

SHOALHAVEN STARCHES



**PROPOSED ETHANOL PRODUCTION UPGRADE
INCLUDING PROPOSED ODOUR REDUCTION AND
WASTEWATER TREATMENT MEASURES FOR
EXISTING AND PROPOSED SHOALHAVEN
STARCHES OPERATIONS - BOLONG ROAD, NOWRA**

**HYDRAULIC, ECONOMIC, SOCIAL AND
ENVIRONMENTAL IMPACTS OF FLOODING**




MAY 2008

WEBB, McKEOWN & ASSOCIATES PTY LTD



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MAY 2008

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1. INTRODUCTION

1.1 Background

Shoalhaven Starches is located on the northern overbank of the Shoalhaven River, approximately 1.5kms downstream of Nowra Bridge (Figures 1 to 4). The plant has been on this site since 1970 and has expanded considerably since that time (Figure 2). Shoalhaven Starches propose to undertake the following works (termed ethanol plant upgrade and odour reduction works in this report) on the floodplain in 2008 (shown on Figure 5):

- to construct additional plant facilities within the existing complex south of Bolong Road and including to the west of Abernathy's Drain,
- to establish a new packing plant and container loading area, including new railway spur line on vacant land north of Bolong Road and west of Abernathy's Drain (Creek),
- adaption of the approved Pond No. 7 as a wastewater treatment pond, (these proposed works do not increase the flood affectation above what was considered in previous reports as part of the approval for Pond No. 7.)

This report details the likely hydraulic, economic, social and environmental impacts of flooding as a result of the proposed works. It should be noted that this report only comments on works likely to impact upon flooding.

Webb, McKeown & Associates have undertaken a number of similar assessments for previous works in the area. The reports listed below have considered the individual and cumulative effects of the following previous developments on flooding:

- **Proposed BOC Gases CO₂ Plant and Dairy Farmers' Pond at Bomaderry Hydraulic Assessment of Cumulative Effects, July 2000.**
This assessed the hydraulic impacts of works undertaken in the area since 1990, in two stages:
Stage 1: to include the 5 storage ponds opposite the Paper Mill and the approved protein isolate plant,
Stage 2: as for Stage 1 plus the proposed BOC Gases CO₂ Plant and the Dairy Farmers' pond.
- **Further Development within the Manildra Starches Plant off Bolong Road, Bomaderry, Hydraulic Assessment, 6 October 2000.**
This report assessed the impacts of additional infrastructure within the Shoalhaven Starches plant. It concluded that no further computer modelling was required to evaluate the hydraulic impacts of additional development within the built up area of the plant (Figure 3). Some of the currently proposed works in 2008 are outside the built up "envelope" of the plant area

identified in this October 2000 report and for this reason this present hydraulic assessment has been undertaken.

- **Construction of Pond No. 6, December 2000 to March 2001**

A number of reports were prepared and these are summarised below.

- Manildra - Effluent Storage Pond No. 6, Hydraulic Assessment, 18 December 2000,
- Manildra - Effluent Storage Pond No. 6, Advice Regarding Possible Mitigation Measures, 9 January 2001,
- Manildra - Effluent Storage Pond No. 6, Hydraulic Assessment - Velocities, 16 January 2001,
- Manildra - Effluent Storage Pond No. 6, Economic, Social and Environmental Impacts of Flooding, 23 February 2001,
- Manildra - Effluent Storage Pond No. 6, Economic Impacts of Flooding, 23 March 2001,
- Letter from Webb McKeown & Associates to Shoalhaven City Council, Re: Development Application No. 00/3555 - Proposed Effluent Pond No. 6, 29 March 2001.

- **Construction of Pond No. 7 and Works at Plant, 25th October 2002**

This report assessed the impacts of constructing Pond No. 7 together with additional works at the plant. It represented an amalgamation of the previous reports, produced for approval of Pond No. 6, with an update to include the incremental effects of the proposed Pond No. 7 and additional works at the plant.

- **Proposed Flour Mill - Manildra Starches Plant, off Bolong Road, Bomaderry, Hydraulic Assessment, March 2007**

This report assessed the potential flood impacts and concluded that they are insignificant given the intensive development already present. However there was a need to consider the flood hazard and structural assessment and these would need to be addressed as part of the Construction Certificate.

1.2 Study Area

The area fronting Bolong Road in the vicinity of Shoalhaven Starches and east to the Paper Mill comprises a mix of rural and industrial properties immediately downstream of the residential area of Bomaderry (see Figure 1). The three largest industrial developments on the floodplain are the Shoalhaven Starches plant, Dairy Farmers (now largely vacant) and the Shoalhaven Paper Mill. There are also a number of other buildings in the vicinity of Bolong Road, including industrial/commercial properties west of the Shoalhaven Starches plant and rural residential buildings within the areas to the east. The floor levels of these properties were surveyed in January 2001 in order to obtain a better appreciation of flooding impacts (Figure 1).

1.3 Approach

Each development on the floodplain has the potential to cause an impact upon flood levels. Whilst the individual impacts may be small the cumulative increases from several developments may be significant. Therefore, the proposed works in 2008 need to be assessed in the context of total cumulative impacts of all development within the immediate area. It is not possible to itemise all of the developments on the floodplain and their effects since white settlement. For the purposes of this report the nominal starting date for the assessment of cumulative effects is 1990. This date was agreed previously (refer July 2000 report) and approximately corresponds to the floodplain development status at the time when the current design flood level information was established (Lower Shoalhaven River Flood Study report prepared by Webb, McKeown & Associates in April 1990 for the Department of Public Works).

For the above reasons the impacts assessed in this report represent the cumulative increases for all development by Shoalhaven Starches and others (Dairy Farmers pond) since 1990 and not just the incremental effects of the proposed ethanol upgrade and odour reduction works in 2008 (as shown on Figure 5).

The impacts can be subdivided into hydraulic (changes in flood level, flow and velocity), social, economic and environmental.

An assessment of such impacts is required in order to advise the proponent of the possible damages to the existing and proposed structures making up the plant, and also to advise Council of the likelihood of any increase in risk to other occupiers or users of the floodplain. It should be noted that the three main floodplain users (Shoalhaven Starches, Dairy Farmers (now largely vacant) and the Paper Mill) work in conjunction or co-operation with each other. Each have swapped or sold land on the adjoining floodplain in recent times to suit their commercial needs.

Shoalhaven Starches and the Paper Mill “share” the railway line which passes through all three properties. Shoalhaven Starches also supplies product to the Paper Mill. These two plants are located on the banks of the river in order to distance themselves from the urban environment and to be close to an unlimited supply of water. They also require a large amount of “flat” land for their operation with good road and rail access. Shoalhaven Starches makes excellent use of the floodplain by irrigating and farming the land using recycled water from the plant (initially stored in the seven effluent ponds).

2. HYDRAULIC IMPACTS

2.1 General

The potential impacts of works within the floodplain on hydraulic characteristics are twofold - firstly a loss of temporary floodplain storage volume and secondly a loss of flow area. It is the loss of flow area which produces the greatest impact, as the area of floodplain storage lost due to all works since 1990, represents approximately less than 1% of the total available floodplain storage area for the northern floodplain (say 3000+ hectares).

The hydraulic assessment was undertaken using the CELL Model established for the *1990 Lower Shoalhaven River Flood Study*, prepared for Public Works in April 1990 by Webb McKeown. Whilst more sophisticated computer programs are now available the CELL Model is the most up to date hydraulic model of the Lower Shoalhaven River floodplain available and is capable of assessing the two impacts on hydraulic characteristics outlined above. The model layout is shown on Figure 6 with ground levels in the local area on Figure 7. To establish, calibrate and determine design flood levels using a more current hydraulic model would take several months to complete.

The CELL Model was run for the Extreme, 1%, 2% and 5% AEP (Annual Exceedance Probability) design events for three scenarios:

- Existing conditions as at 1990.
- Current development conditions, assumed to be Stage 2 Works plus construction of Pond No. 6 (already constructed), Pond No. 7 (under construction) and the proposed works at the plant outside the agreed envelope as part of the October 2002 report.
- Proposed development conditions as above PLUS the ethanol upgrade and odour reduction works proposed in 2008 (Figure 5).

2.2 Hydraulic Impacts

Hydraulic impacts can be subdivided into the following categories:

- increase in water level,
- increase in frequency of inundation,
- increase in duration of flooding,
- increase in extent of inundation at the perimeter of the floodplain,
- increase in velocity of floodwaters across the floodplain.

An assessment of each of these is provided in the following sub-sections.

