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Phase Three – Damage Mitigation Feasibility

Feasibility and Final Report for Brisbane Valley Flood Damage Minimisation Study

Prepared by
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Queensland Government
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Document Approval

I endorse the contents of this BVFDMS Feasibility and Final Report

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1.0 Introduction

In February 2004, an application for funding was submitted to the Department of Emergency Services (DES) under the Natural Disaster Mitigation Program (NDMP) 2004-2005 for the proposed Brisbane Valley Flood Damage Minimisation Study (BVFDMS). The aim of the proposed project was to gain a greater understanding of the potential damage caused by a range of flood events in the Brisbane River Catchment and to consider, if applicable, reviewing the dam operating rules to improve flood mitigation.

The total project cost was $591,000 and was to be conducted over an 18 month period commencing in the 2004-2005 financial year. The funding contributions were split in thirds between:

- the federal government (Department of Transport and Regional Services – DoTaRs),
- state government (DES) and
- stakeholder organisations:
    - Brisbane City Council (BCC),
    - Ipswich City Council (ICC),
    - Esk Shire Council (ESC),
    - Laidley Shire Council (LSC),
    - Kilcoy Shire Council (KSC),
    - South East Queensland Water Corporation (SEQWater),
    - SunWater,
    - Department of Natural Resources and Water (DNRW), and
    - The Bureau of Meteorology (BOM).

Although the project was successful in its funding application, due to the delay in approval of the Funding Agreement by the DES the project did not commence until January 2006. Further, only $531K was initially allocated from the total funding amount with a requirement to submit a "reapplication for funding" for the remaining funds under the 2005-2006 NDMP funding round.

A reapplication for the remaining funds was submitted under the 2005-2006 NDMP funding round. This was not supported by the State Assessment Committee (SAC) due to significant delays in the commencement of the study. However the SAC recommended that the project team prepare a further reapplication for funding under the 2006-2007 NDMP funding round for the remaining funds. This was done however due to the review of the scope of the project following the findings, and consequent closure of the project; the DES was advised by BCC that no further funding would be required to support the project.

This Feasibility and Final Report is a requirement as per the Project Scope (refer to Section 6.0 Project Scope) for Phase Three – Damage Mitigation Feasibility and the Funding Agreement.

2.0 Background

The Brisbane River catchment covers an area of approximately 14,000 square kilometres of which about half is below Wivenhoe Dam. In the catchment below the Dam the main tributaries are:

- The Lockyer River which joins the Brisbane River just downstream of Wivenhoe Dam near Lowood
- The Bremer River which flows into the Brisbane River at Moggill

Heavy rains in these areas can cause flooding of rural districts in the Lockyer and Bremer Valleys and along the Brisbane River. Severe flooding of the cities of Ipswich and Brisbane has occurred on several occasions. Although Wivenhoe Dam significantly reduces the frequency of flooding, major events may still occur

Flood records for Brisbane extend back to the 1840's and indicate that the city has a long history of flooding. The largest flood last century occurred in January 1974, rising to a height of 5.45 metres on the Brisbane City Gauge at the river end of Edward Street. The flood caused widespread damage in Brisbane, affecting at least 8,000 properties. The city of Ipswich and other towns in the catchment have similar risks and incidence.

During large flood events, such as those of 1893 and 1974, major flooding has devastated parts of Brisbane, Ipswich and other parts of the Brisbane River catchment. In the aftermath of the 1974 event, Wivenhoe Dam was constructed with a significant flood mitigation flood storage capacity. This was in addition to the planned enhancement to augment the water supplies of Brisbane and its surrounds.

During flood events, there is significant flood mitigation inherent in Wivenhoe and Somerset Dams. They are operated in conjunction in order to maximise the flood mitigation capabilities. By operating them in accordance with clearly established procedures during floods, safety of the Dams is ensured and hazards to life and property can be minimised. These clearly defined procedures are documented in the Manual of Operational Procedures for Flood Mitigation for Wivenhoe Dam and Somerset Dam, approved under the *Water Act 2000*.

