BRISBANE CITY COUNCIL
CITY DESIGN

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BRISBANE VALLEY FLOOD DAMAGE MINIMISATION STUDY
BRISBANE CITY FLOOD DAMAGE ASSESSMENT

wrm water & environment

Prepared for:

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1 INTRODUCTION

Brisbane City Council (BCC) is currently undertaking a flood damage assessment for Brisbane River floods in the Brisbane City area. The work is being undertaken as part of the Brisbane Valley Flood Damage Minimisation Study (BVFDMS) in conjunction with Ipswich City Council and Esk Shire Council. The study aims to estimate potential flood damage in the Brisbane Valley and then assess the flood operation rules for the Wivenhoe Dam flood gates to determine whether the current rules can be modified to reduce flood damage in the valley.

The analytical work for this study was undertaken by BCC staff. WRM Water & Environment Pty Ltd (WRM) was requested to provide peer review and assistance to BCC (as necessary) to:

- Undertake the flood damage assessment for Brisbane River floods in Brisbane City; and
- Ensure the approach undertaken by BCC is appropriate and consistent with the Ipswich City and Esk Shire approaches.

The level of detail and accuracy of flood damage assessment undertaken in this study was to be commensurate with the overall objective of the study i.e. assessment of the optimum operation of Wivenhoe Dam gates and spillway. Therefore, a highly detailed and precise assessment of absolute flood damages for different flooding scenarios was not required; reasonably accurate relative differences in flood damage between different flooding scenarios were sufficient to address BCC's needs.

This report presents an overview of the methodology adopted by BCC for flood damage estimation and a summary of the study findings. The key simplifications and assumptions used in the study are also documented.

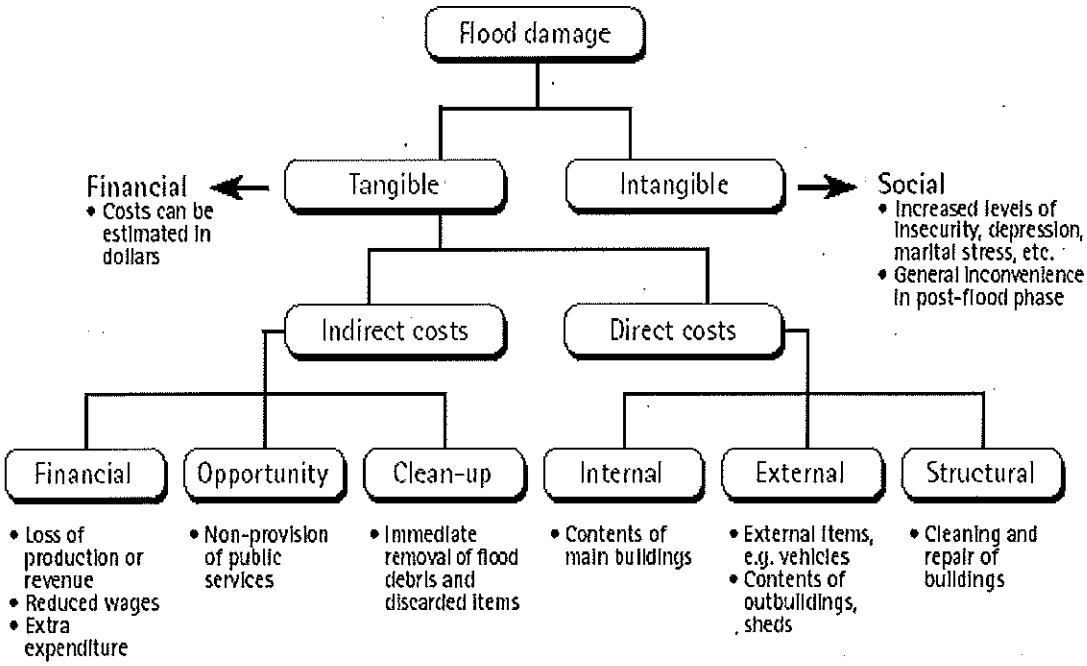
2 TYPES OF FLOOD DAMAGE

2.1 TANGIBLE AND INTANGIBLE DAMAGES

Figure 2.1 shows various commonly recognised types of flood damage. Basically, flood damages can be divided into two major types:

- **Tangible Damages** are the financial costs of flooding and are quantified in dollar terms.
- **Intangible Damages** are the social costs of flooding and are reflected in increased levels of emotional stress and psychological and physical illness.

Intangible damage is difficult to measure and impossible to meaningfully quantify in dollar terms. Nevertheless, it is a very real, significant and often enduring 'cost' that emerges during the recovery phase of a flood disaster.



