Brisbane River 2011 Flood Event – Investigations into Causes of Property Inundation

REVIEW OF INSURANCE REPORTS

- Version A
- 6 November 2011

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Sinclair Knight Merz
ABN 37 001 024 095
Floor 11, 452 Flinders Street
Melbourne VIC 3000
PO Box 312, Flinders Lane
Melbourne VIC 8009 Australia
Tel: +61 3 8668 3000
Fax: +61 3 8668 3001
Web: www.globalskm.com

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1. Introduction

1. This report has been prepared in response to Brief from the Queensland Floods Commission of Enquiry (the "Commission"). The Commission forwarded Sinclair Knight Merz (SKM) a series of reports prepared to assist in the assessment of insurance claims arising from the Queensland flood events of December 2010 and January 2011.

2. The sections of the Brief to which this report responds are as follows:

   1) "Review all hydrology reports and comment on whether the methodology, approach and assumptions are appropriate to answer the questions sought to be answered by the report

   2) Advise on the extent, if any, to which each of the area-wide/regional reports provides a sound basis for determining cause of inundation (for example, stormwater or riverine flooding) of a particular property located within the area or region the subject of the report.

   3) With respect to the WRM Water & Environment report for 86 Queensborough Parade, Karalee, 8 August 2011, how reliable is that desk top assessment of cause of inundation/damage, which did not involve a site inspection?"

3. A summary of the qualifications and experience of the authors of this report are provided in Appendix B.

2. Insurance Reports

2.1. Reports

4. A total of 25 reports were provided for review, as listed in Table 1 (Appendix A). Three different engineering firms were involved in preparing the reports, each of which was engaged on behalf of a different insurance company.

2.2. Questions Sought to be Answered by Reports

5. It is understood that these reports were prepared to assist insurance companies in assessing their liability for flood damage to specific properties resulting from the December 2010 and January 2011 events. Most of these reports have drawn conclusions regarding the likely causes of the most severe property inundation as it is understood that this is a key factor when determining whether a particular claim falls within a policy coverage.

6. A number of different definitions and classification systems have been used in the various documents provided, and these are summarised in Table 2 (Appendix A). The information provided for CommInsure (refer Table 2) states that its policy does not cover "flood", unless it is "flash flooding". It is assumed that this policy does cover inundation by other storm related causes. The information provided for RACQ also includes a specific definition of "flash flooding" which suggests similar policy provisions to CommInsure. It is unclear whether policies for the other insurance companies include coverage for 'flash flooding". Whilst the precise wording of these differs between insurance companies, it is assumed that none of the policies provide coverage against flooding, which is defined as being characterised by overflow or overtopping of the natural or artificial banks of a waterway, lake or dams. The term "rising water" is used in one of the definitions. The definitions of "flash flooding" are that it is characterised again by overflow or overtopping of the natural or artificial banks of a waterway, lake or dams, but occurring within 24 hours of the commencement of "intense rainfall".

7. It is beyond the scope of this report to comment on the various definitions provided, except if they appear to have resulted in difficulties in differentiating between the likely causes of the most severe inundation of a particular property to the extent as to whether or not it triggers an insurance liability. This is commented on in Section 2.4.

8. It is interesting to note that most definitions that were provided to us appear to differentiate "flooding" from "flash flooding" purely on the basis of the elapsed time between property inundation and the commencement of the storm or rainfall which caused this inundation. The mechanism for this inundation could be the same in both cases, ie overflow or

overtopping of a waterway. It is assumed in such cases that "flash flooding" would take precedence, and if inundation occurred due to overflow or overtopping of a waterway, it would be deemed to be "flash flooding" if it occurred within 24 hours of the start of the storm which caused it, and "flooding" if it occurred more than 24 hours after the start of the storm which caused it.

9. In this report, "inundation" refers to water covering any part of a property or floor.

2.3. Discussion of Reports

10. The majority of the reports were finalised within two to three months after the floods under investigation. While this timing facilitated the collection of anecdotal and visual evidence relevant to the inundation, it precludes taking advantage of the greater body of processed evidence that becomes progressively available in later months. In some cases a staged approach was undertaken whereby a subsequent investigation was undertaken with additional information to resolve uncertainties highlighted in an earlier analysis.

11. Table 1 lists all of the reports provided, and a number of characteristics relevant to consideration of the questions in the brief. In particular, the table provides a summary of:
    - whether the report relates to broad regions or specific properties;
    - information and analyses used in preparing the report;
    - whether site inspections were undertaken during preparation of the report;
    - whether the report assigns causes of inundation to specific individual properties or groups of properties, as distinct from broad conclusions regarding the likely nature and causes of flooding across broad regions;
    - definitions used to classify the causes of flooding; and,
    - in cases where the report did assign causes of inundation to specific individual properties or groups of properties, the basis of these assessments.

12. This review is restricted to providing comment on the appropriateness of the method, approach and assumptions used to prepare the reports. No checks have been undertaken on the quantitative accuracy of any of the assessments made.

2.3.1. Regional Reports

13. Of the regional reports, the majority assigned likely causes of flooding to broad regions rather than to groups of specific properties. It is assumed that there is no intention to use these reports to assign likely causes of inundation to specific properties or groups of specific

properties, but rather to provide background information to assist other more detailed investigations of specific properties or groups of properties.

14. The majority of these regional reports were desktop studies involving:
    - analysis of rainfall information to assign likely average recurrence intervals (ARI)[1] to rainfall at specific locations;
    - analysis of the relative timing of rainfall and peak water levels; and,
    - investigation of likely flood inundation extents based on aerial photography and/or derived mapping extents based on recorded peak water levels and terrain data.

    These studies generally did not involve any site investigations, particularly of individual properties.

15. The significant exceptions to this were reports 3, 4, 5, and 6 (report 7 also relates), which did assign likely causes of flooding to groups of specific properties. These reports indicated that it was not possible to assign the likely cause of inundation to some properties without undertaking additional site specific investigations. Report 5 is a refinement of report 4, based on additional investigations including "visual checks", "review of terrain and drainage channel/culvert details", and "detailed inspections and interviews with residents". These additional investigations significantly reduced the numbers of properties for which it had not previously been possible to assign a cause of inundation.

16. It appears that inundation due to flooding was assigned to a number of properties without undertaking any specific site inspections or other site specific investigations. Whilst it is not clear from the report exactly how this was done, it is assumed that it has been based on strong evidence that:
    - the property was within an area of inundation, based on either aerial photography or a flood extent derived from peak water levels and appropriately accurate terrain data;
    - the local rainfall was unlikely to have been sufficient to significantly surcharge the local drainage system; and,
    - the property was inundated at least 24 hours after the commencement of the catchment rainfall that caused the inundation (which by the policy definitions adopted preclude the cause of inundation being a "flash flood").

17. If this strong evidence was not available, it is assumed that further site specific investigations were deemed necessary to assign a likely cause of flooding.

[1] The "ARI" of an event is another way of expressing the probability that the rainfall of a given depth is exceeded in any one year.

