstone Power Station. Ash Handling including Piping.
- Stanwell Power Station. Design Check on General Civil.
- Patrick Container Terminal - Port of Brisbane. Flooding and General Civil.

Expert Services:

1993: for Mulgrave Shire Council; Land Resumption Compensation Case in Land Court. (Flooding)
1993: for Mulgrave Shire Council; Development Appeal (Kamerunga Villas) in Planning and Environmental Court. (Flooding)
1994: for Pullenvale Residents Action Group, on Rezoning Appeal. (Flooding and Water Quality)
1994: for Development Consulting, on Rezoning Appeal for a Development with a Large Detention Basin at Calamvale. (Flooding and Drainage)
1994: for an Earthworks Contractor Regarding a Disputed Claim Over Levee Bank Construction at Mungindi. (Flooding)
1995: for a Developer on Bohle River Works. (Flooding and Water Quality)
1995: for Residents on Flooding, Murrumba Downs. (Flooding)
1995: for Residents on Flooding, Dayboro. (Flooding)

Expert Services for Phillips Fox; Caboolture Shopping Centre Extension Appeal in Planning and Environment Court. (Flooding)

Expert Services for Mulgrave Shire Council; Land Resumption Compensation Case in Land Court. (Flooding)

Expert Services for Mulgrave Shire Council; Development Appeal (Kamerunga Villas) in Planning and Environmental Court. (Flooding).

Papers/Publications

May 2007 QELA Conference Presentation – The Approval and Appeal Process in QLD and NSW, Experts view on soil and water issues.

Nov 2004 Publication - 'Application of Australian Runoff Quality Draft Chapter 6 – A model approach', Water Sensitive Urban Design Conference, 2004, Adelaide.

Jul 2004 'Integrated High Order Water Quality and Hydrodynamic Analysis', 8th National Conference on Hydraulics in Water Engineering, July 2004.

Nov 2002 Publication - 'Hervey Bay Storm Surge', 30th PIANC Congress, Sydney 2002.

Nov 2001 'The Use of Runoff Event Monitoring in Validating Sediment Control Measures', 9th Annual Conference, International Erosion Control Association, Nov 2001.

Nov 2001 'Specialist 2D Modelling in Floodplains with Steep Hydraulic Gradients', 6th Conference on Hydraulics in Civil Engineering, Nov 2001.

Mar 2001 'Planning Implications of New Technology in Floodplains', RAPI Conference, Gold Coast, 2001.

Nov 1999 'Best Management Practices for Water Quality Control', and 'Zero Flooding Impact Assessments; the need for full two dimensional analysis', 8th International Conf. on Urban Stormwater Drainage, 1999.

Jul 1999 'Desktop Ship Simulation for a new Port Facility in The Gulf of Papua', Coasts and Port '99.
Mar 1997 'Implications of the Nifsan -v- G.C.C.C. ruling on floodplain hydraulics', Qld Envir. Law Assoc., 1997.

Jul 1994 'What the Community Needs to Know – Approaches to Community Construction for Water Engineering Projects', I.E. Aust., Queensland Division, 1994.

Nov 1993 'Hydraulic Assessment of Floodplain Development: Case Studies', The Institute of Municipal Engineering, Goondiwindi, 1993.

Jul 1993 'Long Term Environmental Planning – Weipa Port Dredging', 11th Australasian Conf on Coastal and Ocean Engineering. Townsville, 1993.

Mar 1993 Integrated Hydrologic and Hydraulic Modelling', WATERCOMP '93. The Second Australasian Conference on Technical Computing.

Mar 1992 'Russell and Mulgrave River Catchment Management', Invited Guest speaker for Queensland River Trusts Conference, Cairns, 1992.

Nov 1990 'Recent Studies of Port Dredging and Offshore Spoil Dumps', Third Australasian Port and Harbour Conference 1990, IE Aust.

Aug 1990 'Barron River Airport Bend Study - An Exercise in Joint Numerical and Physical Modelling', Conf. on Hyd. in Civil Eng., 1990, IE Aust.

May 1989 'Comparison and Evaluation of Current Dynamic Flow Models', WATERCOMP '89. The First Australasian Conference on Technical Computing in the Water Industry, Melbourne, 1989.

May 1989 Publication - Dynamic Flow Modelling : Comparison and Evaluation of Current Models - final Report', ACADS International publication No. U-249, May 1989.