At the time of the application development, an upgrade process to the Wivenhoe Dam was underway with the construction of a three bay right abutment fuse plug spillway, as a dam safety mechanism to cater for floods in the probability range of 1:5,000 to 1:100,000 (or extremely rare events). In conjunction with this upgrade, the Dam operational procedures were being rewritten for very rare events to avoid if possible the operation of the fuse plug spillway. These operational procedures concentrated on dam safety as the first priority and used an increasing step release procedure depending on dam water level, with the second priority to minimise flooding effects downstream.

Nevertheless, there was ongoing concern by BCC and ICC that major flood events of a return period of 1:50 ARI to 1:100 ARI could adversely affect their respective communities and infrastructure. The project team considered that more could be done

and this was an excellent opportunity to review the dam operating rules. This review would be assisted by the modelling work undertaken in the years since the original rules were formulated.

BCC, ICC and ESC have development controls framed around the 100year ARI standard to minimise flood damage. However older development and infrastructure are below this level.

This project was focussed on gaining an understanding of how damage varies with flow and return period and then optimising the operation of the Dams after dam safety considerations were taken into account. The aim being to keep the flood levels below crucial thresholds where possible.

In order to complete the flood damage analysis some modelling of flood profiles would be required in areas not covered by existing studies. The level of risk was about understanding these thresholds and managing the Dam operations to minimise the damage to properties, buildings and infrastructure downstream of the Dams.

Hundreds of thousands of dollars have been invested by stakeholders over the past decade to develop more comprehensive understandings of the flooding characteristics of the Brisbane River and its tributaries. The consequent flood profiles, flood models, spatial information (eg from aerial based laser surveys), and geographic information systems can now form the foundation for building a flood damage model. All this information was not available when the dam operating rules were last reviewed.

The BVFDMS was an ideal opportunity for Federal and State agencies, Local Governments and SEQWater to work together to optimise the operations of the dams so that the significant damage that can occur from flood events would be minimised.

3.0 Project Purpose

The aim of this project was to gain a greater understanding of the potential damage caused by a range of flood events in the Brisbane River Catchment. It was anticipated that this could lead to the modification of the "operating rules" for Somerset and Wivenhoe Dams and thus minimising potential damage caused by a given flood event. The "operating rules" prescribe when water should be released from the dams and what quantity of water should be released during flood events.

4.0 Project Objectives

The objectives of the project were:

- To gain a greater understanding of the potential damage caused by a range of flood events in the Brisbane River catchment
- To determine if the "operating rules" for Somerset and Wivenhoe dams can be modified and thus minimise damage caused from a given flood event

To meet the project objectives, the following tasks were to be undertaken

- Develop a series of updated and regionally consistent flood damage models for Brisbane City Council, Ipswich City Council and Esk Shire Council
- Produce a consolidated regional flood damage model for the Brisbane River catchment area
- Refine the Bureau of Meteorology forecasting model for the Brisbane River catchment area and to obtain a better understanding of the modelling process by all flood operation centres
- Develop a refined warning system leading to a better informed (and hence resilient) community
- Determine if the "Operational Procedures" for the Brisbane Valley Dams can be modified to achieve a more effective flood mitigation outcome

5.0 Project Success Factors

This project was to be deemed successful if

- There was an increased understanding of the flood damage
- Lower flood damage by changing the operating rules of the dam
- Findings were adopted by Councils
- Increased collaboration and understanding across agencies

6.0 Project Scope

The BVFDMS consisted of a preliminary scoping study and five phases over the life of the project as follows.

6.1 Study Phase One Scoping

The scoping study involved a comprehensive literature review to ensure that all related references, previous studies, models and information were identified and assembled for the project.

6.2 Phase Two Damage Assessment

This phase involved producing a common methodology for collation of flood data and damage data. It also involved the refinement and understanding of flood levels and their relationship with infrastructure and development within BCC, ICC and ESC boundaries. The flood data and damage data were built on existing (limited) information (e.g. floor levels in Local Government areas) and new information gained from current air photography and Aerial Laser Survey ground levels. Some areas required new ground level surveys to complete the overall damage assessment.

This phase of the project was to estimate only the *potential direct flood damage* (internal, external and structural damage) to residential, commercial, industrial and public properties. It did not estimate flood damage to public infrastructure (e.g. roads

and bridges), sports and recreational areas, parks and gardens, and conservation areas. Indirect damages (e.g. financial, clean up and opportunity costs) and intangible damage (e.g. social costs associated with flooding) have not been included in the damage estimates.