18. This methodology is based predominantly on the availability of recorded rainfall and flood level data, and on actual or derived flood inundation extents. It assumes that:
    - recorded rainfall data is available and accurate, and is representative of rainfall at the specific property locations;
    - recorded peak water level data is available and accurate; and,
    - terrain data is available and sufficiently accurate, and that these can be used in conjunction with any available aerial flood photography to estimate peak flood inundation extents at specific property locations.

19. These assumptions are generally reasonable, and are unlikely to result in any significant errors. Some judgement will clearly be required to determine the strength of the evidence, particularly at the margins of flood inundation extents, and where significant reliance has been placed on interpolation techniques to map peak flood extents.

20. Full details of all site specific investigations to determine likely causes of flooding for properties for which these were deemed to have been required have not been provided, other than that they included "visual checks", "review of terrain and drainage channel/culvert details", and "detailed inspections and interviews with residents". Whilst these would probably have varied from property to property it is assumed that they would have included a range of:
    - comparison of property floor levels with recorded flood levels;
    - comparison of property locations with recorded to derived flood inundation extents;
    - inspection of local drainage systems;
    - inspection of local topography;
    - estimation of local runoff and whether this could have been sufficient to cause the inundation that reportedly occurred;
    - confirmation of timing of inundation and how this related to peak water levels and local rainfall; and,
    - consideration of any news reports or anecdotal evidence provided by residents.

21. Because different techniques will be appropriate to different property locations, and it is unclear from the reports which analyses were applied to which properties, it is not possible to draw a firm conclusion as to whether the methodologies applied were appropriate to particular properties.

2.3.2. Property Specific Reports

22. Eight reports have been provided relating to six specific properties (two reports have been provided for two of the properties). Site inspections and discussions with the owners were undertaken as part of investigation on five of the six properties – the exception being the report on 86 Queensborough Parade, Karalee (report 24).

23. The types of investigations undertaken varied from property to property (refer Table 3, Appendix A). They generally focussed on resolving the following questions necessary to support a conclusion regarding the likely cause of inundation:

    a) Is it probable that the property was subject to inundation from flooding of an adjacent waterway? The investigations involved:
        - analysis of peak water levels from the relevant adjacent river or creek relative to ground and floor levels at the site;
        - aerial photographs showing the extent of inundation in the vicinity of the site during the event;
        - other photography taken during the event;
        - discussion with the owners and other witnesses regarding nature and timing of inundation;
        - previous investigations, particularly any that included mapping of major flood inundation extents; and,
        - analysis of debris and water marks in and in the vicinity of the property indicating inundation levels;

    b) Is it likely that local stormwater runoff or surcharge of the local drainage system was the primary cause of inundation? The investigations involved:
        - analysis of local rainfall records to determine likely average recurrence interval, and thus whether it was likely to have been sufficient to exceed the capacity of the local drainage system (this was undertaken for all six properties);
        - analysis of timing of local rainfall relative to timing of peak water levels, and thus whether peak water levels were likely to have been associated with local stormwater runoff or flood inundation (this was again undertaken for all six properties); and,
        - consideration of the size of the local catchment, and intensity of local rainfall, and whether this would have generated sufficient depth of local runoff to cause the reported inundation depths.

c) What was the timing of peak inundation relative to the commencement of the rainfall that caused this inundation (relevant particularly for "flash flooding" coverage)?

24. Many of the assumptions implicit in these investigations are similar to those described above for the regional reports. Other underlying assumptions include:

- that debris marks observed within a short time after the relevant event provide a reasonable representation of peak inundation levels that occurred; and,
- the reasonableness of using simple hydraulic methods to check that flow depths resulting from local catchment runoff would be significantly less than the actual inundation depths.

25. The results of the investigations that rely on the two assumptions listed above have generally been used as supporting evidence, rather than primary evidence of flooding as the cause of inundation. This is considered appropriate in these circumstances

26. The reports concluded that all six properties were inundated due to flood. In all six cases the evidence in support of this conclusion is strong:

a) *6 Eriboll Close, Middle Park.* A photograph taken by the owner during the event shows a water level above the floor level of the property and inundation of the adjacent golf course. The inundation extent photography provided by ICA shows water surrounding the property on three sides. Rainfall analysis showed the intensity of local rainfall to be relatively insignificant (less than a 1 year ARI event) and thus very unlikely to have been sufficient to exceed the capacity of the local drainage system. The estimated floor level of the property is of the order of 250 mm below the peak flood level estimated from adjacent Brisbane River gauges, and the upper catchment rainfall that caused flooding along the Brisbane River commenced some three days prior to peak inundation levels at the site. The owner of this property had expected floor level survey to be undertaken during the site inspection, but this was not done. Measurements were however taken on site and local contour information obtained, and this was reconciled with recorded peak flood level information. This is considered sufficiently accurate as supporting evidence of the conclusion that the property was inundated due to flooded.

b) *23-25 Mathew Court, Burpengary*. Local rainfall analysis showed the intensity of local rainfall to be relatively insignificant (less than a 1 year ARI event) and thus very unlikely to have been sufficient to exceed the capacity of the local drainage system. Runoff from the local catchment would not be sufficient to cause inundation depths consistent with debris marks noted during the site inspection in March 2011. Downstream gauge records indicated there was a "major flood peak" on Burpengary Creek at the time of inundation. A previous report indicates that the property is in an

area subject to inundation by overflows from Burpengary Creek during a major flood event, and the upper catchment rainfall that caused flooding along Burpengary Creek commenced some two days prior to peak inundation levels at the site. The Burpengary Creek gauge closest to the site was not operating during the peak of the event, necessitating peak inundation levels to be estimated on the basis of debris marks.

c) *12/13 Bridge Street, Redbank, Ipswich.* Analysis of local rainfall and the size of the local catchment showed that this would not be sufficient to cause the reported inundation of 4.5 metres above ground level. The timing of the peak inundation was consistent with the timing of peak flood levels on the Brisbane River. Peak inundation occurred was more than a day after peak local rainfall and thus too late to have been caused by runoff from the relatively small local catchment, and the upper catchment rainfall that caused flooding along the Brisbane River commenced some two days prior to peak inundation levels at the site. Whilst the report notes that "Ipswich City Council's on-line mapping identifies that the property is located entirely within the 100 year ARI flood extent", the report, which was dated 8 April 2011, does not appear to use or make reference to the 2011 flood extent mapping presented in the ICA's Ipswich LGA report (report 2), which was released on 20 February 2011. This mapping appears to cover Goodna Creek in the vicinity of the property. The authors of the reports on the Redbank property were also joint authors of this ICA report. The ICA report does note that the extents of inundation were "indicative only and should not be used for assessing flood behaviour at individual properties. The degree of uncertainty is greatest around the limits of inundation." Whilst we have made no attempt to undertake a comprehensive search for other available information beyond the reports provided to us, we are also aware of the existence of aerial photography of the Redbank area flown around the time of the flood peak, and which we understand to have been available on the Queensland Government website from 1 April 2011. The report on the Redbank property does not appear to have used or made any reference to this flood photography. It should be noted, however, that the evidence in support of the conclusion that property inundation was caused by flooding is strong, even without use of all available relevant information.