2.2.1 Increase in Water Level

An increase in water level is probably the most obvious effect of works upon the floodplain. A summary of the design flood levels (1990 conditions) is provided in Table 1, together with the cumulative impacts of construction of all works since 1990, plus the proposed 2008 ethanol plant upgrade and odour reduction works.

Table 1: Design Flood Levels at Key Locations

Location	Design Flood Level (mAHD) Relative Impact (m)			
	5% AEP	2% AEP	1% AEP	Extreme
Shoalhaven Starches plant (Cell 26)	4.2 (0.11)	4.8 (0.10)	5.3 (0.07)	7.3 (0.08)
Dairy Farmers' (Cell 29)	3.8 *	4.6 (0.02)	5.1 (0.04)	7.2 (0.07)
Paper Mill (Cell 57)	3.8 *	4.5 (0.02)	5.0 (0.05)	7.2 (0.08)
Rural area North of Bolong Road (Cell 48)	3.8 *	4.5 *	5.0 (0.04)	7.1 (0.10)
North of Bolong Road and West of Shoalhaven Starches plant (Cell 4)	3.8 (0.04)	4.6 *	5.0 (0.03)	7.2 (0.08)
South of Bolong Road and West of Shoalhaven Starches plant (Cell 18)	5.0 (0.02)	5.4 (0.03)	5.8 (0.04)	7.8 (0.08)

Notes: *The values in brackets represent the cumulative flood impacts (as indicated on Figures 8a, b, c & d) of works undertaken since 1990 (including all seven ponds and the proposed ethanol plant upgrade and odour reduction works).*

** indicates that the impact is equal to or less than $\pm 0.01m$.*

Small differences between the flood impacts indicated above and those published in previous reports by Webb McKeown may be evident due to slight changes in the hydraulic model structure and how the ponds and other works are represented.

Figures 8a to d indicate the cumulative differences in flood level of all works on the floodplain since 1990 (Stage 2 works, all ponds, as well as the proposed ethanol plant upgrade and odour reduction works). It is apparent that the proposed ethanol plant upgrade and odour reduction works will only marginally increase design flood levels (differences shown in boxes on Figures 8a to d).

The main impact of increasing flood levels is a greater depth of inundation of residential and commercial/industrial floor levels. Table 2 provides a listing of all surveyed buildings and critical infrastructure (data obtained in January 2001) and the relative depths of inundation in the various design flood events. The majority of these buildings are indicated on Figure 1.

As part of the present study additional residential floor levels were obtained along Hannigans Lane and Edwards Avenue (refer Appendix B). The floor levels are:

- No. 125 - 4.29 mAHD,
- No. 190 - 4.15 mAHD,
- No. 191 - 4.22 mAHD,
- No. 219 - 3.54 mAHD,
- cottage near Meadow Grove - 4.42 mAHD.

No. 219 would be first inundated in a 5% AEP event with the other buildings inundated in a flood between the 5% and 2% AEP event. In a 1% AEP event No. 219 would be inundated to a depth of 1.6 m and the others by approximately 1 m. Figures 8a to 8d indicate that in events up to and including the 1% AEP event the cumulative hydraulic impacts of the existing and proposed works on the floodplain by Shoalhaven Starches have nil impact north of Edwards Avenue. Thus these buildings are not adversely affected by the works. In the Extreme event No. 125 could experience an increase of +0.02 m and for this reason is included in Table 2.

Table 2: Critical Infrastructure/Floor Levels

	Floor Level (mAHD)	Comment	Depth of Inundation (m) for 1990 Conditions			
			5% AEP	2% AEP	1% AEP	Extreme
PAPER MILL PLANT - comprises some 60 buildings. The majority are at ground level with the main plant on two floors. For impacts refer Cell 57 in Table 1.						
Level of stormwater inlet	3.00	Above this level overland flow will enter the "contaminated" drainage system and require treatment before discharging to the river.	0.8	1.5	2.0	4.2
Administration	3.40	Floor levels range from 3.4 to 3.7 mAHD.	0.4	1.1	1.6	3.8
Coal Feeder Entry	3.58	Above this level the coal feeder becomes inundated.	0.2	0.9	1.4	3.6
Drawing Office	3.60		0.2	0.9	1.4	3.6
Finished Product Store	3.72	Paper is stored in rolls on the floor or on pallets for shipping.	0.1	0.8	1.3	3.5
Soda Plant	4.33	Floor raised above ground level.	-0.5	0.2	0.7	2.9
Transformer & Switchroom	4.45	Following the March 1978 flood a 1 m high (approx.) concrete wall was constructed around the building.	-0.7	0.0	0.6	2.8
Electrical Substation	4.55	Floor raised above general ground level.	-0.8	0.0	0.5	2.7
RESIDENCES NEAR BOWELD - For impacts refer Cell 57 in Table 1.						
Building	4.24	Use unknown.	-0.4	0.3	0.8	3.0
Residence	4.64		-0.8	-0.1	0.4	2.6

Proposed Ethanol Production Upgrade including Proposed Odour Reduction
and Wastewater Treatment Measures - Bolong Road, Nowra
Hydraulic, Economic, Social and Environmental Impacts of Flooding

	Floor Level (mAHD)	Comment	Depth of Inundation (m) for 1990 Conditions			
			5% AEP	2% AEP	1% AEP	Extreme
BOWELD FACTORY - Steel Fabricating Factory. For impacts refer Cell 57 in Table 1.						
Garage Floor	4.47		-0.7	0.0	0.5	2.7
Factory Floor	4.71		-0.9	-0.2	0.3	2.5
Residence	7.53	Elevated above general ground level.	-3.7	-3.0	-2.5	-0.3
Office	8.22	Elevated above general ground level.	-4.4	-3.7	-3.2	-1.0
HANNIGANS LANE - For impacts refer Cell 48 in Table 1 except for Lot 125 refer Cell 43 on Figure 8.						
#120 Residence	3.87		-0.1	0.6	1.1	3.2
Lot 2 Residence	4.17		-0.4	0.3	0.8	2.9
#80 Residence	4.26		-0.5	0.2	0.7	2.8
Lot 1 Residence	4.36		-0.6	0.1	0.6	2.7
#92 Residence	5.02		-1.2	-0.5	0.0	2.1
Lot 125	4.25		-0.5	0.2	0.7	2.8
DAIRY FARMERS - The Plant (now largely vacant) was constructed approximately 18 years ago and is elevated over 1.5 m above the general ground level. For impacts refer Cell 29 in Table 1.						
Transformer & Switchroom	5.70	This is the lowest building to be affected.	-1.9	-1.1	-0.6	1.5
Main Floor	6.30	The plant and storerooms are all built at the same level.	-2.5	-1.7	-1.2	0.9
SOUTH OF BOLONG ROAD AND WEST OF SHOALHAVEN STARCHES PLANT - For impacts refer Cell 18 in Table 1.						
1. Office - Shoalhaven Steel	4.19		0.8	1.2	1.6	3.6
2. Workshop RMS Sheetmetal (Shoalhaven Starches)	3.63		1.4	1.8	2.2	4.2
3. Factory -agricultural industrial machinery (Shoalhaven Starches)	4.12		0.9	1.3	1.7	3.7
4. Factory - fuel injection specialists (Shoalhaven Starches)	4.20		0.8	1.2	1.6	3.6
5. Showroom - Tractor Plus (Shoalhaven Starches)	4.11		0.9	1.3	1.7	3.7
6. Office - Cleary Bros	5.05		0.0	0.4	0.8	2.8
7. Project Office - rented by Shoalhaven Starches	7.24		-2.2	-1.8	-1.4	0.6
8. Office Block - Dairy Farmers (Shoalhaven Starches)	7.18		-2.2	-1.8	-1.4	0.6
9. ACF Store (old)	4.91		0.1	0.5	0.9	2.9
9. ACF Store (new)	4.80		0.2	0.6	1.0	3.0
10. Office - Minad Complex	4.72		0.3	0.7	1.1	3.1
10. Warehouse - Minad Complex	4.81		0.2	0.6	1.0	3.0
NORTH OF BOLONG ROAD AND WEST OF Shoalhaven STARCHES PLANT - For impacts refer Cell 4 in Table 1.						