The key input data used for potential flood damage estimation were classified into five (5) groups

- Property data
- Topographic data
- Floor level data
- Flood level data
- Flood stage damage curves

The data collected from the five groups were then combined to form a property flood damage database. This data was combined with the recently completed flood models using GIS techniques to develop flood damage curves (flow versus damage) for Brisbane City, Ipswich City and Esk Shire Council.

6.3 Phase Three Damage Mitigation Feasibility

In this phase, the Steering Committee reviewed the output from the Damage Assessment phase and agreed on the set of damage thresholds as a lead in to the Modelling phase. A Project "halt" option was incorporated at this stage in the event that there are no clear damage threshold points identified on the flood damage curves.

Note: The project was halted at this stage. It was agreed by the Steering Committee that the damage curves derived did not indicate an opportunity to target changes in dam operations in order to avoid a damage threshold. However all stakeholders considered that the communities of all Councils gained significantly from the work to this point through:

- A better understanding of flooding and its effects
- A better understanding of how Wivenhoe impacts on flooding downstream
- The sharing of this knowledge across all the agencies involved as this will form the basis for flood emergency planning, including pre-emptive flood preparations and post flood recovery

6.4 Phase Four Modelling

If the project were to continue, using the outcomes from the Damage Assessment phase, the Modelling phase would:

- Integrate the Bureau of Meteorology hydrology model with the Dam operations model
- Identify a range of flood scenarios for the Brisbane River catchment
- Link the flood damage models into a consolidated flood damage model for the area

- Run a range of flood scenarios against the consolidated model to identify opportunities to manipulate flood levels to minimise damage
- Conduct a sensitivity analysis ("what if") on the consolidated model

6.5 Phase Five Assessment

The consolidated model would be used for a rigorous assessment of options for refining the operating rules in the Manual of Operational Procedures.. This would involve "trade offs" of damage for the greater community good. It would also define clear trigger points, based on measurable inputs, to identify operational changes.

6.6 Project Peer Review

This phase was to involve both a peer review and an expert panel that would review the project outcomes before they were to be implemented.

7.0 Peer Review

During Phase Two of the project, BCC engaged WRM Water & Environment Consultants to undertake a peer review and to assist as necessary to:

- Undertake the flood damage assessment for Brisbane River floods in Brisbane City
- Ensure that the approach undertaken by BCC is appropriate and consistent with both the ICC and ESC approaches

All analytical work for this phase of the project was undertaken by BCC staff.

8.0 Reporting

Over the life of the project a number of reporting requirements were identified to comply with both internal and external conditions of the funding received to support the project.

Internally, the types of reports produced included:

- Monthly project status reports
- Monthly cash flow analysis
- Monthly cost summary reports
- Monthly project timeline reports
- Technical Working Group Meeting Minutes
- Steering Committee Meeting Minutes

At each Steering Committee and Technical Working Group meeting, all reports were presented, analysed, discussed and endorsed.

In line with the project's Funding Agreement, at the conclusion of each milestone a number of reports were produced, endorsed and provided to DES for review and acceptance. These reports included

- NDMP – Executive Summary
- NDMP – Project Milestone Reports
- NDMP – Financial Reports

All reports produced internally and externally were endorsed and accepted by all stakeholders.

As mentioned in section 6.0 Project Scope, a number of reports were to be produced at the conclusion of each phase. As the project was halted at the end of Phase Three, the following reports were produced

- Brisbane Valley Flood Damage Minimisation Study – Literature Review prepared by Kellogg Brown and Root Pty Ltd, August 2005
- Brisbane Valley Flood Damage Minimisation Study – Brisbane City Flood Damage Assessment prepared by WRM Water & Environment, October 2006
- Brisbane Valley Flood Damage Minimisation Study – Ipswich City Flood Damage Assessment prepared by WRM Water & Environment, November 2006
- Brisbane Valley Flood Damage Minimisation Study – Esk Shire Flood Damage Assessment prepared by WRM Water & Environment, February 2007
- Brisbane Valley Flood Damage Minimisation Study – Damage Feasibility Report prepared by BCC, June 2007

9.0 Project Findings

At the completion of Phase Two, there was an expectation from the Technical Working Group that a "step" would appear in the damage curves flood discharge for each Council. This step would represent a potential target for revision to the dam operation. If dam outflow could be held below the flow represented by the step then there is the potential for significant damage reduction.