d) *312 Long Street East, Graceville.* Rainfall analysis showed the intensity of local rainfall to be relatively insignificant (less than a 1 year ARI event) and thus very unlikely to have been sufficient to exceed the capacity of the local drainage system causing inundation of the property (which was inundated to 2.4 m above floor level). Aerial photography shows the site to be entirely within the extent of inundation. The depth of inundation is consistent with peak levels along the Brisbane River, and the upper catchment rainfall that caused flooding along the Brisbane River commenced some three

days prior to peak inundation levels at the site. It is worth noting that the site inspection undertaken as part of preparation of this report was undertaken in June 2011, some five months after the inundation event. The evidence in support of the conclusion that this property was subject to inundation by flooding is very strong, and the timing of the site inspection is considered immaterial.

e) *86 Queensborough Parade, Karalee, Ipswich*. Analysis showed the intensity of local rainfall to be relatively insignificant (less than a 1 year ARI event) and thus very unlikely to have been sufficient to exceed the capacity of the local drainage system. The local catchment draining the site was very small, and peak water levels recorded along Bundamba Creek were some 4 metres above ground levels at the property. Whilst not entirely clear from the evidence, it appears likely that the upper catchment rainfall that caused flooding along the Bremer River, which in turn backed up along Bundamba Creek, commenced around two days prior to peak inundation levels at the property. Given that the strength of the evidence that the property was flooded to significant depth from the Bremer River backing up Bundamba Creek, we do not consider that a site inspection would have been necessary to confirm the cause of inundation.

f) *2 Mannikin Street, Narangba*. Runoff from the local catchment would not be sufficient to cause the reported inundation depths, and rainfall intensities in the upper catchment of Burpengary Creek were around 100 year ARI but were only between 2 and 20 year ARI in the vicinity of the property. It is unclear whether the relevant insurer offers coverage against "flash flooding". This is relevant because whilst it does appear clear that the inundation resulted from overtopping of Burpengary Creek, it is not clear whether this was caused by intense rainfall that commenced within 24 hours of peak inundation levels.

2.4. Summary and Common Issues

27. Subject to specific commentary above, the methodology, approach and assumptions used in those reports which have assigned likely causes of inundation to specific properties or groups of properties are generally considered sound. This applies to both reports on specific properties, and regional reports that have assigned likely causes of inundation to groups of specific properties.

28. Where flooding has been assigned as the cause of inundation, all reports have used have used a range of appropriate evidence and investigations at each site to support this conclusion. Whilst the types of investigations undertaken varied from property to property depending the generally on the availability of information, they generally focussed on

resolving the following questions necessary to support a conclusion regarding the likely cause of inundation as follows:

a) Is it probable that the property was subject to inundation from flooding of an adjacent waterway? The investigations involved:
   - analysis of peak water levels from the relevant adjacent river or creek relative to ground and floor levels at the site;
   - aerial photographs showing the extent of inundation in the vicinity of the site during the event;
   - other photography taken during the event;
   - discussion with the owners and other witnesses regarding nature and timing of inundation;
   - previous investigations, particularly any that included mapping of major flood inundation extents; and,
   - debris and water marks in and in the vicinity of the property indicating inundation levels.

b) Is it likely that local stormwater runoff or surcharge of the local drainage system was the primary cause of inundation? The investigations involved:
   - analysis of local rainfall records to determine likely average recurrence interval and thus whether it was likely to have been sufficient to exceed the capacity of the local drainage system;
   - analysis of timing of local rainfall relative to timing of peak water levels, and thus whether peak water levels were likely to have been associated with local stormwater runoff or flood inundation; and,
   - consideration of the size of the local catchment, and intensity of local rainfall, and whether this would have generated sufficient depth of local runoff to cause the reported inundation depths.

c) What was the timing of peak inundation relative to the commencement of the rainfall that caused this inundation (relevant particularly for “flash flooding” coverage)?

29. It is considered appropriate to assign flooding as the cause of inundation to a specific property without undertaking any specific site inspections or other site specific investigations, provided there is strong evidence that:

a) the property was within an area of inundation, based on either aerial photography or a flood extent derived from peak water levels and appropriately accurate terrain data, or

that peak water levels in the waterway adjacent to the property were above property levels;

b) local rainfall was unlikely to have been sufficient to significantly surcharge the local drainage system; and,

c) in instances where the insurer provides coverage against "flash flooding", the property was inundated at least 24 hours after the commencement of the catchment rainfall that caused the inundation.

30. Some judgement is clearly be required to determine the strength of the evidence, particularly at the margins of flood inundation extents, and where significant reliance has been placed on interpolation techniques to map peak flood extents.

31. Review of these studies did not reveal evidence of any particularly common problems, and, as noted previously, conclusions regarding the primary cause of inundation at all sites relied on a range of evidence rather than single piece of evidence. Issues encountered at some sites and referred to above included:

a) Time between inundation event and site inspection. In one instance, a site inspection was undertaken some five months after the inundation event. In this particular example, the timing of the inspection was considered immaterial to the conclusion. The timing of a site inspection might however become significant if there was strong reliance on evidence which might reduce in strength over time, for example, debris marks.

b) Debris marks were used as supporting evidence at one site, though the relevant site inspection was undertaken two months after the event. Whilst we are not aware of full details of the debris marks, it is considered likely that these will have provided some reasonable indication of likely inundation depths.

c) Gaps in stream gauge records. In one instance the stream gauge closest to the site was not operating during the peak of the flood event. In this case it was considered that other evidence was sufficient to support a conclusion that property inundation was primarily due to flooding.

d) Reliance on estimated property floor levels. In one instance a property owner expressed surprise that the floor level of his property was not surveyed during the site inspection. In this case measurements were taken on site and local contour information obtained, and this was reconciled with recorded peak flood level information. This was considered sufficiently accurate evidence to support the conclusion that the property was flooded.

e) As noted previously, it is unclear whether all insurers provide coverage against "flash flooding", and if so, how this is defined. In one of the site specific reports, whilst it is clear from the evidence presented that the inundation was caused by "flood" overflow from a waterway, it is less clear whether this was caused by significant rainfall that commenced within 24 hours of peak inundation levels. This could be an issue if the relevant insurer provided coverage for "flash flooding". This was the only clear example in the reports provided where the insurance definitions could have potentially resulted in problems in deciding whether inundation was caused by "flood" or "flash flood".

f) In some cases it appears that flood extents derived from peak flood levels and available terrain data were used as supporting evidence. Whilst it is possible that this might result in some minor inaccuracies depending on the reliability of gauge information and the accuracy of available terrain data, this is considered unlikely to be a significant issue if used in conjunction with other supporting evidence. As noted previously, and consistent with advice provided with this mapping, additional site specific investigations should be undertaken for properties at the margins of mapped flood inundation extents.

g) Whilst no attempt has been made in this review to source additional information beyond that available in the reports provided, we cannot be sure that all reports have made use of all relevant information that would have been available at the time. One of the reports on a specific property appears not to have made use of indicative flood extent mapping, and aerial flood photography showing flood extent, both of which were understood to have been available prior to the report being finalised, though it is noted that the conclusions were strongly supported by the alternative evidence used.