	Floor Level (mAHD)	Comment	Depth of Inundation (m) for 1990 Conditions			
			5% AEP	2% AEP	1% AEP	Extreme
11. Workshop - Bibis Auto Electrical	5.33		-1.5	-0.7	-0.3	1.9
12. Old cottage used as a workshop	6.42		-2.6	-1.8	-1.4	0.8
13. Old fuel depot office	6.30		-2.5	-1.7	-1.3	0.9
14. Office #27	7.34		-3.5	-2.7	-2.3	-0.1
15. Assumed vacant house #29	7.79		-4.0	-3.2	-2.8	-0.6
16. Shop - Mobil service station	7.99		-4.2	-3.4	-3.0	-0.8
17. Nowra Truck & Tractor	7.95		-4.2	-3.4	-3.0	-0.8
18. Factory	7.21		-3.4	-2.6	-2.2	0.0
19. New office	7.58		-3.8	-3.0	-2.6	-0.4
20. Ridleys grain warehouse	7.48		-3.7	-2.9	-2.5	-0.3
21. Az-Nu Upholstery	6.53		-2.7	-1.9	-1.5	0.7
22. Linfoot Smash Repairs	6.47		-2.7	-1.9	-1.5	0.7
23. Milk Aware office	6.46		-2.7	-1.9	-1.5	0.7
24. Kitely Metal Roofing	6.65		-2.9	-2.1	-1.7	0.6
25. Office/factory Park'n'Ride	6.64		-2.8	-2.0	-1.6	0.6
26. Shell oil products	8.34		-4.5	-3.7	-3.3	-1.1
27. Shell service station	8.93		-5.1	-4.3	-3.9	-1.7

Notes:

1. A negative number indicates that the flood level is below the floor level by the amount shown (i.e. not inundated).
2. The site description is as per the survey in 2001 and some buildings may have changed ownership and/or name.

2.2.2 Increase in Frequency of Inundation

An increase in frequency of inundation occurs as a result of an increase in flood level. For example, a rise in flood level of 0.1 m within the 2% to 1% AEP flood range would represent an approximate 10 year increase in frequency of inundation (say from a 1 in 70 year to a 1 in 60 year). This impact is of particular importance if flooding occurs more frequently (say in less than a 5% AEP event) or has major implications such as closure of a road or factory. Bolong Road is first cut in approximately a 5% AEP event or smaller. However Table 1 indicates minimal impact in a 5% AEP event and thus minimal increase in frequency of inundation of Bolong Road or those buildings first inundated in a 5% AEP event.

2.2.3 Increase in Duration of Inundation

Figure 9 provides a graph of time versus water level for the area containing the Paper Mill (Cell 57) in various design events. This graph, termed a Stage Hydrograph, shows the cumulative changes in water levels and effects on inundation times which have occurred as a result of all works on the floodplain since 1990, including the proposed works shown on Figure 5. The location was chosen as it produces the greatest cumulative increases in level.

Table 3 provides an example of the increases in duration of inundation for the transformer at the Paper Mill (floor at 4.5 m AHD).

Table 3: Duration of Inundation for the Transformer at the Paper Mill

Event	Transformer Floor Level of 4.5 mAHD		
	Duration of Inundation	Increase in Duration Following all Works Since 1990	% Increase
Extreme Flood	> 48 hours (estimate)	2 hours	4%
1% AEP	16 hours	$\frac{3}{4}$ hour	5%
2% AEP	level just reaches 4.5 mAHD		
5% AEP	level does not reach 4.5 mAHD		

The results indicate that there is no significant increase in the duration of inundation due to the cumulative effects of all works on the floodplain since 1990.

2.2.4 Increase in Extent of Inundation

The northern floodplain is low lying land (ground levels at 2 m AHD or below - refer Figures 7a and 7b) with no areas of high ground except around the perimeter. It is entirely inundated by floodwaters in say the 10% AEP event and greater. Thus any increase in flood level, caused by development, will only result in an increase in the extent of inundation around the perimeter of the floodplain. The increased area of inundation will vary between floods and depends upon the grade of the topography at the perimeter and the length of the perimeter. A flat grade will result in a large increase in area, whilst a steep grade will result in only a small increase. The following preliminary assessment provides an indication of the likely extent of any increase.

The assumed areal extent of inundation on the northern side of the Shoalhaven River is some 3000+ hectares (based upon mapping undertaken for the *Draft Lower Shoalhaven Floodplain Risk Management Study*).

All of the works undertaken since 1990 have been located along Bolong Road and near the river. As the effects of development on the floodplain decreases with distance from the works, this means that a large part of the perimeter of the floodplain will not be affected by an increase in flood level. Many

parts of the perimeter are over eight kilometres away (near Berry) and as such will experience nil increase in flood level. Even the nearest edge of the floodplain at Bomaderry is still some two kilometres from the ponds which are the major contributors to an increase in flood level (Figure 1). For calculation purposes we have assumed that three kilometres of perimeter will be affected in the 1% AEP event by an increase of (say) 0.1 m (this is a conservative value with a more realistic value of 0.03 m (Cell 4 in Table 1)). We have used Council's Airborne Laser Scanning (ALS) data to estimate the lateral increase in flood extent (approximately 2 m) and this indicates an areal increase of approximately 6000 m².

2.2.5 Increase in Velocity of Floodwaters

Comparison of velocities between different floodplain conditions is more complex than comparison of peak levels. The main difference being that the peak flood velocity may not necessarily occur at the same time as the peak flood height. More often than not it will occur when floodwaters first enter an area at a time of very small flow. This velocity is generally not relevant for comparison purposes. A more appropriate velocity is that which is experienced at peak flood height since, in combination with the deepest floodwaters this is likely to represent the greatest flood hazard. Consequently the assessment has been made using peak height velocities. The CELL model provides the average velocity for a cross-section at peak flood height. It should be noted that local velocities between obstructions may be higher than this average velocity.

Velocities are only available in the CELL Model at Weirs or Cross Sections. On the northern floodplain the cells are linked by Weirs (refer Figure 6) and the average velocities were obtained at all relevant locations. The effect of the works at the plant on velocities cannot be accurately assessed using the CELL Model due to the relatively small scale of the proposed works. For this reason the study has focussed on the area near the storage ponds.

Change in Velocity – Results – 1% AEP Event

The changes between the 1990 conditions and all works on the floodplain since 1990 including the proposed ethanol plant upgrade and odour reduction works at the plant are evaluated below.

At all weirs in the vicinity of the storage ponds the velocities at peak height are less than 1 m/s and generally less than 0.5 m/s. This is to be expected as the depth of inundation is 3 m to 4 m and the area acts as floodplain storage with very little hydraulic gradient across the area.

Weir 115 to the south of the ponds indicates no change in velocity from 0.7 m/s whilst Weir 136 (north western end of ponds) indicates an increase from 0.3 m/s to 0.4 m/s, Weir 134 (west of ponds) indicates an existing velocity of 0.2 m/s which will reduce to less than 0.1 m/s. Weir 133 (north west of ponds) shows an increase in velocity of from 0.2 m/s to 0.3 m/s. This is to be expected as there is an increase in flow across this weir due to construction of the ponds.

Weir 50 indicates little change in velocity from 0.2 m/s but a significant change in the peak flow due to construction of the ponds. Weirs 114 (Bolong Road) and Weirs 52 & 54 indicate no significant changes. The most significant changes are at Weir 137 (0.2 m/s to 0.5 m/s) and Weir 118 (0.3 m/s to 0.7 m/s).

In general the changes in velocity are largely confined to the area in and around the ponds where flows have been re-directed as a result of the “barrier” caused by their construction. Elsewhere there are no significant changes in velocity.

It should be noted that the majority of changes occur on land owned by Shoalhaven Starches. The main exceptions are on Bolong Road (Council owned) and on other private ownerships (largely the Paper Mill). The effect of changes in velocity will have little impact on rural lands as it is unlikely that this will cause any increases in erosion or damages. Along Hannigans Lane where five residential properties are located (Weir 134) there is a slight reduction in velocity as a result of construction of the ponds.

At Sections 49 and 14.1 (immediately west of the Shoalhaven Starches plant) there is no significant change in peak velocity.

2.2.6 Discussion

The results provided on Figures 8a to d can be summarised as follows:

- Blocking of the flow path due to all the works at or near the Shoalhaven Starches plant since 1990 have slightly increased flood levels in the immediate upstream area but also results in less floodwaters entering the northern floodplain. This produces a slight reduction in the affectation caused by construction of the wet weather storage ponds. This issue is discussed further in Section 4.7.
- In the 5% AEP event (an event of similar magnitude to the March 1978 flood) there is no increase in flood level (or consequent changes in extent of inundation etc.) as a result of the works constructed and proposed on the floodplain since 1990 at the Paper Mill or north of Bolong Road. There is an exception of +0.11 m at the Shoalhaven Starches plant itself, and +0.02 m immediately west of the Shoalhaven Starches plant. This means that in the smaller more frequent events, up to a 5% AEP, the works on the floodplain have little impact. The main reason for this is that there is little flow across the northern floodplain in these events as the floodplain predominantly acts as a flood storage area with only a small flow across the river bank itself (refer Figure 7b which shows high ground along the northern river bank). In the smaller floods (up to the 5% AEP) the northern floodplain is largely filled by local catchment runoff and particularly from Broughton Creek. In larger events where flows breakout from the main river, the impacts become more significant. It should be noted that

in the 5% AEP event the northern bank of the Shoalhaven River is only just overtopped (at a few locations) and thus the impacts of the works on the floodplain for this event may produce anomalous results due to the shallow depths.