However, this was not the case as in place of the step was a smooth curve. When these findings were presented to the Steering Committee in February 2007, it was agreed that further hydrograph investigations were needed to determine whether the steep slope result would alter, and, instead a step would then emerge.

9.1 Flood Level Vs Damage Curves

Each Council's damage curves findings presented opportunities for enhanced flood emergency planning and the potential for mitigation through future planning and policy modifications.

The graphs below illustrate the damage curves for flood discharge for each Council including the estimated flood damage costs.

Brisbane City Council

Table 4.1 Residential and Non-Residential Flood Damage Summary Results, Brisbane City

Flood Discharge (m^3/s)	Residential			Non-Residential			Total Damage ($million)
	Total Damage ($million)	No. of Flood Damaged Properties	Average Damage Per Property ($1000)	Total Damage ($million)	No. of Flood Damaged Buildings	Average Damage Per Building ($1000)	
1000	0	0	0	0.002	1	2.06	0.002
2000	0	0	0	0.24	1	241.48	0.24
3000	0.40	29	13.78	0.71	4	177.81	1.11
4000	4.22	138	30.56	1.75	26	67.12	5.97
5000	29.10	831	35.02	13.30	125	106.41	42.40
6000	98.27	2052	47.89	59.07	383	154.23	157.34
7000	225.76	4073	55.43	169.27	803	210.80	395.03
8000	382.63	6280	60.93	288.54	1356	212.78	671.17
10000	718.21	10296	69.76	589.12	2259	260.79	1307.33

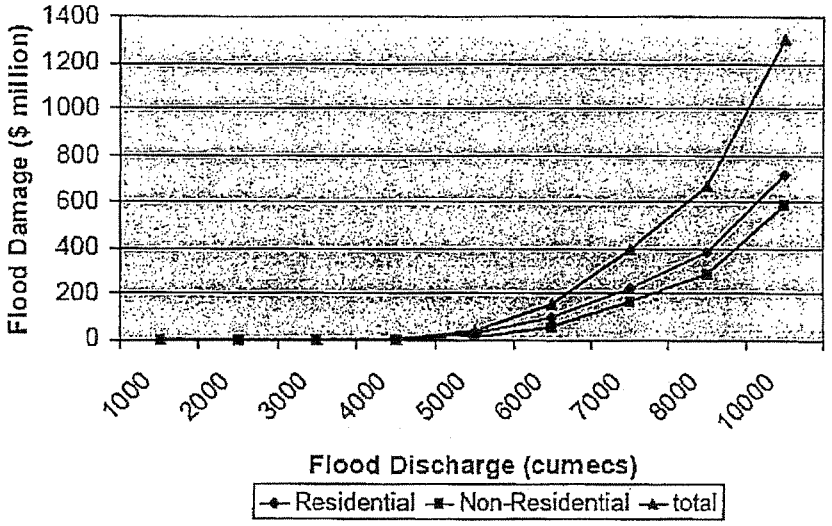

Figure 4.1 Residential, Non-Residential and Total Flood Damage Estimates, Brisbane City

The difference in damage costs between a 6000 and 7000 cumec flood in Brisbane City was approximately $250M with double the number of residential and non-residential properties affected. In addition, the difference in damage costs between a 7000 and 8000 cumec flood event was approximately $275M.

Ipswich City Council

Table 4.1 Residential and Non-Residential Flood Damage Summary Results, Ipswich City

Flood Discharge (m^3/s)	Residential			Non-Residential			Total Damage ($million)
	Total Damage ($million)	No. of Flood Damaged Properties	Average Damage Per Property ($1000)	Total Damage ($million)	No. of Flood Damaged Buildings	Average Damage Per Building ($1000)	
1000	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0
3000	0.23	6	38.09	0.03	2	15.06	0.26
4000	3.97	98	40.50	1.14	102	11.22	5.11
5000	19.09	393	48.58	3.99	152	26.23	23.08
6000	54.20	899	60.29	10.59	212	49.96	64.79
7000	110.59	1558	70.98	24.50	315	77.77	135.09
8000	181.95	2425	75.03	47.50	449	105.78	229.45
10000	327.42	4161	78.69	102.33	845	121.11	429.75