3. Conclusions

32. Subject to specific commentary above, the methodology, approach and assumptions used in those reports which have assigned likely causes of inundation to specific properties or groups of properties are generally considered sound. This applies to both reports on specific properties, and regional reports that have assigned likely causes of inundation to groups of specific properties. Where flooding has been assigned as the cause of inundation, all reports have generally used have used a range of appropriate evidence and investigations at each site to support this conclusion. The types of investigations undertaken varied from property to property depending the generally on the availability of information.

33. We did not find any evidence of any particularly common problems, and, as noted previously, conclusions regarding the primary cause of inundation at all sites relied on a range of evidence rather than single piece of evidence. Issues encountered at some sites and referred to above included:

    a) Time between inundation event and site inspection – this could potentially be problematic if there was strong reliance on evidence which might reduce in strength over time (for example, debris marks);

    b) Gaps in stream gauge records – in one instance the stream gauge closest to the site was not operating during the peak of the flood event;

    c) Reliance on estimated rather than surveyed property floor levels;

    d) Difficulties in differentiating between flooding and flash flooding, in cases where policies provide no “flood” coverage, but do provide coverage against “flash flooding”;

    e) Potential inaccuracies in flood extents derived from peak flood levels and available terrain data; and,

    f) Failure to make use of all available and relevant information.

Appendix A
Summary tables of salient features

Table 1 – Key features of insurance reports

Ref	Commissioning Organisation	Consultant/ Author	Title and Date	Regional or Site Specific	Region or Site	Basis of Study	Site Inspections	Flooding Causes Assigned to Individual Properties	Flooding Causes Subdivided Into	Basis of Conclusions for Flooding of Individual Properties	Notes/ Comments
1	Insurance Council of Australia	WRM Water and Environment, Water Matters International and Worley Parsons	Flooding in Brisbane City LGA, 20 February 2011	Regional	Brisbane City	• Rainfall intensity analysis • Analysis of relative timing of rainfall and peak water levels • Maps of maximum flood inundation extents (created using a mapping algorithm)	No	No	• Flooding – "relatively high waterflow that overtops or breaches the natural or artificial banks in any part of a waterway, lake or dam. • Flash flooding – "floods that peak within 6 hours of commencement of the period of intense rainfall" • Overland Flow – "surface runoff before it enters a waterway"	NA	Note on maps of maximum flood extent created using mapping algorithm: "are indicative and should not be used for assessing flooding behaviour at individual properties".
2	Insurance Council of Australia	WRM Water and Environment, Water Matters International and Worley Parsons	Flooding in Ipswich City LGA, 20 February 2011	Regional	Ipswich City	• Rainfall intensity analysis • Analysis of relative timing of rainfall and peak water levels • Maps of maximum flood inundation extent (created using a mapping algorithm)	No	No	• Flooding – "relatively high waterflow that overtops or breaches the natural or artificial banks in any part of a waterway, lake or dam. • Flash flooding – "floods that peak within 6 hours of commencement of the period of intense rainfall" • Overland Flow – "surface runoff before it enters a waterway"	NA	Note on maps of maximum flood extent created using mapping algorithm: "are indicative and should not be used for assessing flooding behaviour at individual properties".
3	Insurance Council of Australia	WRM Water and Environment, Water Matters International and Worley Parsons	Flooding in Somerset Regional Council City LGA, 20 February 2011	Regional	Somerset Regional Council	• Rainfall intensity analysis • Analysis of relative timing of rainfall and peak water levels • Reports of breakaway flows in some townships • Flood photographs	No	No	• Flooding – "relatively high waterflow that overtops or breaches the natural or artificial banks in any part of a waterway, lake or dam. • Flash flooding – "floods that peak within 6 hours of commencement of the period of intense rainfall" • Overland Flow – "surface runoff before it enters a waterway"	NA	

Ref	Commissioning Organisation	Consultant/ Author	Title and Date	Regional or Site Specific	Region or Site	Basis of Study	Site Inspections	Flooding Causes Assigned to Individual Properties	Flooding Causes Subdivided Into	Basis of Conclusions for Flooding of Individual Properties	Notes/ Comments
4	RACQ	Water Technology	Investigation of the January 2011 Inundation Event – Brisbane, March 2011	Regional	Brisbane City	• Analysis of relative timing of rainfall and peak water levels • Flood inundation extents (obtained from ICA)	Limited	Yes	• Damage caused by "flood" – "rising water which enters a home as a result of it running off or overflowing from any origin or cause" • "Not possible to formulate an opinion at the time of provision of this report"	Uncertain, but properties assessed as damaged by "flood" assumed to be those clearly within flood inundation extents provided by ICA, for which claims have been received.	
5	RACQ	Water Technology	Investigation of the January 2011 Inundation Event – Brisbane, Annexure A, 21 April 2011	Regional	Brisbane City	Annexure to Report 4. As above plus: • Site inspections of specific properties including terrain and drainage culvert/channel details • Discussions with residents of selected properties • Rainfall intensity analysis • Further analysis of relative timing of rainfall and peak water levels	Yes	Yes	Refinement of assessments in Report 4, including reassignment where considered appropriate, and addition of: • "inundation as a result of stormwater runoff"	Uncertain, but assume: • "flood" as above • "stormwater runoff" – site inspections and discussions with residents.	Report acknowledges potential for poorly maintained or old drainage infrastructure.
6	RACQ	Water Technology	Investigation of the January 2011 Inundation Event – Ipswich, March 2011	Regional	Ipswich City	• Analysis of relative timing of rainfall and peak water levels • Rainfall intensity analysis • Flood inundation extents (obtained from ICA) • Discussion with witnesses and owners of affected properties • Preliminary hydraulic modelling to assess impacts of backwater from Brisbane River • Maps of flood inundation extents	Limited	Yes	• Damage caused by "flood" (see definition for Report 4), further subdivided into: • Bremer River, unaffected by Brisbane River tail water • Brisbane River • "Not possible to formulate an opinion at the time of provision of this report" – not clear which flood mechanism, may be outside then inundation zone. Some require further investigation of local issues including proximity to elevated floodplain features and potential restrictive drainage culverts/channels. These have been identified separately.	Uncertain, but properties assessed as damaged by "flood" assumed to be those clearly within flood inundation extents provided by ICA, for which claims have been received. Whether inundated by Bremer River, affected or no by Brisbane River flood levels based on inundation extents determined with assistance of hydraulic modelling for the 'unaffected by backwater' case.	
7	RACQ	Water Technology	Supplementary report on water inundation in the Ipswich region, 14 June 2011	Regional	Ipswich City	Supplementary report to report 6. Includes more detailed hydraulic modelling of impacts of backwater from Brisbane River.	No	No	NA	NA	