- In the 2% AEP event (approximately 0.7 m higher than the 5% AEP or March 1978 flood) there is a maximum cumulative increase of +0.10 m. This is confined to the area near the Shoalhaven Starches plant with up to +0.03 m elsewhere.
- In the 1% AEP event (approximately 1.2 m higher than the 5% AEP or March 1978 flood) the cumulative increases range from 0.03 m to 0.07 m within the locality of the Shoalhaven Starches plant. There is no impact within the Shoalhaven River or the residential areas to the south (Terara or Riverview Road).
- Hazard is defined as the source of potential harm or a situation with a potential to cause loss. The works on the floodplain since 1990 have increased the hazard. However the extent of the increase is minor and does not add significantly to the existing (pre 1990) high hazard (on account of the depth of inundation).

Results for the Extreme flood are also indicated in Table 2 and on Figure 8a. It should be noted that the annual exceedance probability (AEP) of such an event is very low (say 0.01% AEP or smaller).

It should be noted that a change in flood level of up to ± 0.01 m is within the limits of accuracy for the hydraulic model and can therefore be considered negligible. More precise modelling of the impacts of the works (changes in flood levels, velocities and flow directions) would require the application of a more sophisticated hydraulic model combined with more detailed ground survey. The latter (in the form of Council's ALS survey) is now available for a large part of the floodplain.

2.3 Development in a High Hazard Area

The locations of the proposed works as part of the current DA are primarily determined by the availability of land adjacent to the existing Shoalhaven Starches plant. There is no other suitable land available within the local area outside of a high hazard area which can be used for the proposed purposes.

Shoalhaven Starches has a Flood Evacuation Plan (Appendix C) and this should ensure that the occupants (and all other personnel at the plant) will be safely evacuated from the floodplain prior to the flood peak arriving.

3. ECONOMIC, SOCIAL AND ENVIRONMENTAL IMPACTS

3.1 Assessment of Flood Damages

3.1.1 General

This section discusses the economic, social and environmental impacts associated with increases in flood levels caused by all the cumulative developments since 1990 (Figures 8a to d). It is considered that the effects upon velocities (Section 2.2.5) are too small to be quantified in terms of additional damages. The assessment has been based on a site visit to the area, a survey of building floor levels in the area of influence (Figure 1), and discussions with the managements of the Paper Mill and Dairy Farmers (now largely vacant) and inspection of the two plants (undertaken as part of the assessment for Pond No. 6 - 2000/2001).

Survey was undertaken to gain an appreciation of the level at which flood damages will occur in major floods. Due to the complexity of the damages that would occur in such floods, our survey provides only a limited assessment and it would be difficult to provide an exact assessment of individual components. For example, the levels of all electrical motors and other equipment that would incur flood damages would need to be ascertained and their repair/replacement costs calculated.

The impacts discussed would vary in severity with the characteristics of the flood, such as the time of day it occurred (day or night), time of year, day of the week, available warning time, whether it was preceded by a smaller event, and availability of personnel. There are a large number of unknown factors which influence the quantity of damages in any given flood event. For this reason it is often said that "no two floods are the same".

It has been assumed that the proposed railway line spur will incur no damages to the structure itself as a result of flooding. Possible collapse of the structure has not been considered.

The increases in damages to the proponent's plant (Shoalhaven Starches) or land (Shoalhaven Starches own a large part of the land within the northern floodplain) have not been evaluated in this report, as it has been assumed that the proponent has evaluated this as part of its own risk assessment.

3.1.2 Overview

The main issues with regard to the effects of increases in flood level are summarised on Figure 10. Ponding of water in low lying areas on the northern floodplain occurs following periods of heavy and continuous rain. Some parts of the land are only 1 m above high tide and consequently are frequently inundated (Figures 7a and b). This results from direct rainfall over the area and also overflow from the creeks which flow through the area. In larger floods, both Abernethy's Drain and Bomaderry Creek will overtop their banks and inundate the area. This would have occurred in March 1978 and the other floods which occurred in the 1970's (August 1974, June 1975 and October 1976) as well as the April 1988 event. According to residents' reports none of these floods overtopped the northern river bank, in the vicinity of the Shoalhaven Starches plant or the Paper Mill, to any significant extent. The existing works since 1990 and proposed ethanol plant upgrade works on the northern floodplain do not increase flood levels in these "small" floods as there is no significant velocity and the area is a large storage basin. The largest of these events occurred in March 1978 which approximated a 5% AEP flood.

For the above reasons, construction of the existing works since 1990 plus the proposed ethanol upgrade plant works on the northern floodplain will not cause any significant increases in flood levels (and associated economic, social and environmental impacts) in the 5% AEP and smaller events (refer Figure 8d). These are the most frequent events that affect the area, and the above five historical events are typical examples. These "small" events contribute the bulk of what is called the "average annual flood damages" to the properties. These can be calculated by multiplying the estimated damages for a flood by the probability of the flood occurring in a given year, and summing across the range of floods. By this means the smaller floods which occur more frequently, are given a greater weighting than the rare catastrophic floods.

However floods larger than March 1978 will occur and they will overtop the bank, causing a significant inflow of floodwaters to the area. In these larger overtopping floods the proposed and existing works since 1990 on the northern floodplain will have an impact upon flood levels by restricting flow and increasing flood levels. These are much rarer events and generally the majority of the ground is inundated by up to 3 m depth of water. Some plants (Paper Mill) are already inundated by up to 1.5 m depth of water and consequently the small increase in level caused by the existing works since 1990 and proposed ethanol upgrade plant works is unlikely to be significant. In the case of the Dairy Farmers plant, the main building (now vacant) is elevated above the 1% AEP level and is therefore not inundated except in a rarer event.

The most obvious impact of an increase in flood level is an increase in economic damages due to a greater depth of inundation. These impacts are discussed in Section 3.2. However there are also possible social and environmental impacts and these are discussed in the subsequent Sections 3.3 and 3.4 respectively.