May 1988 'Comparison of Dynamic Flow Models', ACADS 2D Modelling of Flood Plains, Melbourne, 1988.

Jun 1985 'ACADS Project on Comparison of Unsteady Flow Models', ACADS workshop, Brisbane 1985.

APPENDIX B: ANALYSIS OF FLOW RECORDS FOR BREMER CATCHMENTS INCLUDING WARRILL CREEK

APPENDIX B - ANALYSIS OF FLOW RECORDS FOR BREMER CATCHMENTS INCLUDING WARRILL CREEK

Paragraph B12 states: "Each value of Q_{lps} was factored to a corresponding flow at Amberley based on a simple relative catchment area relationship (assumed ($Q_{Amb} = 0.6*Q_{lps}$))". Based on the 0.6 factor, I assume he has proportioned catchment areas for Bremer River at Walloon to Warrill Creek at Amberley, as demonstrated below. Table B-1 below summarises the catchment areas and proportion of the total contributing catchment upstream of Ipswich.

Table B-1 - Contributing Catchment Areas

Catchment	Catchment Area (km^2)	Fraction of total area (no Purga Creek)	Fraction of total area (with Purga Creek)
Bremer River @ Walloon	638.6	0.41	0.36
Warrill Creek @ Amberley	913.3	0.59	0.52
Total area (no Purga Creek)	1551.9	-	-
Purga Creek @ Loamside	210.4	-	0.12
Total area (with Purga Creek)	1762.3	-	-

These figures show that the WMA Water catchment area relationship is true when Purga Creek is not considered. However, if Purga Creek is also included in the catchment area relationship, the proportion of contributing catchment for Warrill Creek drops to 0.52.

Using gauging station data extracted from the DERM website, Table B-2 below gives the peak flows for a range of historic flood events for the major contributing catchments upstream of Ipswich.

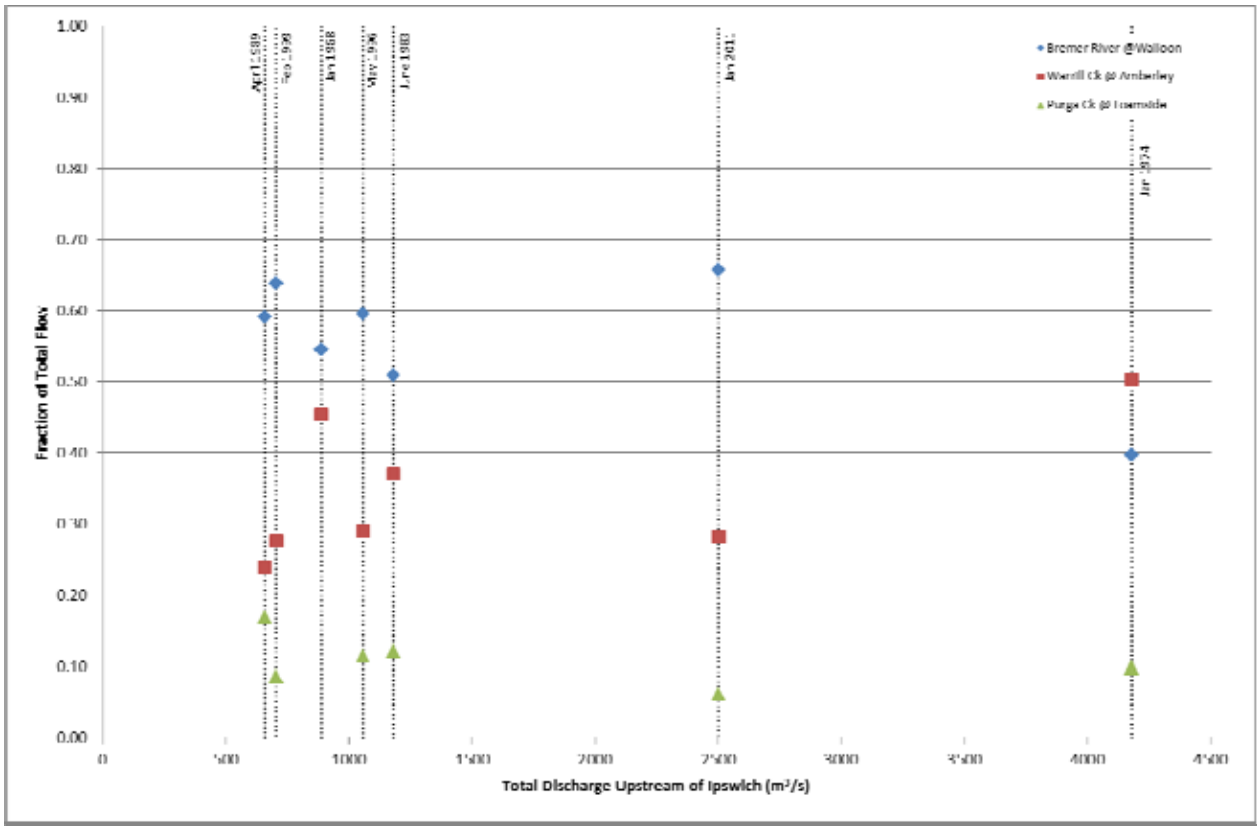
Table B-2 - Peak Flows Upstream of Ipswich for Historic Flood Events