Ref	Commissioning Organisation	Consultant/ Author	Title and Date	Regional or Site Specific	Region or Site	Basis of Study	Site Inspections	Flooding Causes Assigned to Individual Properties	Flooding Causes Subdivided Into	Basis of Conclusions for Flooding of Individual Properties	Notes/ Comments
8	RACQ	Water Technology	Investigation of the January 2011 Inundation Event – Middle Brisbane River Reaches, May 2011	Regional	Middle Brisbane River	• Analysis of relative timing of rainfall and peak water levels • Rainfall intensity analysis • Oblique aerial flood photographs • Discussion with witnesses and owners of affected properties • Site inspections of selected properties in Fernvale and Lowood	Yes (report notes incomplete and on-going at time of completion of report)	Yes	• Damage caused by "flood" • "inundation as a result of stormwater runoff" • "Not possible to formulate an opinion at the time of provision of this report" • "Flash flooding" (single property) – "sudden flood caused by heavy rain that fell no more than 24 hours prior to the flash flood"	Unclear.	
9	IAG	Worley	Impact of January 2011 South-east Queensland Weather Event at Brisbane and Ipswich, 17 February 2011	Regional	Brisbane and Ipswich	• Rainfall intensity analysis • Analysis of relative timing of rainfall and peak water levels	No	No	Five point classification system based on: • Intensity and location of rainfall • Size of river system	NA	
10	IAG	Worley	South East Queensland Weather Event Report, January 2011, 18 February 2011	Regional	South East Queensland	• Rainfall intensity analysis • Analysis of relative timing of rainfall and peak water levels	No	No	Five point classification system based on: • Intensity and location of rainfall • Size of river system	NA	
11	IAG	Worley	January 2011 South-east Queensland Weather Event – Updated Ipswich Area Specific Report, 8 July 2011	Regional	Ipswich	• Rainfall intensity analysis • Analysis of relative timing of rainfall and peak water levels	No	No	Five point classification system based on: • Intensity and location of rainfall • Size of river system	NA	
12	CBA - CommInsure	Worley	South East Queensland Weather Event Report, January 2011, 3 March 2011	Regional	South East Queensland	• Rainfall intensity analysis • Comment on relative timing of rainfall and peak water levels	No	No	CommInsure definitions of: • "Flash flooding" • "Flooding"	NA	Comment that many properties could fit into one or other of the two CommInsure definitions.
13	CBA - CommInsure	Worley	Queensland Weather Event Report, December 2010, 7 April 2011	Regional	Whole of Queensland	• Rainfall intensity analysis • Comment on likely response times	No	No	CommInsure definitions of: • "Flash flooding" • "Flooding"	NA	Comment that many properties could fit into one or other of the two CommInsure definitions.
14	CBA - CommInsure	Worley	January 2011 South-East Queensland Weather Event – Area Specific Report – Post Codes 4303 & 4304, 7 March 2011	Regional	East Ipswich to Moggill	• Rainfall intensity analysis • Comment on likely response times	No	No	CommInsure definitions of: • "Flash flooding" • "Flooding"	NA	Comment that many properties could fit into one or other of the two CommInsure definitions.
15	CBA - CommInsure	Worley	January 2011 South-East Queensland Weather Event – Area Specific Report – Postcode 4303 & 4304 and Barellan Point, 9 March 2011	Regional	East Ipswich to Moggill, and Barellan Point	• Rainfall intensity analysis • Comment on likely response times	No	No	CommInsure definitions of: • "Flash flooding" • "Flooding"	NA	Comment that many properties could fit into one or other of the two CommInsure definitions.

Ref	Commissioning Organisation	Consultant/ Author	Title and Date	Regional or Site Specific	Region or Site	Basis of Study	Site Inspections	Flooding Causes Assigned to Individual Properties	Flooding Causes Subdivided Into	Basis of Conclusions for Flooding of Individual Properties	Notes/ Comments
16	CBA - CommInsure	Worley	December 2010 Queensland Weather Event – Area Specific Report – Postcode 4670, 9 March 2011	Regional	Burnett River catchment	• Rainfall intensity analysis • Comment on likely response times	No	No	CommInsure definitions of: • "Flash flooding" • "Flooding"	NA	
17	CBA - CommInsure	Worley	December 2010 Queensland Weather Event – Area Specific Report – Postcode 4715, 18 April 2011	Regional	Biloela district	• Rainfall intensity analysis • Comment on likely response times	No	No	CommInsure definitions of: • "Flash flooding" • "Flooding"	NA	Comment that many properties could fit into one or other of the two CommInsure definitions.
18	QBE	Water Technology	Individual Site Flood Assessment Report for 6 Eriboll Close, Middle Park, 3 June 2011 and Supplementary Report, 3 June 2011	Site Specific	Brisbane	References Reports 4 and 5. Same basis, but also: • ICA maps of inundation extent • Estimated ground and floor levels • Detailed site inspection • Discussion with owners of affected property	Yes	Yes	Flood event – backwater from Brisbane River	Consideration of all factors, particularly timing of reported inundation, and ICA flood extent.	
19	QBE	Water Technology	Fischer Addendum to Individual Site Flood Assessment Report for 6 Eriboll Close, Middle Park, 3 June 2011 and Supplementary Report, 14 September 2011	Site Specific	Brisbane	Supplementary report to above. Additional information: • Consideration of comments by the owners on the original report • Discussion of consultant report prepared for nearby development • Additional consideration of ground, floor and flood levels	Yes, additional to original site inspection	Yes	Flood event – backwater from Brisbane River	Consideration of all factors, particularly timing of reported inundation, ICA flood extent, and estimated ground, floor and flood levels.	
20	CGU	Worley	Doyle Property, 23-25 Mathew Court, Burpengary, 1 April 2011	Site Specific	Burpengary	• Moreton Bay Regional Council 100 year flood extent maps (depth on property 0.5 to 1.5 m) • Detailed site inspection, including debris marks • Discussions with owners • Rainfall data • Analysis of Burpengary Creek level gauges	Yes	Yes	Waters exceeding the normal confines of Burpengary Creek backing up through drainage lines and flowing through the property	Consideration of all factors.	
21	CGU	Worley	Doyle Property, (2nd report), 25 July 2011	Site Specific	Burpengary	Supplementary report to report above. • Further rainfall analysis • Local catchment overland flow depth calculation	No additional	Yes	Waters exceeding the normal confines of Burpengary Creek backing up through drainage lines and flowing through the property	Consideration of all factors.	

