APPENDIX G

Hydrology

ROADS AND TRAFFIC AUTHORITY
NORTHERN REGION

HYDROLOGY REPORT - SUMMARY

OPTIONS - SHORT LISTING WORKSHOP

GRAFTON BRIDGE PROGRAM

November 2003

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1. INTRODUCTION

The Roads and Traffic Authority is undertaking an investigation of possible bridge locations and approach routes for a new bridge over the Clarence River at Grafton.

Seven route localities have been identified via a broad scale review of the alternatives. The seven localities are identified on the RTA figures prepared for this workshop.

Localities 1 and 2 are located upstream of the existing bridge crossing, while localities 4 to 7 are located downstream of the existing bridge. Locality 3 is in the immediate vicinity of the existing bridge, with alternatives downstream and upstream of the existing structure.

2. FLOOD IMPACTS

The impact of bridges and their approaches are usually measured by:

- **any increase in flood levels (afflux);**
- **any re-distribution of flood flows and flood volumes across the floodplains;**
- **any scour potential adjacent to structures.**

Flow re-distribution is an issue for western NSW rivers but is a lesser issue for NSW coastal rivers.

As noted, bridge and road construction can cause an increase in flood levels (afflux). It should be noted that bridges themselves can be viewed as creating relatively small afflux. However, the bridge approaches across floodplains can cause re-distributions of flood flow and such re-distributions can cause significant affluxes.

3. FLOOD CHARACTERISTICS

The Clarence River is the largest New South Wales coastal river with a catchment of some 19,820 sq kilometres. The river system has a long history of flooding.

The river is essentially confined at Mountain View, 14 kilometres upstream of Grafton, but gradually spreads to an expansive floodplain downstream of Grafton.

In response to the disruption of flooding, major levees have been constructed at North Grafton, South Grafton, and along the river banks in the downstream rural areas. The levees at North Grafton notionally provide protection to the one percent AEP flood, but with no freeboard. However, recent floods in 1996 and May 2001 have shown that the grade of the levee crest downstream of the existing bridge may not provide the expected level of protection.

The levees in South Grafton have been set at a variable freeboard, broadly:

- **existing bridge upstream to Ardent Street drain, freeboard of 0.5 metres;**
- **Ardent Street drain upstream of the Cowan Creek culvert, freeboard of zero metres;**
- **Cowan Creek culvert upstream to the end of works, crest set at 100 millimetres below the flood level to allow controlled overtopping into South Grafton.**

The land use downstream of Grafton is essentially rural.

There are 7 residences that are potentially affected by flooding and thus could have significant flood affectation if affluxes are significant. There are some 6 machinery sheds, generally located at ground level, which may also be affected.

4. FLOOD INFORMATION

Information required for detailed assessment of road levels, waterway openings and afflux created requires:

- **flood level;**
- **flood discharge;**
- **flood flow velocities.**

There have been a number of investigations into flooding on the Clarence River over the past 40 years. The current published information relates to:

- **"South Grafton Levee Augmentation Study", Cameron McNamara 1985 (Reference 1)**
- **"South Grafton Floodplain Management, Flood Study", January 2001 (Reference 2)**

Reference 1 outlined the hydrological analysis and hydraulic modelling used for the investigation and design of the current South Grafton Levee. The hydraulic modelling was undertaken using a program identified as CELLS.

Reference 2 details the development of a one-dimensional network model of the Clarence River between Rogans Bridge and Maclean using the program MIKE-11.

The MIKE-11 model was verified against floods recorded in 1967, 1974, 1980 and 1996 and was shown to adequately represent flood behaviour.

Testing of the calibrated CELLS model and the calibrated MIKE-11 model against the March 2001 event (which was not used in calibration) showed the MIKE-11 model produced better results. Accordingly, the CELLS model has not been used.

The flood frequency for the Clarence River at Grafton has not been updated since Reference 1 was produced. The peak design discharges are listed in Table 1 below, while design flood levels appear in Table 2.

Table 1

Peak Flows, Clarence River at Grafton

Probability	Average Recurrence Interval	Peak Flow
1% AEP	100 year	20,600 cu m/sec
5% AEP	20 year	17,200 cu m/sec
10% AEP	10 year	14,200 cu m/sec

Table 2

Design Flood Conditions, Clarence River Channel - Grafton Bridge Route Options

Locality	Design Flood Level (m AHD)		
	100 yr ARI	20 yr ARI	10 yr ARI
1	8.27	7.45	7.23
2	8.22	7.41	7.21
3	8.04	7.29	7.13
4	7.91	7.20	7.07
5	7.70	7.04	6.96
6	7.59	6.96	6.89
7	7.65	7.01	6.94

Table 3 provides the design flood levels and design flood flows for the southern approach to the bridge for Localities 4 to 7 inclusive.

It should be noted that the flood levels vary from the southern bank of the Clarence River channel to the southern extent of the floodplain because the locality routes are skewed to the direction of flood flows.

Table 3

Design Flood Levels and Flows, Southern Floodplain, Grafton Bridge

Locality	100 yr ARI		20 yr ARI		10 yr ARI	
	Design Flood Flow (cu m/sec)	Design Flood Level (m AHD)	Design Flood Flow (cu m/sec)	Design Flood Level (m AHD)	Design Flood Flow (cu m/sec)	Design Flood Level (m AHD)
4	630	7.56	295	6.93	70	5.87
5	790	7.51	365	6.85	56	6.17
6	930	7.17	435	6.29	44	4.86
7	1,375	7.17	890	6.29	23	4.86

5. PRELIMINARY AFFLUX ASSESSMENT

Preliminary assessment of affluxes created by the bridges on the seven route localities are given in Table 4. It should be noted that the afflux created for Localities 1, 2 and 3 represent bridges spanning the full flood width, while Localities 4, 5, 6 and 7 represent bridges over the Clarence River channel only.

Table 4

Preliminary Assessment of Affluxes - Clarence River Channel

Locality	Afflux (m)	Comment
1	0.046	Say 0.050
2	0.045	Say 0.050
3	0.071	Say 0.075
4	0.087	Say 0.068 (Sedimentation of cross-section suspected)
5	0.099	Say 0.06 (Suspected sedimentation)
6	0.092	Say 0.06 (Suspected sedimentation)
7	0.053	Say 0.060

6. FLOODPLAIN WATERWAY OPENINGS

Waterway openings will be required for Localities 4 to 7 inclusive to provide a level of flood immunity to the approach embankments.

The minimum opening areas and spans assuming a 15 m span for bridging is given in Table 6 below.

Table 5

Minimum Floodplain Openings

Locality	Design Event			
	20 Year ARI		10 Year ARI	
	Area	Spans	Area	Spans
4	165	3	39	2
5	365	6	56	2
6	435	8	44	2
7	890	14	-	-

7. AFFLUXES CREATED

It should be appreciated that the affluxes created and flow redistributions caused by the proposed roads and bridge is a combination of:

- **the road l3evels selected;**
- **the waterway openings provided.**

A comparison of total afflux was derived from the MIKE-11 model for the design once in 100 year flood, as given in Table 7 below.

Table 6

Comparison of Total Afflux

Locality	PWD Cross-section	MIKE-11	Existing RTA	Locality			
				#4	#5	#6	#7
Arthur Street	84	26.88	0				
Dobie Street	85	26.19	0				
Fry Street	86	25.83	0				
Bacon Street	87	25.37	0				
Ex Bridge	88	24.72	0				

REFERENCES

1. "South Grafton Levee Augmentation Study", Cameron McNamara, 1985

2. "South Grafton Floodplain Management, Flood Study", January 2001