Source: NR&W (2002)

Figure 2.1 Types of Flood Damage

2.2 DIRECT AND INDIRECT DAMAGES

Tangible damages can be sub-divided into two major sub-categories:

- **Direct Damage** is the loss in value of an object or a piece of property caused by direct contact with floodwaters.
- **Indirect Damage** is the loss in production or revenue caused by a flood, e.g. the loss of wages, additional accommodation and living expenses and any other extra outlays that occur as a consequence of the flood.

Note that indirect costs are additional to ordinary pre-flood living costs. Indirect costs are typically incurred in the post-flood recovery phase.

2.1.1 Direct Damage

Direct damage can be incurred either as:

- a replacement cost if a flood-damaged item is discarded,
- a repair cost if the item is repaired, or
- a loss in value if the item is neither discarded nor repaired. (Repaired items also suffer a loss in value).

In the first case, the Direct Damage is either the pre-flood value or the replacement cost of the item. In the second case, the damage is the cost of repairs (plus any loss in value). In the third case, the damage is simply the loss in value.

Direct Damage is divided into 3 categories: Internal Damage, External Damage and Structural Damage (see Figure 2.1).

- **Internal Damage** refers to damage to the contents of the main building(s) on a property.
- **External Damage** refers to damage to items external to the main building, e.g. motor vehicles, fences, gardens, the contents of sheds or outbuildings, etc.
- **Structural Damage** refers to the damage sustained by the fabric of a building (foundations, floors, walls, doors, windows, etc.) and the damage sustained by permanent fixtures in the building, such as a built-in cupboards, benches, etc.

2.1.2 Indirect Damage

Indirect Damage is also divided into 3 categories:

- **Indirect Financial Damage** refers to the loss of income or increased expenditure caused by a flood.
- **Clean-up Costs** refer to the cost of labour and materials required to clean out a flooded building. Typical clean-up activities include the hosing down of walls and floors to remove silt, the taking up of flooded carpets, the removal and discarding of irreparably damaged items, the drying of rooms, etc.
- **Opportunity costs** arise from direct damage to public assets. Because of this damage, a period elapses when the public is not provided with these services or is provided with a reduced level of service.

It is difficult to realistically evaluate opportunity costs. On the one hand, opportunity costs can be estimated in terms of the total operating cost of the facility (wages, maintenance, interest on

capital assets, etc). Society is prepared to pay this cost to provide the services; thus their absence must be worth a corresponding amount. On the other hand, during the aftermath of a flood, public employees often undertake non-duty tasks useful to society when not providing public services (e.g. clean-up operations). For reasons of convenience, opportunity costs are estimated as the wages cost over the period public facilities are not operating.

2.3 POTENTIAL AND ACTUAL DAMAGES

Potential Damage refers to the damage that would be sustained if no actions whatsoever were taken by householders or others in an attempt to reduce flood damage, i.e. the damage that would occur if the entire population was absent when a flood occurred.

The Actual Damage sustained at a property is always less than the potential damage. Notwithstanding the shortness or absence of flood warnings, people will attempt to save items by lifting them onto benches or shelves, by shifting motor vehicles, by evacuating their possessions, etc.

Potential and actual damage costs are the same for structural damage, as it is generally impossible to reduce structural damage to buildings in the onset of a flood.

3 ADOPTED METHODOLOGY

3.1 OVERVIEW

This study has estimated **only potential direct flood damage** (internal, external and structural damage) to residential, commercial, industrial and public properties. It has not estimated flood damage to public infrastructure (e.g. roads, bridges), sports and recreational areas, parks and gardens, and conservation areas. Indirect damage (e.g. financial, clean-up and opportunity costs) and intangible damage (i.e. social costs associated with flooding) have not been included in the damage estimates.

BCC has used a GIS based flood damage model for this study. The overall philosophy of this approach is to estimate flood damage for each floodprone property and then accumulate property flood damage over a prescribed flood event and region. This approach will not provide accurate flood damage estimates for each individual property but is expected to provide reasonably accurate total damages for the overall area analysed.

Flood damages have been estimated for 9 different Brisbane River flood discharges at the Port Office ranging from 1000m^3/s to 10000m^3/s. All damage estimates are in 2006 dollar values.

The key input data used for potential flood damage estimation are classified into 5 groups:

- Property data;
- Topographic data;
- Floor level data;
- Flood level data; and
- Flood stage-damage curves.

The above 5 groups of data are combined to form a property flood damage database within the BCC database. GIS software is then used to collate and combine the input data, to perform the necessary calculations and to provide summary results. Note that the study made do with data already available within Council databases, except for flood stage-damage curves i.e. no additional data were collected for the study. The following sections describe the different types of data used and the assumptions and simplifications used for flood damage estimation.