Ref	Commissioning Organisation	Consultant/ Author	Title and Date	Regional or Site Specific	Region or Site	Basis of Study	Site Inspections	Flooding Causes Assigned to Individual Properties	Flooding Causes Subdivided Into	Basis of Conclusions for Flooding of Individual Properties	Notes/ Comments
22	NRMA	Worley	Hydrology report relating to the January 2011 storm - 12/13 Bridge Street, Redbank, 8 April 2011	Site Specific	Redbank, Ipswich	• Ipswich City Council's 100 year flood extent mapping • Local rainfall intensity analysis • Analysis of local stream gauges • Site inspection • Discussion with owners	Yes	Yes	Waters exceeding the normal confines of Floodwater escaping from the normal confines of the Brisbane Rover and backing up Goodna Creek.	Consideration of a range of factors, particularly intensity of local rainfall, downstream flood levels, debris marks on and around the property, timing of flooding and rainfall.	
23	Alliance Australia Insurance	Water Technology	312 Long Street East, Graceville, 22 July 2011	Site Specific	Graceville	• Site inspection • Discussions with owner and neighbours • Water mark on side of house (June 2011) • Aerial flood photography showing flood extent • Rainfall intensity analyses • Brisbane River flood level information • Analysis of relative timing of rainfall and peak water levels	Yes	Yes	Flooding caused by backwater from the Brisbane River	Consideration of a range of factors, particularly Brisbane River flood levels, local rainfall intensity analyses, aerial flood photography, and relative timing of rainfall and peak water levels.	
24	Suncorp	WRM Water and Environment	Rainfall and local storm water behaviours during January 2011 Event - 86 Queensborough Parade, Karalee, 8 August 2011	Site Specific	Karalee, Ipswich	• Rainfall intensity analysis • Bremer River flood levels • Consideration of size of local stormwater catchment • Relative timing of rainfall and peak water levels	No	Yes	Flooding from Bremer River	Range of factors including size of local stormwater catchment, timing of peak water levels relative to rainfall.	
25	AAMI	WRM Water and Environment	Water Damage Assessment - 2 Mannikin Street, Narangba, 7 March 2011	Site Specific	Narangba	• Site inspection • Discussions with owners • Photographs of flood event • Local rainfall intensity analysis • Local catchment overland flow depth calculation • Burpengary Creek flood levels	Yes	Yes	"Floodwater overflowing from Burpengary Creek". Definition of "floodwater" being "The inundation or covering of normally dry land by water which: escapes or overflows from, or cannot enter because it is full or overflow, or is prevented from entering, because other water has already escaped or been released from, the normal confines of any watercourse or lake, including any that may have been modified by human intervention, or reservoir, canal, dam or stormwater channel."	Consideration of a range of factors, particularly Burpengary Creek flood levels, and local catchment overland flow depth calculation.	

Table 2 – Insurance Definitions

Agency	Definitions	Links to Insurance Cover
Insurance Council of Australia	• *Surface Runoff* - Surface runoff is the rainfall that, after hitting the ground, drains away across the ground surface. • *Overland Flow* - Overland Flow is the name given to surface runoff before it enters a waterway. Overland flow is caused by direct local rainfall in the area producing the overland flow. • *Waterway* - A waterway is any physically defined flow path that captures overland flow and conveys it down a catchment to the catchment outlet or terminus. Note that the term „waterway□ includes all types of "flow channels□: • *Flood* - A flood is any relatively high waterflow that overtops or breaches the natural or artificial banks in any part of a waterway, lake or dam. It also includes local inundation caused by overland flows • *Flash Floods* - Flash floods are sudden and unexpected floods that occur with little or no warning. Flash Floods are caused by short, intense rainfalls, generally falling over a relatively small, steep catchment area, often away from the area of interest. Flash floods have been defined as "sudden and unexpected flooding caused by local heavy rainfall or rainfall in another area of the catchment. Often defined as flooding that occurs within six hours of the onset of the flood-generating rainfalls".(DIPNR, 2005). In the USA, flash floods are defined as floods that peak within 6 hours of commencement of the period of intense rainfall.	NA
IAG	Five point classification system based on: • Location and intensity of storm • Size of river system	No links provided
CommInsure	• *Flash flooding* – "the overflow of any lake, creek, river, stormwater channel or any other watercourse (whether natural, altered or manmade). Caused by a storm, where the flooding occurs within 24 consecutive hours of the storm having commenced" • *Flood* – "the inundation of normally dry land by water which has overflowed, escaped or been released from a lake, river, creek, stormwater channel, canal or any other watercourse whether natural, altered or manmade."	• "Flash flooding" is covered • "Unless the damage is caused by flash flooding, this policy does not cover floods."

Agency	Definitions	Links to Insurance Cover
RACQ	• *Flood* - is rising water which enters a home as a result of it running off or overflowing from any origin or cause." • *Flash flood and stormwater runoff* – is a sudden flood caused by heavy rain that fell no more than 24 hours prior to the flash flood or stormwater runoff"	No links provided
AAMI	• *Floodwater* – "The inundation or covering of normally dry land by water which: escapes or overflows from, or cannot enter because it is full or overflow, or is prevented from entering, because other water has already escaped or been released from, the normal confines of any watercourse or lake, including any that may have been modified by human intervention, or reservoir, canal, dam or stormwater channel."	No links provided
QBE (definitions in Water technology report)	• *Flood* – the temporary inundation of land by expanses of water that overtop (ie have exceeded the capacity of)the natural or artificial banks of a watercourse, including a drainage channel, stream, creek, river, estuary, lake or dam, or any associated water holding structure." • *Runoff* is the amount of rainfall that drains along the surface and into the drainage system or directly into the receiving waters. Local runoff is that which occurs local to a point in question (ie within a backyard) and has not yet reached a drainage system" • *Stormwater flooding* is inundation by local runoff caused by heavier than usual rainfall. Stormwater flooding is caused by local runoff exceeding the capacity of an urban stormwater drainage system."	No links provided
CGU	No definitions provided.	
NRMA (definitions provided in Worley report)	Five point classification system , as per IAG	
Alliance Australia Insurance (definitions in Water technol.ogy report)	As per QBE	
Suncorp	No definitions provided	

Table 3 – Details of Property Specific Reports

Property Location	Reports Refs	Local Rainfall Intensity Analysis	Relative Timing of Rainfall and Peak Water Level	Flood Inundation Extents	Site Inspection	Discussions with Owners/ Witnesses	Site flood photographs	Ground and Floor Levels Relative to Peak Flood Levels	Consideration / Estimation of Local Catchment Runoff
6 Eriboll Close, Middle Park	18,19	Yes	Yes	Yes – 2011 event aerial photograph and ICA inundation extent	Yes	Yes	Yes – including flood marks on walls	Yes, - ground and floor levels estimated, not surveyed	Consideration
23-25 Mathew Court, Burpengary	20,21	Yes	Yes	Yes – within Moreton Bay Council 100 year inundation extent	Yes – debris marks noted	Yes	No, however debris marks noted	Yes	Estimation
12/13 Bridge Street, Redbank	22	Yes	Yes	Yes – within Ipswich City Council's 100 year inundation extent	Yes	Yes	No, however owner noted flood level on wall	Yes	Consideration
312 Long Street East, Graceville	23	Yes	Yes	Yes – 2011 event flood photography	Yes	Yes	Yes, and brown flood mark noted on outside of house, and inundation marks on inside of house	No	Consideration
86 Queensborough Parade, Karalee,	24	Yes	Yes	Yes – 2011 event flood photography	No	No	Yes – as per flood inundation extents	Yes	Consideration
2 Mannikin Street, Narangba	25	Yes	Yes	No	Yes	Yes	Yes	Unclear	Estimation

Appendix B
Curriculum Vitae of Reviewers

David B Sheehan

Global Services Leader – Natural Resource Management

Qualifications:

Bachelor of Engineering (Civil) (First Class Hons.), University of Melbourne, 1976

Master of Engineering Science, University of Melbourne, 1981

Affiliations:

Member, Institution of Engineers, Australia (Membership No. 15755)

Past Chairman, Institution of Engineers, Australia, Victorian Water Engineering Branch

Fields of Special Competence:

Over 30 years experience in flood hydrology and hydraulics; urban and rural drainage and flood mitigation; flood plain management; water quality management; water resources management; project management.