Event date	Total combined flow (m^3/s)	Recorded Peak Flow (m^3/s)			Proportion of Total Flow		
		Bremer River @ Walloon	Warrill Creek @ Amberley	Purga Creek @ Loamside	Bremer River @ Walloon	Warrill Creek @ Amberley	PurgaCreek @ Loamside
Jan 1968	887	484	403	-	0.55	0.45	-
Jan 1974	4179	1660#	2108	411	0.40	0.50	0.10
June 1983	1182	602	437	143	0.51	0.37	0.12
Apr 1989	658	389	158	111	0.59	0.24	0.17
May 1996	1058	630	307	121	0.60	0.29	0.11
Feb 1999	706	451	195	60	0.64	0.28	0.08
Jan 2011	2501	1645*	706	150	0.66	0.28	0.06

Gauging records does not have data at the Walloon gauge for this event. Magnitude of flow has been taken from SEQWater data

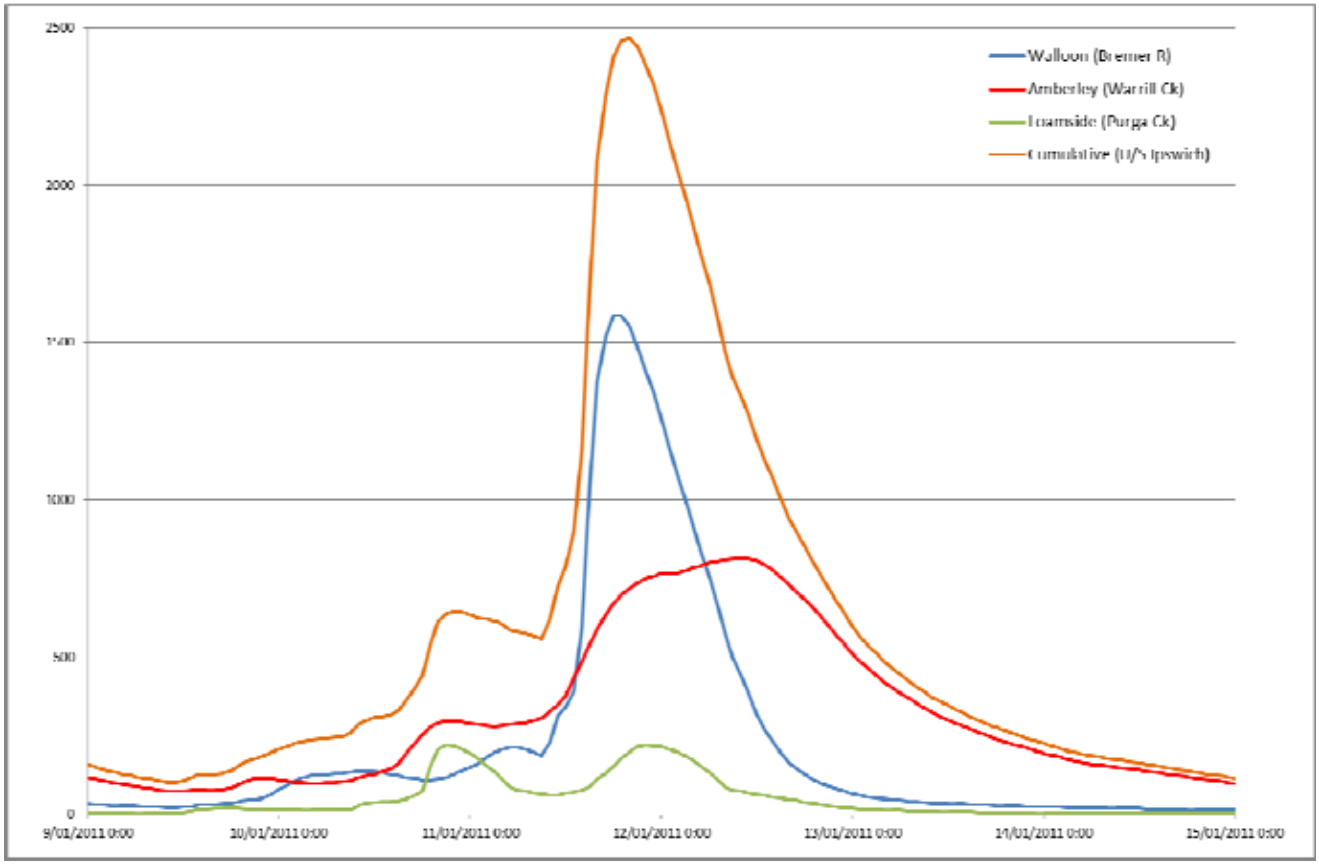
* Gauging record indicates quality for this value as 'suspect'; value taken from URBS model data supplied by SEQWater