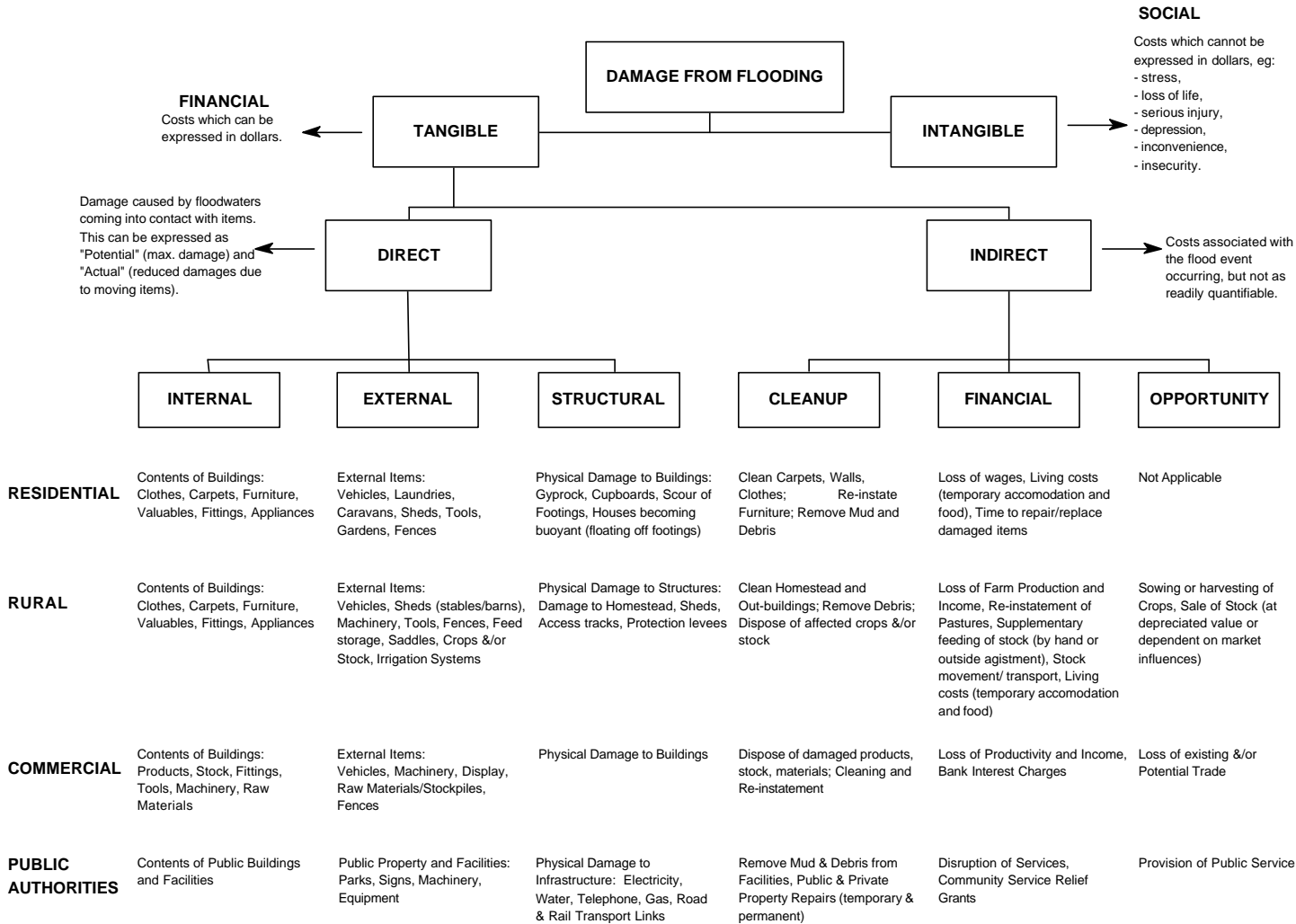
3.2 Economic Impacts

Economic flood damages can be subdivided into *Tangible* (for which a monetary value can be assigned) and *Intangible* (for which a monetary value cannot be assigned). The range of possible flood damages is provided in Table 4.

This study has focussed on the increases in damages to the nearby buildings, and in particular, the Paper Mill and Dairy Farmers plants (now vacant). The main tangible damages to these operations are:

- structural damages to buildings,
- water damage to equipment/furniture/carpets,
- loss of production because of inundation or restricted access,
- loss/damages to stock,
- loss of wages to workers or the cost to the company of paying staff,
- clean up costs.

Table 4: Flood Damage Categories



Each of these factors contributes to the economic losses caused by flooding. Table 2 summarises the levels of the buildings and other critical infrastructure in the area of influence, and compares them with the design flood levels to give an approximate depth of inundation. A significant factor affecting the actual extent of damages experienced is the level of preparedness and responsiveness of the owner to flooding.

It has been assumed in the assessment that the relatively minor increases in flood levels caused by the cumulative works would have a negligible impact on the likely structural damages to any building.

There are formulae for estimating flood damages based upon surveys carried out after past floods. These are appropriate for use on residential properties, but are of less relevance for commercial and industrial properties due to the large range of possible usages and consequent damages (concrete batching plant versus an electrical store, for example).

Based upon a typical formulae (developed from the Nyngan and Inverell floods in early 1990 and increased for CPI) the maximum increases in flood damages applicable to a residential building for a range of increases in flood level are:

- 0.02 m increase in level = \$7400 increase in damages,
- 0.05 m increase in level = \$10900 increase in damages,
- 0.1 m increase in level = \$16500 increase in damages,
- 0.2 m increase in level = \$26900 increase in damages.

The maximum increase occurs when the floor just becomes inundated. The following are the relative increases if the floor was already inundated by 0.5 m depth of water:

- 0.02 m increase in level = \$1400 increase in damages,
- 0.05 m increase in level = \$3300 increase in damages,
- 0.1 m increase in level = \$6400 increase in damages,
- 0.2 m increase in level = \$11800 increase in damages.

It should be noted that the above figures are “average” values, and at particular locations the actual damages may be considerably more or less. The above values are compatible with the current Department of Environment and Climate Change guidelines on assessment of flood damages and reflect an increase above those provided in our October 2002 report.

The following sections discuss the likely economic impacts at each of the major areas of development shown on Figure 1.

3.2.1 The Paper Mill

The Paper Mill is on land which is at around 3 m to 4 mAHD and last experienced significant flooding in March 1978. The administration building was inundated to an approximate depth of 0.5 m in that event. Assuming the floor level to be at 3.7 mAHD (Figure 1) this gives a peak level of 4.2 mAHD, which is a similar level to that shown on Figure 24 of the *Lower Shoalhaven River Flood Study - April 1990* for this flood.

The plant has a comprehensive “Emergency Flood Policy and Procedures” document. This indicates measures which should be taken to reduce damages at the plant and is reliant on flood warning advice. Floods have occurred in the past (the last major one being March 1978) which have closed the plant. From discussions with the management, the plant was closed for 2 to 3 days in March 1978 and incurred damages to stock, fittings and electric motors. The actual extent of damages was not quantified by the company.

Figure 8d shows that the Paper Mill will experience no increase in flood level in a 5% AEP event, a 0.02 m increase in a 2% AEP event (Figure 8c), and a 0.05 m increase in a 1% AEP event (Figure 8b), as a result of the cumulative effects of all works since 1990.

Loss of Production

According to the management, the greatest economic cost of flooding to the Paper Mill is loss of production. The mill operates for 363 days a year, and significant costs are involved with shutting down and restarting the plant. As a result of the surrounding low land the Paper Mill becomes inundated in floods smaller than the 5% AEP event, and is unable to continue with production (as happened in March 1978). Table 2 indicates that a depth of say 0.1 m or 0.2 m above the stormwater inlet (which is at an RL of 3.0 mAHD) would force the plant to shut.

Figure 8d indicates that the cumulative increases due to the works since 1990 do not affect the Paper Mill in the 5% AEP event (and smaller). Therefore, since a 5% AEP flood already closes the plant, there would be no increase in the frequency of plant closures as a result of the cumulative existing and proposed works since 1990.

Loss of Stock

Loss of stock is probably the next biggest cost. Any stock, whether it be at the intermediate or final stages of production, is damaged by water. The finished product warehouse and the areas with intermediate product are at 3.72 mAHD (Table 2). The product is generally stored in stacks (roll on top of roll) and at this level some damages will occur to stock at the 5% AEP level.

It is not possible to quantify the increase in stock lost from the cumulative impacts of the works (0.05m in the 1% AEP) because the extra height of the floodwaters may or may not reach another roll of stock. There is also considerable variation in the height of the rolls. A 0.05 m increase (or more) will

produce no increase in damages if the increase is contained within the already affected roll. In the unlikely situation that the 0.05 m increase during a 1% AEP flood will affect a higher roll there will be an immediate increase in damages.

Management advised of the importance of flood warning in reducing flood damages. Given adequate and accurate warnings it is possible to move stock off the site or re-stack the rolls to minimise damages.

Electrical Equipment

Electrical equipment (motors, transformers) are the most likely mechanical items to be affected by floodwaters in the mill. As long as the plant is shut down, and the motors do not operate when inundated, the majority of the motors can be salvaged by drying them out after the flood. This was the case in March 1978. It is inevitable that some motors will be lost (high humidity, failure to adequately dry or some other problem) when restarting occurs. A large percentage of motors affected by flooding are at floor level and therefore are inundated in a 5% AEP event (before the cumulative works since 1990 have an influence). For these motors any increase in the level of inundation because of the works will have no impact on flood damages. Undoubtedly there are some motors and equipment which are at a slightly higher level and the 0.05 m increase (1% AEP) will just inundate them and require them to be dried out or replaced. In this situation there will be an increase in flood damages. However, the damages from this particular source are likely to be only a very small percentage when compared to the total damages bill in such a flood.

Management advised the importance of flood warning in reducing flood damages. Given adequate and accurate warnings it is possible to shut down earlier thereby maximising the potential to salvage motors following inundation.

3.2.2 Dairy Farmers

The plant (now largely vacant) is on land which is at approximately 4 m to 5 mAHD but the floor level (of the whole plant) has been raised to 6.3 mAHD (Table 2). The cumulative impacts of the existing and proposed works at Dairy Farmers are nil in the 5% AEP event (Figure 8d), 0.02 m in the 2% AEP event (Figure 8c), and 0.04 m in the 1% AEP event (Figure 8b). However, there is no increase in damages to the plant in these events as the floor level is some 1.2 m above the 1% AEP level.