Relevant Experience:

Current position: Global Services Leader – Natural Resource Management (SKM)

Responsible for the development and deployment of the firm's global capabilities in Natural Resource Management, focusing on Catchment Management, Ecology and Water Quality, Groundwater, Hydrology and Water Resources, and Marine and Coastal Sciences.

- Responsible for financial, service delivery and people management of Operations Centre providing natural resource management services to range of government and private clients.
- Melbourne Water: Project Director for Redevelopment Service Scheme Projects - 2005/06 and 2006/07. Involved development of drainage scheme works in 10 catchments, required to cater for projected future development.
- West Gippsland Catchment Management Authority: Project Manager for investigation of the potential impacts of a second entrance to the Gippsland Lakes.
- City of Bunbury: Development of Bunbury Floodplain Management Strategy.
- Mildura Rural City Council: Project Manager for preparation of the Sunraysia Drainage Strategy, and Mildura Urban Stormwater Quality Management Plan. This comprised development of physical, institutional and funding strategies for management of irrigation and urban drainage in the Sunraysia region to 2050, and included an extensive stakeholder consultation program.

Egis Consulting Australia (formerly CMPS&F Pty Limited), Melbourne

1995 to 2001:

Manager, Water Resources Section.

As Manager of the Water Resources Section, responsible for directing, co-ordinating and providing technical input to projects as follows:

- North Central Catchment Management Authority, Victoria: Review and update of the 1985 Lower Loddon Hydrologic Study. This involved updating a highly complex RORB hydrological model to account for flood events subsequent to the original study.
- NRE, Victoria: GIS-based mapping of existing and interpreted flood data for the North Central, East and West Gippsland and Glenelg-Hopkins Regions of Victoria, as part of NRE's Flood Data Transfer Project (project fees $1.5 million).
- Melbourne Water: Preparation of digital flood inundation maps and property flood information databases as part of the Melbourne Water Drainage Survey Project covering several hundred kilometres of drains across 26 municipalities in metropolitan Melbourne (project fees $2 million).
- Baulderstone Hornibrook, Melbourne: Hydraulic investigations of the impacts of the Melbourne City Link works on flood levels along Moonee Ponds Creek. Studies undertaken included mathematical modelling, and physical modelling of a complex reach that included bridges, roadway support pylons, a lake and architectural features.
- Government of Sarawak, Malaysia: Development of an urban drainage master plan for state capital city of Kuching (population approx. 400,000), as part of the Sg Sarawak Environmental Control and River Management Study.
- Nangiloc Colignan Committee of Management: Detailed design of a pumped drainage scheme serving a major irrigated horticultural area south of Mildura, as part of an overall salinity management plan. The scheme incorporated more than 50 km of pipelines and 100 drainage sumps.
- VicRoads: Hydrologic and hydraulic investigations to determine Calder Freeway bridging requirements of the complex Campaspe River flood plain immediately to the south of Kyneton. Hydraulic investigations were undertaken using a transient two-dimensional flow model.

CMPS&F Environmental (Formerly Camp Scott Furphy Pty Ltd), Melbourne 1992 to 1995:

Senior Water Resources Engineer

Technical control and/or project management of water resources, drainage, flood plain management, hydrology and water quality projects including the following:

- Department of Defence, Army: Investigation and detailed design of drainage works, including works to protect the downstream face of an existing retarding basin in the event of overtopping. (Project value approx. $0.9m)
- Melbourne Water: Independent technical review of Salt Creek and Roseland Grove Major Drainage Scheme designs.
- Shire of Euroa: Flood study of Euroa township (population 3,000), which straddles the flood plains of both Sevens and Castle Creeks. Mitigation options investigated included levee bank construction, and adoption of appropriate planning controls.
- City of Doncaster and Templestowe: Investigation and detailed design of a backlog drainage scheme in an area of intensive residential development. (Project value approx. $0.5m).
- Thiess Contractors: Specialist review of a complex freeway drainage system designed to cater for a peak flow of 40 cumecs.
- Shire of Cobram: Town levees upgrade including investigation and design of 12 km of levees up to 2.5 m high.
- Government of Malaysia: Detail design of major and secondary urban and rural drainage and flood mitigation work for the Federal Territory of Labuan (total project value approx. M$40 million). Aspects of particular relevance included flooding from combined tide and storm events and use of storage basins and tidal gates to mitigate flooding.

Appointed Associate of CMPS&F Pty Limited in 1994.

Kinhill Engineers Pty Ltd, Melbourne

1991 to 1992:

Senior Project Engineer. Projects included:

- Shire of Melton: Project Manager for the Melton South Drainage Strategy Study which included use of artificial wetlands for removal of nutrients and sediment from urban stormwater.

Binnie & Partners Pty Ltd, Melbourne (Acquired by Kinhill Engineers in October 1991)

1986 to 1991:

Senior Project Engineer. Projects included:

- Department of Conservation and Environment: Project Manager for hydrological study of flood events within Wyperfeld National Park.
- Shire of Kaniva: Project Manager for Shire of Kaniva Rural Drainage Study.
- City of Morwell: Project Manager for a flood mitigation and flood plain management study for Waterhole Creek.
- City of Waverley: Project Manager for development of a drainage strategy for a large urban municipality in the eastern suburbs of Melbourne.
- Shire of Swan Hill: Project Manager for the Swan Hill and Tyntynder Flats Flood Plain Management Study. Considerations included geotechnical stability of existing levee banks, flood damage assessment for irrigated agricultural area, and development of structural and non-structural flood mitigation options.
- Rural Water Commission: Seconded to the Commission's flood plain management section to prepare maps showing extent of land liable to flooding in the Shires of Wangaratta, Oxley and Beechworth.
- Freehill, Hollingdale & Page (Solicitors): Expert witness on flooding issues to Administrative Appeals Tribunal Hearing concerned with expansion of an existing piggery.
- Alor Setar Town Drainage Scheme, Malaysia: Conceptual and detailed design of M$15m urban drainage scheme, including 18 cumec capacity pumping station, sluice gate, bund, floodway, and trunk and secondary drains.
- State Electricity Commission of Victoria: Technical co-ordination of non- steady state computer modelling study to determine the extent of flooding caused by hypothetical dam failures.
- Public Works Department, Brunei: Responsible for hydraulic engineering aspects of a drainage standards manual for the State of Brunei.

Binnie & Partners Pty Ltd, Melbourne

1980 to 1985:

Engineer. Project involvement included:

- Public Works Department, Brunei: Visited Brunei to investigate stream diversion requirements around the International Airport and to estimate runoff from adjacent urban development schemes.
- Black Dog Creek Improvement Trust: Investigated alternative schemes for draining farmland subject to water-logging damage in north-east Victoria.
- State Rivers and Water Supply Commission of Victoria: Responsible for development and operation of an hydraulic cell model of 120 sq km of the Ovens and King River flood plains upstream of Wangaratta.

- Commonwealth Department of Housing and Construction: Responsible for design and analysis of new tidal channel drainage system as part of redevelopment of Brisbane International Airport. Primary considerations included estuary hydraulics and channel stability.
- State Rivers and Water Supply Commission of Victoria: Hydrological investigations as part of a comprehensive study of flooding at Wangaratta.