3.2 PROPERTY DATA

The following property data have been used:

- Property location (centroid of the building footprint);
- Property type (residential, commercial, industrial, public);

- For residential properties, the type of dwelling (fully detached low set, fully detached highset, fully detached highset, multi-unit single storey and multi-unit double storey);
- For non-residential properties, the type and size (floor area) of the enterprise.

Some of the above data were readily available in Council's property database. The other data were inferred and/or estimated from fire service and city plan (land use) codes for properties.

It is noted that non-detached multi-unit residential buildings have been considered to have only a single unit because there is insufficient information in the Council database to determine the number of ground floor units in these buildings.

3.3 TOPOGRAPHICAL DATA

Topographical data was required to determine the ground level at each of the floodprone properties. This data were obtained from Council's digital elevation model (DEM) of the Brisbane Valley.

3.4 FLOOR LEVEL DATA

Council's database did not have actual floor levels of buildings, but had maximum roof and eave levels of buildings.

- For residential dwellings, the floor level was estimated assuming a difference of 2.7m between the eave level and the floor level. If the difference between the estimated floor level and the ground level at the building footprint is less than 1.5m the dwelling was assumed to be lowset. If the difference was higher than 1.5m but lower than 2.7m the dwelling was assumed to be highset. If the difference was higher than 2.7m then the dwelling was assumed to be double or multi-storey depending on the magnitude of the difference.
- For non-residential buildings, the floor level was assumed to be 0.1m above ground level.

3.5 FLOOD LEVEL DATA

Council has estimated Brisbane River flood levels for 1000m^3/s, 2000m^3/s, 3000m^3/s, 4000m^3/s, 5000m^3/s, 6000m^3/s, 7000m^3/s, 8000m^3/s and 10000m^3/s flood discharges at the Port Office using the Mike-11 model. The model results have then been used to generate peak flood level surfaces for the Brisbane River floodplain for each of the above flood discharges. These flood surface were used to determine first, whether a property is floodprone, and second, the flood levels at each floodprone property.

3.6 STAGE-DAMAGE CURVES

Relationships between depth of flooding and flood damage (i.e. stage-damage curves) are used to estimate potential direct (internal, external and structural) damage at each floodprone property. The stage-damage curves vary from property type to property type, and within each

property type depending on building type, size, etc. Ideally, for accurate estimation of flood damage, locally relevant stage-damage curves for each property type in Brisbane should be used. Unfortunately, such curves are not available. Therefore, for residential properties, the stage-damage curves recently developed for Maroochy Shire (WRM, 2006) have been used. Maroochy Shire curves are expected to provide a reasonable representation of Brisbane flood damages. For non-residential properties, the stage-damage curves recommended in NR&W (2002) have been used. The stage-damage curves adopted in this study are given in Appendix A.

It is noted that the information available in the Council database to determine damage classes for non-residential (i.e. commercial, industrial and public) properties is limited. Therefore, the damage classes currently assigned for non-residential properties should be considered as only indicative and should be carefully checked if more accurate estimates of non-residential flood damage estimates are required in the future.

4 SUMMARY RESULTS

Table 4.1 and Figure 4.1 show a summary of residential, non-residential and total potential flood damage that will be experienced in the Brisbane City area for flood discharges ranging from 1000 m^3/s to 10000 m^3/s. The number of residential properties and the number of non-residential buildings that will incur flood damage for each of the flood events are also shown. Note that some of the non-residential properties have more than one building within the property. Also note that there will be additional properties that experience some yard inundation without incurring flood damage.