Dairy Farmers was built over 20 years ago and it has therefore not experienced any significant flooding, although flooding has affected their supply from dairy farmers in the past. This plant is now vacant and we presume there is no current Flood Evacuation Plan. When in operation there was no Plan as the likelihood of inundation above floor level is small (due to the raised floor level).

It should also be noted that Dairy Farmers have themselves contributed to the cumulative increases in flood levels as the Stage 2 works include construction of the Dairy Farmers pond (see Figure 1).

Flood Damages

The greatest cost to Dairy Farmers from flooding (when operating) is associated with the loss of production. This would first occur when water levels prevent travel by staff and trucks along Bolong Road. This would occur in less than a 5% AEP event, as would have happened in March 1978. As there is no increase in flood levels (Figure 8d) in such an event, the frequency of loss of production at Dairy Farmers (when operating) is not affected by the cumulative works.

Because the floor of the plant is high, the plant (when in operation) experiences no damages to equipment or stock in a 1% AEP or smaller event. The lowest floor level within the plant is 5.7 mAHD (transformer) and this floor would only be inundated in an event greater than the 1% AEP (say a 0.2% AEP), with a cumulative increase due to the works since 1990 of between 0.04 m and 0.07 m for this event. Quantification of the full extent of losses in an event which reaches the floor level (6.3 mAHD) would be difficult as not all the equipment within the plant would be located at floor level. Product (when Dairy Farmers was in operation) was stored in sealed containers stacked on top of each other and it is unlikely to be seriously damaged with any such increase.

The main point to note is that the cumulative increases will only affect the factory floor in a very large event (say in a 0.1% AEP or rarer) which has a very low probability of occurrence within the likely operational life of the plant (an indicative life of the plant is 30 years though it is presently closed).

3.2.3 Boweld Fabrication Plant

This steel fabricating factory is located along Bolong Road between Dairy Farmers and the Paper Mill. The cumulative increases in flood level since 1990 experienced here are similar to those at the Paper Mill (refer Figures 8a to d). A large part of the plant is uncovered and will experience no adverse impact from inundation. For the remainder there may be a minor increase in damages. Management advised previously that it is relatively easy to raise welding equipment to a higher level.

The factory and garage floor are inundated in the 1% AEP event and are potentially affected by the cumulative increases. A detailed survey of this factory was not undertaken but it was noted that both low lying floors (garage and factory floor) are first inundated in the 2% to 1% AEP flood range.

The residence and office are not inundated in the Extreme event and therefore are not impacted by the cumulative increases.

3.2.4 One Residence and Building near Boweld

The two buildings near Boweld would both be affected by the cumulative increases. In a 1% AEP event there would already be a reasonable depth of water through the buildings without any impacts from the cumulative works (0.05 m in the 1% AEP). An indication of the magnitude of the increases in damages is given in Section 3.2.8.

3.2.5 Five Residences along Hannigans Lane plus Edwards Avenue

There are five residential buildings along Hannigans Lane which are affected by the cumulative increases. The increases are nil in the 5% AEP and 2% AEP events, 0.04 m in the 1% AEP event and 0.1 m in the Extreme event. One of the residences (#120) is first inundated in the 5% AEP event for which there is no increase in level. All the properties would be affected by the increases in flood level, and this would increase economic damages correspondingly. An indication of the magnitude of the increases in damages is given in Section 3.2.8. Four out of the five residences are inundated by 0.5 m depth of water in the 1% AEP event with the other by less than 0.1 m.

Lot 125 in Edwards Avenue is only adversely affected in the Extreme event where the depth of inundation is 2.8 m. An additional 0.02 m is considered to have nil impact on the level of damages.

3.2.6 Properties South of Bolong Road and West of Shoalhaven Starches Plant

This area is impacted by 0.02, 0.03 and 0.04 m cumulative increases in the 5%, 2% or 1% AEP events respectively.

All properties except No's 7 and 8 are inundated in the 5% AEP event and thus are affected by the cumulative increases on flood levels. Property No's 7 and 8 are first inundated (and affected by any increase in flood level) in events approaching the Extreme event (i.e. a very low probability of occurrence within the life of the structures). It should be noted that a number of these buildings have been purchased by Shoalhaven Starches (refer Table 2).

3.2.7 Properties North of Bolong Road and West of Shoalhaven Starches Plant

This area is first affected by the cumulative increases in the 5% AEP event (0.04 m) and there is nil impact in the 2% AEP event and 0.03 m increase in the 1% AEP event. The area consists of commercial and industrial buildings and none are used for residential habitation (February 2008).

Nine of the 17 buildings are not inundated in the Extreme event and are therefore never affected. Seven of the 17 buildings are affected but only in events approaching the Extreme flood. Only building No. 11 (Bibis Electrical workshop), which has the lowest floor level, will be affected in events just greater than the 1% AEP event. It is therefore impacted by the increases in flood level for all events greater than the 1% AEP event.

No account was taken of the plant within Council's sewage treatment works. It is noted that the treatment ponds are overtopped in (about) a 5% AEP event with a consequent discharge of effluent to the Shoalhaven River. The cumulative increases in flood levels would therefore not increase the frequency of overtopping of the ponds.

3.2.8 Quantitative Assessment of the Increase in Tangible Flood Damages

Table 5 provides a quantitative analysis of the incremental increase in flood damages due to all of the cumulative development which has occurred on the floodplain since 1990. Due to the large amount of machinery and materials at the Paper Mill an accurate analysis of the damages would be extremely difficult. As part of preparation of the reports for Pond No. 6 in March 2001, Australian Paper (the operators of the Paper Mill) provided a letter of 22 March 2001 which states: *"We have reviewed the possible impact of an incremental increase in level of a hundred-year flood on our operation and advise that we believe the extra financial burden will be negligible"*. The Paper Mill have provided an updated letter of 20th March 2008 (Appendix A) which indicates that the extra financial impact of a 10cm rise in the 1% AEP (100 year flood) will be negligible.

The damages estimates provided in Table 5 do not include intangible or external damages (vehicles and outside amenities) but do include structural, indirect and direct damages.

Table 5: Increases in Tangible Flood Damages as a Result of Cumulative Development on the Floodplain since 1990 including the Proposed Ethanol Plant Upgrade and Odour Reduction Works

Location	Flood	Extreme	1% AEP	2% AEP	5% AEP	Net Present Value of Increases in Damages
1. Paper Mill	It has been assessed by the Paper Mill management as negligible.					
2. Boweld Fabrication Plant		\$400	\$4,000	\$100	\$0	\$600
3. One residence and building near Boweld		\$1,600	\$5,800	\$1,900	\$0	\$1,400
4. Five residences in Hannigans Lane		\$5,000	\$12,600	\$0	\$0	\$2,100
5. Dairy Farmers (now vacant)		\$21,500	\$0	\$0	\$0	\$1,500
6. South of Bolong Road and West of Shoalhaven Starches		\$7,100	\$5,200	\$7,100	\$16,500	\$6,600
7. North of Bolong Road and West of Shoalhaven Starches		\$10,400	\$0	\$0	\$0	\$700
TOTAL		\$46,000	\$27,600	\$9,100	\$16,500	\$12,900

NOTES:

- 1) Our assessment of damages is based upon "average values" and at particular locations the actual damages may be more or less. The residential damages have been updated to be compatible with the current DECC guidelines on flood damage assessment. Average values have been used for commercial and industrial damages and the actual values could vary significantly from those calculated.
- 2) Net present value calculations are based on an interest rate of 7% over a 50 year period.

3.3 Social Impacts

Social impacts from flooding include stress and anxiety, risk to life, disruption to work and services, isolation and depression. The majority of the buildings in this area are for commercial and/or industrial purposes. The social impacts of flooding for these properties relate primarily to loss of productive work and the increase in stress associated with it. As discussed in the previous section, most of the businesses would already be shut down before the cumulative increases produced a significant effect in this regard.

The residential properties experience greater social impacts because of the personal loss involved. For the seven residential properties affected by the cumulative increases in flood level, there may be increases in damages due to the existing and proposed works. However it is unlikely that the relative increases in level (less than 0.1 m in events up to and including the 1% AEP) will invoke a significant social impact in any particular flood.

There will be no significant or sudden increase in the risk to life as a result of the cumulative increases.