University of Melbourne

1977 to 1979:

Postgraduate research: Masters thesis on sediment transport in open channel flow.

Environment Protection Authority, Melbourne

1977:

Graduate Engineer, Water Quality Section

- Member of a team examining water quality in the Yarra catchment and Lake Burrumbeet.

Registrations:

Chartered Professional Engineer, Australia

Appointments:

Chairman, Organising Committee, 2002 Hydrology and Water Resources Symposium.

Awards:

- A T Danks Exhibition for Civil Engineering, University of Melbourne, 1975.
- Dixon Scholarship for Engineering Mathematics, University of Melbourne, 1975.
- McFarland Scholarship, Ormond College, University of Melbourne, 1976.
- Commonwealth Postgraduate Research Award, 1977.

Papers and Presentations:

- Sheehan D B, Charteris A B and Barry C R, 2006, 'Impacts to the Hydraulic Regime of Gippsland Lakes due to a Second Entrance', 15th New South Wales Coastal Conference, Coffs Harbour.
- Sheehan D B, Middelmann M, Jordan P, Zoppou C and Druery C, 2005, 'National Catalogue of Flood Studies', NSW Floodplain Management Authorities Conference, Narooma.
- Sheehan, D B and Alexander, D, 2003, 'Irrigation Management Information and Reporting System (IMIRS) Project', ANCID 50th National Irrigation Conference, Shepparton.
- Sheehan, D B and Graze, T H, 1998, 'Digitised Technology for Urban Flood Mapping', Hydrastorm Conference on Urban Stormwater Management, Adelaide.
- Sheehan, D B and O'Dell, M, 1990, 'Altor Setar Town Drainage, Malaysia', Conference on Hydraulics in Civil Engineering, Sydney.
- Sheehan, D B and Rippin, K G, 1986, 'Ovens River Floodplain Management' Hydrology and Water Resources Symposium, Brisbane.
- Sheehan, D B, 1982, 'Energy Loss Parameters for Flow Profile Computation: Ovens - King Floodplain at Wangaratta', ACADS Workshop/Forum on Energy Loss Parameters for Flow Profile Computation Programs, Melbourne.
- Sheehan, D B, 1981, 'Sediment Transport in an In-stream Settling Basin', M.Eng.Sc. Thesis.

Curriculum Vitae

Dr Rory Nathan

Practice Leader Hydrology

Qualifications

- B.E.(Agr), University of Melbourne, 1980
- M.Sc., D.I.C., University of London, 1984
- Ph.D., University of Melbourne, 1990

Affiliations

- Fellow, Institution of Engineers, Australia
- Australian Representative, Floods Committee, International Committee on Large Dams
- Member Hydrology Sub-committee, NSW Dams Safety Council
- Honorary Fellow, Department. Civil Engineering., Monash University
- Past Honorary Fellow, Dept. Civil and Environmental Engin., University of Melbourne

Awards

- Named as member of "Top 100 Most Influential Engineers" in Australia, 2009
- National Civil Engineer of the Year, awarded by the Institution of Engineers, 2000
- W.H. Warren Medal (1992, 1998, and 2005) for the best paper in Civil Engineering (national award by the Engineers Australia).
- ASCE Journal of Irrigation and Drainage Engineering Best Research Paper Award (1997)
- G.N. Alexander Medal (1998) for the best paper in Hydrology and Water Resources, (national award by the Engineers Australia)
- Best presentation of a technical paper at the Hydrology & Water Resources Conf. (1993)
- ACEA Award of Excellence (1998).
- Victorian Engineering Excellence Award (2003).

Fields of Special Competence

Dr Rory Nathan has around 30 years experience in engineering hydrology in both the academic and consulting fields. He is actively involved in a number of research projects under the auspices of Engineers Australia and with the University of Melbourne. While he has generally worked in areas of flood estimation, hydrological processes, regionalisation, and catchment hydrology, he has developed specialist skills in the following areas:

- Estimation of extreme hydrologic events (floods and low flows)
- Characterisation of risk for dam safety
- Hydrologic estimation in ungauged catchments
- Regionalisation of hydrologic information
- Characterisation of flow regimes for environmental flows
- Modelling and simulation of hydrologic processes
- Hydrologic model development and application

Relevant experience

- Convenor and senior author of the national guidelines for the estimation of large to extreme floods published by the Institution of Engineers Australia.

- Member Technical Steering Committee for revision of national guidelines for general flood estimation ("Australian Rainfall and Runoff").
- Contracted by Queensland Floods Commission of Inquiry to provide expert review of factors relevant to the magnitude of the January 2011 flood that devastated the City of Brisbane.
- Contracted by the U.S. Bureau of Reclamation to provide input to the development of guidelines on the characterisation of hydrologic inputs for risk analysis
- Contracted by the U.S. Army Corps of Engineers to help formulate research directions to be undertaken in the area of hydrologic risk using federal agency funding
- Contracted by the Murray Darling Basin Commission to oversee and review the flood risk assessment of Hume Dam being undertaken by NSW State Water (and SMEC).
- Member of panel undertaking risk review of the Dam Safety Program for Western Australia's South-West Irrigation Dams
- Member, Expert Review Panel for the Preliminary Risk Assessment of the portfolio of dams owned by the Hydro-Electric Authority, Tasmania
- Member, Expert Review Panel for the Preliminary Risk Assessment of Somerset, Wivenhoe, and North Pine Dams owned by the South East Queensland Water Board
- Member, Expert Review Panel for the upgrading of Rosslynne Dam owned by the Southern Rural Water
- Project Manager consequence assessment and risk characterisation of Dartmouth Dam (Goulburn-Murray Water)
- Project Director for the consequence assessment and risk characterisation of Hume Dam (DLWC, NSW)
- Variously Project Manager and Project Director for the estimation of hydrologic loads, risk characterisation, and consequence assessment of several dams owned by Goulburn-Murray Water (and its predecessor the Rural Water Corporation); Dartmouth, Eildon, Cairn-Curran, Nillhacootie, Laanacoorie, Mokoan, Waranga, Buffalo, Fyans, Bellfield, Rocklands,
- The estimation of hydrologic loads and review of spillway adequacy for many major water storages owned by the (then) Rural Water Corporation (Eildon, Dartmouth, Laanacoorie, Wartook, Bellfield, Fyans, Waranga, Lonsdale, Rocklands, Pine, Taylors, Cairn-Curran, Tullaroop, Upper Coliban, Lauriston, Malmsbury, Buffalo, and Pykes Creek).
- Responsible for event tree development and risk characterisation of hydrologic inputs to the Preliminary Risk Assessment of all dams owned by the Snowy Mountain Hydro-Electric Authority.
- Responsible for the derivation and characterisation of hydrologic and hydraulic inputs to the Preliminary Risk Assessment of all dams owned by South Australia Water.
- Use of quantitative risk analysis for evaluation of floodplain development options for AMP
- Provision of advice to ACTEW/AGL on how to best account for climatic variability in the development of options for their future water supply options (ongoing)

Publications

Dr Nathan has published around 60 papers in refereed journals and books, and a further 100 papers in refereed conference proceedings, on a wide range of engineering and environmental hydrology subjects.