Figure B-1 – Proportion of flows upstream of Ipswich for major contributing catchments



Flow hydrographs at the various gauges in the vicinity of Ipswich are given in Figure B-2 below. This shows that the majority of flow upstream of Ipswich is within the Bremer River catchment with a lesser contribution from the Warrill Creek catchment.

Figure B-2 – Flow hydrographs for January 2011 event



APPENDIX C: URBS MODEL RATING CURVES FOR IPSWICH CBD

Ipswich Flood Frequency Analysis – URBS Comparison

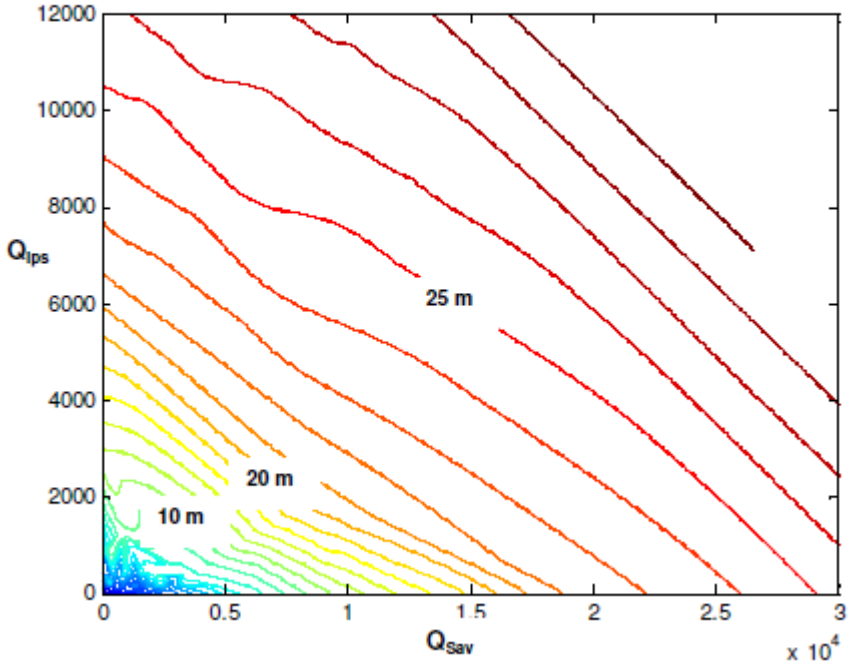
Using Ipswich 1% AEP flood levels from WMA Water's Supplementary Report – Ipswich Flood Frequency Analysis (FFA) to derive peak 1% AEP flows at Ipswich to compare estimated 1% AEP flood levels predicted with SEQ Water's calibrated URBS model.