3.4 Environmental Impacts

Flooding is a natural part of the life cycle of a floodplain and sustains the ecosystem by providing nutrients to the environment. Prior to European settlement the area around Bolong Road would have been inundated by floods and the flora and fauna would have adapted to this regime. The majority of the area is now developed for rural purposes (primarily by Shoalhaven Starches) with the remainder being used for industrial purposes. The area to the north of Bolong Road consists of cultivated rural grasslands which are irrigated from the storage ponds.

There are three main issues with regard to the impacts of flooding on the environment. The first is the duration of inundation, the second is the depth of inundation and the third is the velocity of flow. The latter has been ignored in this investigation as the cumulative works have negligible impacts upon velocities.

During floods, water can remain over the land for several days causing the non water tolerant flora species on the floodplain to rot, impacting on the water quality of the runoff. Figure 9 indicates that the existing and proposed developments do not have a significant impact upon the duration of inundation by floodwaters. Any increases in flood levels will therefore not impact upon the process of flora species decaying as a result of inundation.

The entire northern floodplain is inundated by of the order of three metres of water in a major event, the increase (of typically less than 0.1 m) caused by the cumulative works represents only a small percentage of this. The potential impacts on plants occurs when their roots are submerged for some time which causes non water tolerant species to rot and ultimately die. In this case, the increases in flood levels will not cause a significant increase in the number of plants affected by water inundation. Therefore, based on the available information, this environment will not sustain any significant ecological impact from an extra 0.14 m (maximum in the Extreme event) depth of floodwaters due to the works.

A further issue is whether the cumulative increases will cause environmental impacts elsewhere. Potentially, flooding causes industrial wastes and gross pollutants to wash downstream. These types of impacts could be attributed to overflows from process plants or solid wastes washing away during floods. Generally these types of impacts would occur at the beginning of a flood event (frequency of about 5% AEP), at which time there would be no impacts from the existing since 1990 and proposed works (refer Figure 9).

Off possible concern is the failure of the ponds and release of the effluent. This has been addressed in our previous reports. These concluded that as the pond crest levels are at approximately the Extreme flood level, and assuming the banks of the ponds do not fail, the probability of the effluent being released into the floodplain due to flooding is very small and has not been considered further. Possible failure of the embankments has been considered by others.

The storage of goods on the western side of Abernathy's Drain in the proposed storage yard could potentially increase the level of environmental harm if pollutants are released as a result of inundation during a flood. This risk is considered to be low as the material is stored in containers which are unlikely to result in significant "leakage" during a flood. Also the material stored is of a non-toxic nature.

4. MITIGATION MEASURES

4.1 Overview

The hydraulic impacts of the proposed ethanol upgrade and odour reduction works (increase in flood level, change in velocity or flow) cannot be negated by any sustainable means but the consequences of the impacts can be minimised.

Flood management measures such as dredging the Shoalhaven River to increase the channel's capacity have been considered, but these are not environmentally friendly, socially acceptable or economically viable to negate or reduce the increases in flood levels. Direct mitigation of economic damages through levees or flood proofing of buildings is also not viable. The main difficulty with levees lies in maintaining accessibility to the buildings or area as well as internal drainage within the leveed area and possible adverse hydraulic impacts elsewhere.

Property or response management are the most appropriate measures for addressing the associated environmental, economic and social effects of the cumulative flood impacts. The following provides a summary of possible mitigation measures.

4.2 Modify the Proposed Design or Relocate the Works

4.2.1 Proposed New Packing Plant and Container Loading Area - including Railway Spur Line

The packing plant and container loading area is located within a flood storage area which will have minimal restriction on flow paths. It is bounded to the west by high ground (Figure 7b), to the north by Council's sewage plant and to the south by properties along Bolong Road. As far as possible the works are located away from Abernathy's Drain.

It is not possible to relocate or re-design the layout to further minimise the hydraulic impact as these works must be close to the existing rail line.

In conclusion the size, shape and general dimensions of the works have been designed to provide minimal hydraulic impact, whilst at the same time recognising the necessary site requirements (adjacent to the rail line).

4.2.2 Works at the Plant

The proposed new equipment is necessary for the continued growth of the plant. Due to site constraints, it is not possible to alter the locations and designs to any significant extent in order to minimise the hydraulic impacts.

4.3 Improve Flood Warning System

The Shoalhaven River has an ALERT flood warning system which is operated by Council and the Bureau of Meteorology. Discussions with the Paper Mill management (and indicated in their Emergency Flood Policy document) have confirmed the importance of flood warning in reducing flood damages (move product, raise pumps). If the flood warning system was improved (as proposed in the Riverview Road Floodplain Management Plan) this would provide a benefit to all floodplain users. In doing so this action may reduce the potential increases in economic damages at the Paper Mill and elsewhere resulting from the increases in flood levels.

There are a variety of ways of improving the ALERT system and these are documented in the Riverview Road Floodplain Management Study and Plan. These measures would also provide benefit to all other floodplain users.

4.4 Provide or Improve Flood Emergency Plans

As noted previously, the Paper Mill already has an Emergency Plan. In discussions with the management of the Paper Mill in 2001 it was apparent that improvements could be made which may further reduce potential damages.

The main improvement could be achieved by a re-examination of the workings of the plant and updating of the Emergency Plan. Survey of the motors/equipment would also assist in ensuring that the actions proposed in the plan accurately “target” the affected areas in the most cost effective and timely manner. For example, the benefits of moving stock may far outweigh any other possible measure. However, there is also the possible opportunity to introduce some flood preventative measures (raising switch gear, for example). The feasibility of such proposals would need to be examined by a qualified mechanical/electrical expert. If these works were carried out they may eliminate the increases in damages caused by the cumulative increases in flood levels.

There is no Emergency Plan for Dairy Farmers and it is unlikely that providing such a plan would be of benefit on account of the low probability of the plant itself being inundated and as the plant is presently vacant.

It is unlikely that Emergency Plans for residential and small commercial premises would be beneficial, due to the relatively high turnover rate, and as such it has not been considered further.

4.5 Provide Depth Indicators

Signs indicating water depth can assist floodplain users in evacuating the floodplain. It has been noted that at present there are few along Bolong Road. Provision of such signs would assist in minimising future damages for all occupants along Bolong Road and increase their awareness of the flood hazard.

4.6 Improved Flood Awareness and Preparedness

One of the most beneficial means of reducing flood damages to existing buildings (residential, commercial and industrial) is to improve the awareness and preparedness of the occupants. There are a number of ways of undertaking such a scheme and these are outlined in the Riverview Road Floodplain Management Plan. Funding of a scheme would assist in improving the community's flood awareness and consequently reducing flood damages.

4.7 Dedication of a Floodway on the Northern Bank

The DLWC (correspondences of 27th June 2002, 15th January 2001 and previous) has proposed the idea of dedicating a "floodway" zone on the northern bank. This would provide a "cap" on future development in the area and also ensure that present or any future development does not impact upon the major flow paths in the area. This concept was examined as part of the investigation for Pond No.6 (March 2001) and the outcomes are summarised as follows.

In order to examine the effects of further development along the river bank, a series of hydraulic model simulations were undertaken as part of the studies for Pond No. 6. The objective was to use the hydraulic CELL Model to demonstrate that "beyond say a limit of 100 metres no further development should be permitted", on account of the significant increase in flood levels.

The model results did not support the proposition that the river bank is a critical area for preventing further development. A run simulating a 100 m wide barrier to flow (parallel to the river bank) immediately east of the Shoalhaven Starches plant indicated a ± 0.01 m or less impact on river levels for the range of flood events (5% AEP to Extreme). The main reasons for this result are discussed below:

- the northern river bank is relatively high (4.4 m to 5.4 mAHD) which means that the bank is only just overtopped (by a maximum of 0.3 m) in the 5% AEP event (refer Figure 7b),
- the northern river bank is some six kilometres long (Bomaderry to Broughton Creek). 100 m represents less than 2% of the total distance,

- there is a minor increase in flood level (0.01 m or less) in the Shoalhaven River as a result of the 100 m barrier. This consequently produces an increase in flow over the remainder of the river bank (this can be a significant increase in total flow as the river bank is relatively long) which partially compensates for the isolated loss of overflow area on the northern bank,
- in the 1% AEP event a 100 m barrier will reduce the flow over the river bank at this location (Weir 109) by approximately 100 m³/s out of a total flow of 270 m³/s (37% reduction). However a 100 m³/s increase in flow in the Shoalhaven River represents only 0.7% of the total flow of around 14 000 m³/s. This increase is easily spread across the 1 kilometre wide river resulting in the nominal increase in flood level of 0.01 m or less. As indicated in Section 2.2.6 our results indicated that the increases in flood level due to the storage ponds were partially mitigated by reducing the flow into the northern floodplain. Flood levels do rise in the Shoalhaven River but by less than 0.01 m,
- the main reasons for the impacts associated with the Storage Ponds (No's. 1 to 7) is that they occupy a relatively large waterway area in a 1% AEP event (say 3 m high and approximately 550 m long by 550 m wide), and together with a "flat" flood gradient this means that any increases are transmitted a long way upstream. Within the Shoalhaven River proper there is a much "steeper" flood gradient and any impacts dissipate within a shorter distance.