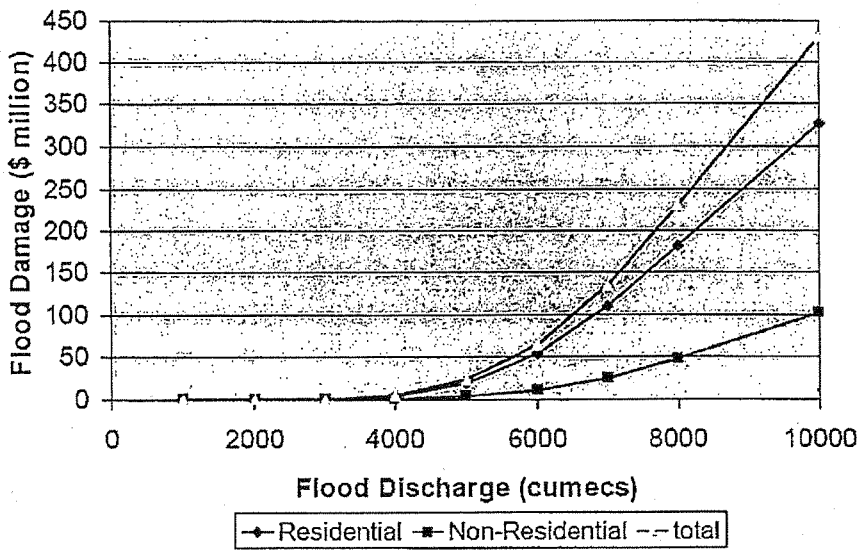

Figure 4.1 Residential, Non-Residential and Total Flood Damage Estimates, Ipswich City

The difference in damage costs between a 6000 and 7000 cumec flood in Ipswich City was approximately $70M with double the number of residential and non-residential properties affected. In addition, the difference in damage costs between a 7000 and 8000 cumec flood event was approximately $90M.

Esk Shire Council

Table 4.1 Residential and Non-Residential Flood Damage Summary Results, Esk Shire

Flood Discharge (m^3/s)	Residential		Non-Residential		Total Damage ($million)
	Total Damage ($million)	No. of Flood Damaged Properties	Total Damage ($million)	No. of Flood Damaged Buildings	
1,000	0.23	2	0	0	0.23
2,000	0.46	5	0	0	0.46
3,000	0.84	9	0	0	0.84
4,000	2.41	26	0	0	2.41
5,000	3.34	33	0	0	3.34
6,000	5.18	55	0	0	5.18
7,000	8.20	92	0.05	1	8.25
8,000	15.02	161	0.10	2	15.12
10,000	24.13	235	0.70	13	24.83
12,000	31.59	307	2.73	34	34.33

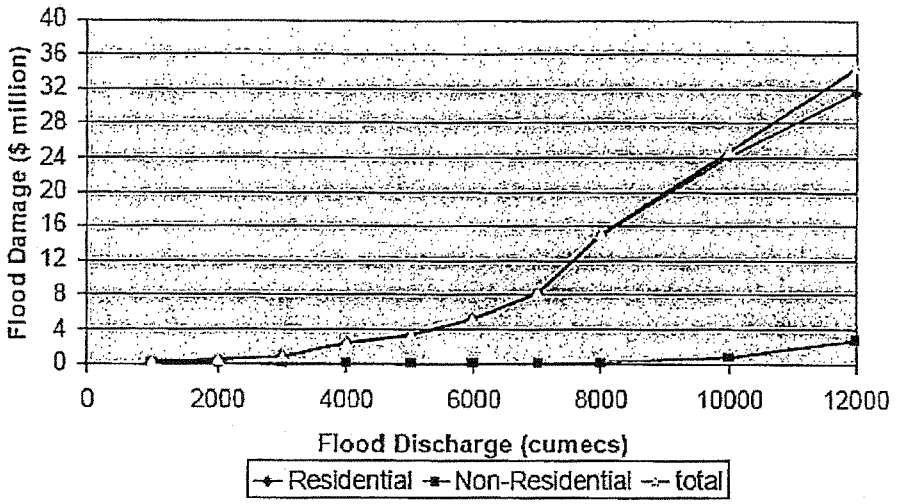

Figure 4.1 Residential, Non-Residential and Total Flood Damage Estimates, Esk Shire

The difference in damage costs between a 6000 and 7000 cumec flood in Esk Shire was approximately $3M with nearly double the number of residential and non-residential properties affected. In addition, the difference in damage costs between a 7000 and 8000 cumec flood event was approximately $7M.