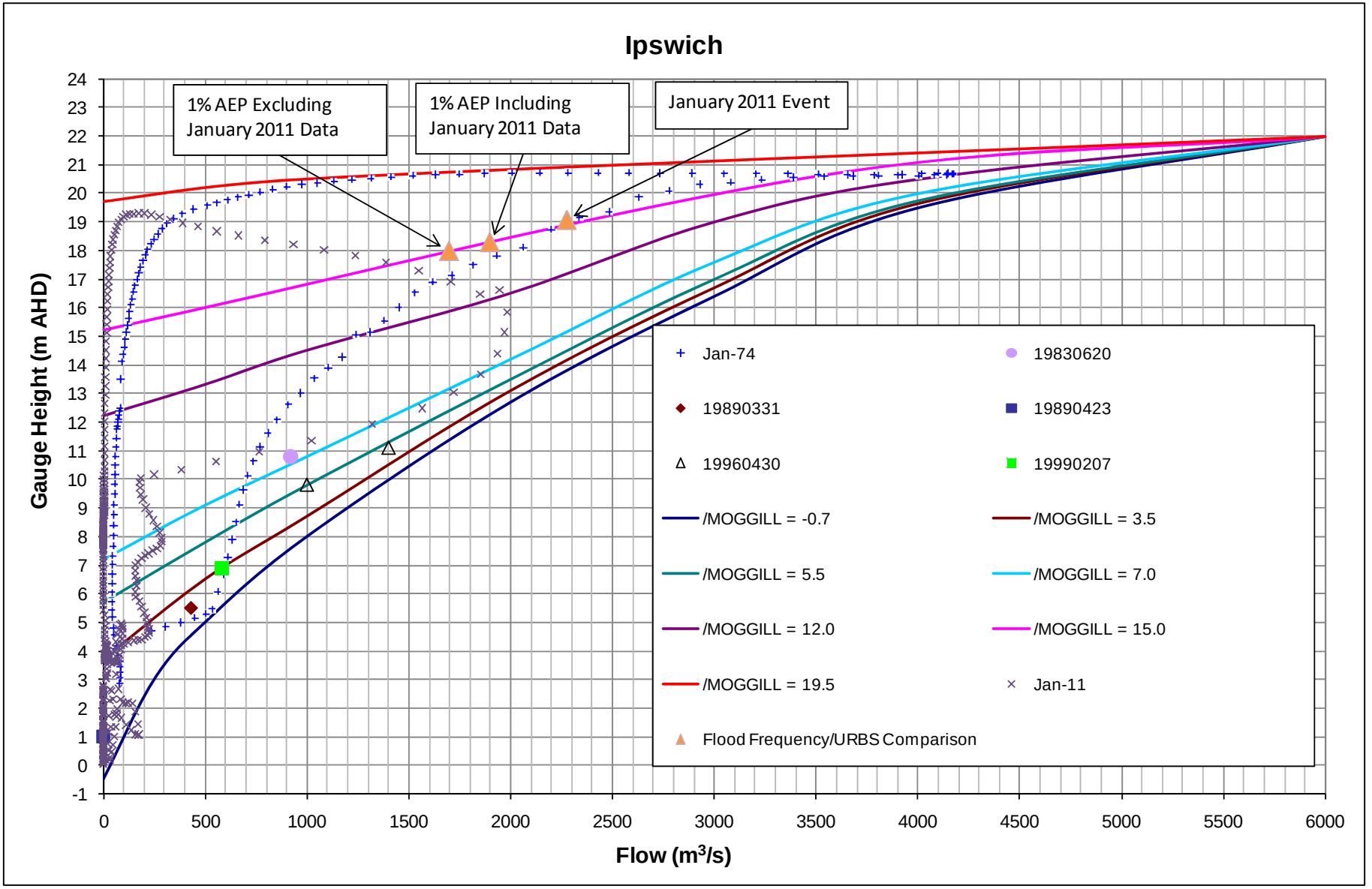
Table C1 – 1% Flow and Level Comparison

	1% AEP	
	Excluding January 2011 Data	Including January 2011 Data
Peak Water Level (mAHD) (WMA Water Ipswich FFA)	20.0	20.6
$Q_{savages}$ (m^3/s)	8300	9800
$Q_{Ipswich}$ (m^3/s)*	1700	1900
Peak Water Level (mAHD) (SEQWater's Ipswich URBS rating– Refer Figure C1)	18.0	18.3

* Derived from Figure B6, WMA Water's Supplementary Report - Ipswich Flood Frequency Analysis

Figure B6: Contours of Ipswich flood level relationship with Q_{Sav} and Q_{Amb}





Source: SEQWater

Figure C1

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