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

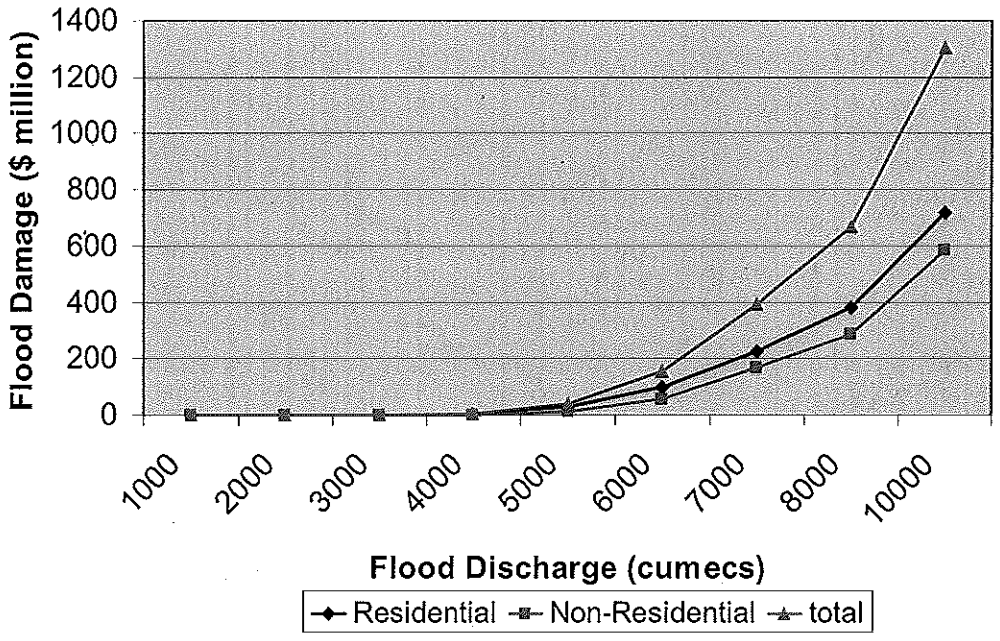


Figure 4.1 Residential, Non-Residential and Total Flood Damage Estimates, Brisbane City

5 REFERENCES

NR&W (2002) 'Guidance on the Assessment of Tangible Flood Damages', prepared by the Department of Natural Resources and Water, Queensland Government, 2002

WRM (2006) 'Stage-Damage Relationships for Flood Damage Assessment in Maroochy Shire', report prepared for Maroochy Shire Council by WRM Water & Environment Pty Ltd, June 2006

APPENDIX A – ADOPTED STAGE DAMAGE CURVES

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Adopted Residential Damage Curves

(Based on Maroochy Shire Curves – All damage values in 2006 dollars)

DOF AFL (m)	Potential Internal Damages ($1000's)				
	FD/SS	FD/DS	FD/HS	MU/SS	MU/DS
0	0	0	0	0	0
0.025	11.6	9.1	2.2	5.1	4.4
0.5	28.1	20.3	5.5	28.7	11.1
1	42.2	31.7	8.5	36.5	15.1
2	50.7	38.7	10.2	39.7	17.1

DOF AFL (m)	Potential Structural Damages ($1000's)				
	FD/SS	FD/DS	FD/HS	MU/SS	MU/DS
0	0	0	0	0	0
0.025	10.4	7.9	3.2	11.2	5.9
0.5	15	11.5	3.8	15.1	8.9
1	18.9	14.6	5.3	18.6	10.3
2	25	19.1	5.8	18.9	12.6

DOF AGL (m)	Potential External Damages ($1000's)				
	FD/SS	FD/DS	FD/HS	MU/SS	MU/DS
0	0	0	0	0	0
0.025	2	2	2	0.9	0.9
0.5	15.9	15.9	15.9	15.3	15.3
1	34.5	34.5	34.5	27.6	27.6
2	36	36	36	28.6	28.6

Notes:

DOF	Depth of Flooding
AFL	Above Floor Level
AGL	Above Ground Level
FD	Fully Detached
MU	Multi Unit
SS	Single Storey
DS	Double Storey
HS	High Set

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Adopted Non-Residential Damage Curves

(Based on ANUFLOOD data given in NR&W (2002) Guidelines)

DOF AFL (m)	Potential Direct Damage (2006 $ Values)				
	Value Class[a]				
	1 Very Low	2 Low	3 Medium	4 High	5 Very High
Small Properties (Floor Area <186m²)			($)		
0	0	0	0	0	0
0.25	3,745	7,490	14,980	29,960	59,925
0.75	9,365	18,725	37,455	74,905	149,815
1.25	14,045	28,090	56,180	112,360	224,720
1.75	15,605	31,210	62,425	124,845	249,690
2	16,540	33,085	66,165	132,335	264,670
Medium Properties (Floor Area 186-650m²)			($)		
0	0	0	0	0	0
0.25	11,860	23,720	47,440	94,890	189,765
0.75	28,715	57,430	114,855	229,715	459,425
1.25	43,145	87,390	174,780	349,610	699,130
1.75	48,375	96,755	193,510	387,020	774,035
2	51,500	103,000	205,995	411,990	823,975
Large Properties (Floor Area >650m²)			($/m²)		
0	0	0	0	0	0
0.25	12	26	54	104	207
0.75	66	133	262	524	1,053
1.25	138	275	554	1,104	2,206
1.75	225	454	906	1,811	3,620
2	270	541	1082	2,163	4,328

[a] Value Class relates to the enterprise's susceptibility to flood damage with 1=very low and 5=very high

DOF Depth of Flooding
AFL Above Floor Level