From these preliminary results it is clear that dedication of a "floodway" zone is necessary to prevent total "blocking" of the northern river bank. However, the results indicate that blocking (say) a 100 m wide strip, does not have a significant impact upon flood levels.

The flow path across the northern river bank is the key control which determines how much of the floodwaters passing under Nowra Bridge enters the northern floodplain. The bank has the highest ground levels in the immediate area and thus any reduction in its capacity will reduce the ability of floodwaters to reach the overbank floodplain. The developments along Bolong Road, including the small commercial/industrial buildings in the eastern part of Bomaderry, the Shoalhaven Starches, Dairy Farmers and Paper Mill plants have all contributed to a reduction in the capacity of the flow path. Any further intense development along the river bank will need to be examined in detail. However, the ponds which are the main impediment to flows are all located some 500 m from the river bank. Thus their impact on the flow paths from the river is negligible as the floodwaters have largely dissipated once they cross Bolong Road.

4.8 House Raising

House raising is a means by which the entire house can be raised (typically on piers) above the nominated flood levels. In this way flood damages within the house can be eliminated to the nominated level. However external damages and the risk to life in moving to/from the house during a flood are not affected. This measure is really only appropriate for non-brick buildings on piers (our

preliminary inspection indicates that all buildings along Hannigans Lane may be suitable). The cost is typically \$60,000 per building and this measure has been widely used throughout NSW. It generally cannot be used for commercial/industrial buildings due to their size and as they are typically on concrete slabs.

5. SUMMARY

5.1 Impacts

The cumulative hydraulic impacts of all works on the northern floodplain undertaken since 1990, including the proposed works, will increase flood levels as indicated on Figures 8a to d. An appreciation of the incremental effects of the proposed works (ethanol plant upgrade and odour reduction works) can also be obtained from these Figures.

The economic impacts of the increases will vary from property to property. In many cases, the buildings affected are already inundated before any increases in level occur. This means that the majority of flood damages have already been incurred and any incremental increases in flood damages due to the works will be relatively minor.

The Paper Mill is inundated in a 5% AEP event (as occurred in March 1978) and the increase in depth of inundation is only a small fraction of the total depth experienced at the site. Some stock and equipment will be affected whilst for other fixtures there will be no increase in damages. Overall, it is considered that there will be an increase in damages, but it is likely to be only a small percentage of the total.

The Dairy Farmers plant (now vacant) is raised some 1.2 m above the 1% AEP flood level and so will experience no inundation (or increases in flood damages) until approximately a 0.1 % AEP event.

The frequency of closing a plant due to flooding is the greatest cost to the owners. The two largest plants on the floodplain (excluding Shoalhaven Starches) are the Paper Mill and Dairy Farmers. For both of these plants (and we presume Boweld) this occurs at the 5% AEP (or a lower) level which is not affected by the cumulative increases (Figure 8d).

Social impacts are closely tied to economic impacts but are most influenced by the occurrence of floods. Therefore once the area is evacuated (say a 5% AEP event), the social impacts do not increase significantly and are generally unaffected by the cumulative increases.

Environmental impacts associated with the increases in flood levels are negligible as there is little impact upon the duration of inundation, and the increases in level represent only a very small percentage increase in overall depth of flooding.

5.2 Future Development

The effects of the impacts must also be considered in light of the possible future uses of the land. As far as one can foreshadow at this time, the majority of the northern floodplain will remain as rural land as there is little opportunity for non flood compatible development due to the considerable depths of inundation and flood hazard. For these areas the impacts on future users will be nil.

There will undoubtedly be some further expansion or re development within the existing three major plants in the future, and the increases in flood levels due to the works may require equipment or floors to be set at a higher level, assuming that the owners wished to construct above a certain AEP. This might involve some additional expense (additional fill) to achieve this objective, but it is unlikely to be significant and in many cases (raising electrics) there will be no real increase.

5.3 Possible Floodplain Management Measures

Shoalhaven Starches cannot directly negate the hydraulic impacts of the works it has constructed or proposes to construct. For example it is not possible to construct a wet weather storage or wastewater treatment pond of the required dimensions with no increases in flood level or construct plant or associated works which does not in some way obstruct a flow path (e.g. railway spur line, container storage).

In order to compensate for the adverse impacts of the existing and proposed works, a range of management measures have been considered which will at least partially offset the potential increases in damages caused by the cumulative impacts of the existing and proposed works on the northern floodplain since 1990.

6. COMPLIANCE WITH DCP NO. 106 - FLOODPLAIN MANAGEMENT

6.1 Background

DCP 106 provides information and development controls needed to prepare and assess development applications on flood prone land where a Floodplain Management Plan has been prepared.

It is noted that a Final Shoalhaven River Floodplain Risk Management Plan has not been issued but a Draft has been with Council for over 12 months and is in the last stages of being finalised. In light of this the proposed works have been assessed assuming that there is a current Floodplain Risk Management Plan for the study area.

6.2 Determination of Relevant Controls

Land Use Category: Industrial + Earthworks + Non-Urban Open Space.

Flood Planning Area: (taken from Draft Shoalhaven River Floodplain Risk Management Study)
High Hazard Floodway adjacent to the bank of the Shoalhaven River and
High Hazard Flood Storage away from the bank.

6.3 Compliance Requirements

The following requirements need to be satisfied in order to comply with DCP 106 - Floodplain Management. The responses are provided in Capitals and in Bold beneath.

Floor Level of Buildings:

1% AEP + 0.5 m (Flood Planning Level)

SHOALHAVEN STARCHES WILL UNDERTAKE THEIR OWN FLOOD DAMAGE RISK ASSESSMENT FOR EACH BUILDING, TAKING INTO ACCOUNT THE USE OF THE BUILDING, DAMAGE POTENTIAL, ACCESS REQUIREMENTS AND OTHER SUCH INFORMATION. THESE DETAILS WILL BE ADDRESSED AT THE DETAIL DESIGN STAGE AND SUBMITTED WITH THE CONSTRUCTION CERTIFICATE.

Building Components:

Any part of the building below the Flood Planning Level must be built of flood compatible materials.
THESE DETAILS WILL BE ADDRESSED AT THE DETAIL DESIGN STAGE AND SUBMITTED WITH THE CONSTRUCTION CERTIFICATE.

Structural Soundness:

An appropriate Consulting Engineers Report must be provided stating that the building/structure can withstand floodwaters including debris and buoyancy forces up to a 0.2% AEP event (or 1% AEP + 0.5 m whichever is the higher).

THESE DETAILS WILL BE ADDRESSED AT THE DETAIL DESIGN STAGE AND SUBMITTED WITH THE CONSTRUCTION CERTIFICATE.

Flood Affectation:

An appropriate Consulting Engineers Report is provided stating that the development will not increase flood hazard or flood damage to other properties or adversely affect flood behaviour for a 5% AEP up to the PMP scenario.

DOCUMENTED AS PART OF THIS PRESENT REPORT

Access:

Reliable emergency vehicle and pedestrian access is required during a 1% AEP event.

IT IS NOT POSSIBLE TO PROVIDE EMERGENCY ACCESS DUE TO THE LOW LYING NATURE OF BOLONG ROAD. SHOALHAVEN STARCHES HAS A FLOOD EVACUATION PLAN (APPENDIX C) AND THIS WILL ENSURE ALL STAFF ARE SAFELY REMOVED FROM THE SITE PRIOR TO INUNDATION.

Flood Evacuation Plan:

An Engineers Report must be provided demonstrating that permanent, fail safe, maintenance free measures are incorporated in the development to ensure the timely, orderly and safe evacuation of people is possible from the area and that it will not add significant cost and disruption to the community or SES.

REFER SHOALHAVEN STARCHES FLOOD EVACUATION PLAN IN APPENDIX C.

Management and Design:

The applicant is to demonstrate that there is an area where hazardous and valuable goods can be stored above the flood planning level.

THESE DETAILS WILL BE ADDRESSED AT THE DETAIL DESIGN STAGE AND SUBMITTED WITH THE CONSTRUCTION CERTIFICATE.