9.2 Hydrographs

In October 2006, the project's Technical Working Group met to review the preliminary damage curve results for BCC and whether there were possible opportunities to review the Dam Operations to minimise damage by reducing dam peak outflow by 2,000 cumecs by using early release of flow. That is, whether 2000 cumecs could be released earlier over 24 hours so that the peak outflow could be reduced by the same amount; if so, how this could be achieved?

As mentioned above, in February 2007, the project's Steering Committee was briefed on the project's progress to date and was explained that there was an assumption that there would be a "step" in the damage curves which would then indicate the need to review the Dam Operation rules. As there was no step in the preliminary results this left the future of the project in question.

The Steering Committee agreed to approach SEQWater to commission SunWater to produce a series of hydrographs to demonstrate the flood damage difference between 6000 and 7000 cumecs and between 7000 and 8000 cumecs. The Steering Committee was interested in seeing as to whether there could be any effect on these flood series by bringing an 8000 cumec flood down to a 7000 cumec flood as the damage savings could be substantial.

First, the Steering Committee wanted to examine the dam flows as they affected downstream flood levels / flows. This was done by selecting some examples of design and historical flood events using the operational program WivOps.

What SunWater found was that the operation of the Wivenhoe Dam successfully separates flood peaks downstream from flood peaks from upstream. Therefore, the only flood mitigation options available was in the early release phase of the operation of the dam as this is the only phase that directly effects downstream peaks.

This means that changing the operation rules of the dam would only have minimal effect on the peak flood downstream so there was little opportunity to affect flows below the Q100 level.

10.0 Conclusion

The BVFDMS has highlighted the importance of the dam operation rules holding the dam water back until after the peak flow occurs downstream. Before the initiation of the BVDMS, it was considered that holding the water back was not as important as early release. What this project has proven is that it is critical to hold the flood waters back. Thus is the understanding of the relationship between Dam Safety and Dam Operations in terms of damage has significantly improved, resulting in enhanced flood management capabilities.

In addition, having completed Phases One, Two and Three of the project, the outputs have provided excellent information for BCC, ICC and ESC emergency planning and response capabilities to a Brisbane river flood event. All Councils now have improved information on the number of people, residential and non residential properties affected for a series of flood events.

It was agreed by the Steering Committee that on the basis of the results of the hydrographs, there would have been no significant benefit in continuing with the project. Thus the project was halted at the conclusion of Phase Three. However, the Steering Committee deemed that the project was a success and identified the following benefits from the project:

- Significant improvement to the understanding from all stakeholders of how Wivenhoe affects flooding in the three council areas;
- The damage curves quantified that the current Wivenhoe Dam Operating rules are flexible enough to minimise damage downstream and upstream;
- All representatives have a much better appreciation of Wivenhoe and its operations;
- For BCC, ICC and ESC, now having data regarding floor levels and the number of people affected, by area, for emergency planning and response purposes; and
- Better tools now available for Flood Damage Analysis and consistent application across BCC, ICC and ESC.

Appendices (enclosed CD)

Project Status Reports:

- February 2007
- March 2007
- April 2007
- May 2007
- June 2007

Milestone Three Reports:

- NDMP – Executive Summary
- NDMP – Project Milestone Report
- NDMP – Financial Report

Project Outputs:

- *Brisbane Valley Flood Damage Minimisation Study – Literature Review* prepared by Kellogg Brown and Root Pty Ltd, August 2005.

- *Brisbane Valley Flood Damage Minimisation Study – Brisbane City Flood Damage Assessment* prepared by WRM Water & Environment, October 2006.

- *Brisbane Valley Flood Damage Minimisation Study – Ipswich City Flood Damage Assessment* prepared by WRM Water & Environment, November 2006.

- *Brisbane Valley Flood Damage Minimisation Study – Esk Shire Flood Damage Assessment* prepared by WRM Water & Environment, February 2007.

- *Brisbane Valley Flood Damage Minimisation Study – Hydrographs* prepared by SunWater, March 2007.