GOSFORD CITY COUNCIL

MUDFLAT CREEK FLOODPLAIN RISK MANAGEMENT PLAN

AUGUST 2008

WEBB, McKEOWN & ASSOCIATES PTY LTD

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MUDFLAT CREEK FLOODPLAIN RISK MANAGEMENT PLAN

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FOREWORD

The NSW State Government's Flood Prone Land Policy provides a framework to ensure the sustainable use of floodplain environments. The policy is specifically structured to provide solutions to existing flooding problems in rural and urban areas. In addition, the Policy provides a means of ensuring that any new development is compatible with the flood hazard and does not create additional flooding problems in other areas.

Under the Policy, the management of flood liable land remains the responsibility of local government. The State Government subsidises flood mitigation works to alleviate existing problems and provides specialist technical advice to assist Councils in the discharge of their floodplain risk management responsibilities.

The Policy provides for technical and financial support by the Government through the following sequential stages:

1. *Formation of a Floodplain Risk Management Committee*
   - an advisory committee of Council which includes representatives of relevant Government authorities and the community.
2. *Data Collection*
   - compilation of existing data and collection of additional data.
3. *Flood Study*
   - determine the nature and extent of the flood problem.
4. *Floodplain Risk Management Study*
   - evaluates management options for the floodplain in respect of both existing and proposed development.
5. *Floodplain Risk Management Plan*
   - involves formal adoption by Council of a plan of management for the floodplain.
6. *Implementation of the Plan*
   - construction of flood mitigation works to protect existing development,
   - use of Local Environmental Plans to ensure new development is compatible with the flood hazard.

The Mudflat Creek Floodplain Risk Management Plan constitutes the fifth stage of the management process for Mudflat Creek and its catchment area. Webb, McKeown & Associates were commissioned by Gosford City Council to prepare this floodplain risk management plan on behalf of Council's Floodplain Risk Management Committee. The study project was jointly funded by Gosford City Council and State and Federal Governments. The report documents the work undertaken and provides a summary of the proposed floodplain management measures for Mudflat Creek. This Plan should be reviewed every 2 years or after a major flood event.

EXECUTIVE SUMMARY

The NSW Government's Flood Prone Land Policy provides for:

- a framework to ensure the sustainable use of floodplain environments,
- solutions to flooding problems,
- a means of ensuring new development is compatible with the flood hazard.

Implementation of the Policy requires a staged approach, the fifth stage of which is the preparation of a Floodplain Risk Management Plan which documents the proposed floodplain management measures.

The Mudflat Creek Flood Study (Stage 3) was initiated as a result of flooding of local roads and residential areas, most recently in July 1988, January 1989, February 1990, February 1992 and February 2002. It was completed by Webb, McKeown & Associates for Gosford City Council in 2006 and incorporates the floodplain between Fraser Road and Brisbane Water.

The Mudflat Creek Floodplain Risk Management Study was prepared by Webb, McKeown & Associates for Gosford City Council in 2008 to:

- review the nature and extent of the flood hazard in light of the recently completed Flood Study (2006),
- assess a range of management measures for existing and proposed development,
- determine potential impacts of future development and assess measures to mitigate these impacts (if required).

The objectives of the Mudflat Creek Floodplain Management Plan are to:

- reduce the flood hazard and risk to people and property in the existing community and to ensure future development is controlled in a manner consistent with the flood hazard and risk,
- reduce private and public losses due to flooding,
- protect and where possible enhance the creek and floodplain environment,
- be consistent with the objectives of relevant state policies,
- ensure that the floodplain management plan is fully integrated with Council's existing corporate, business and strategic plans, meets Council's obligations under relevant Acts and has the support of the local community,
- ensure actions arising out of the management plan are sustainable in social, environmental, ecological and economic terms,
- ensure that the floodplain management plan is fully integrated with the flood response procedure and other relevant catchment management plans,
- establish a program for implementation and a mechanism for the funding of the plan and should include priorities, staging, funding, responsibilities, constraints and monitoring.

Description of Creek Systems: Mudflat Creek has a catchment area of approximately 123 hectares and lies entirely within the boundaries of Gosford City Council. It drains into Brisbane Water through the lower area of Killcare.

A large portion of the lower section of the catchment has been developed for residential purposes. This takes in the area bounded by Fraser Road, Stanley Street and Hardys Bay. The upper section of the catchment largely comprises natural bushland or rural land type, although there is some residential development predominantly around Stewart Street, The Scenic Road and Wards Hill Road.

Within the study area there are two road crossings over the creek at Fraser Road and Noble Road. Between these crossings the creek runs through the rear of residential properties. The majority of which contain drainage easements. Overbank areas in many areas are confined due to the presence of fences, garden beds and sheds. Residents have also constructed footbridges to gain access over the creek. Upstream of Fraser Road the creek is confined to a relatively deep and narrow channel on a steep gradient.

Building Floors Inundated and Tangible Flood Damages: The following table indicates the number of building floors inundated and the tangible flood damages.

Table i): Buildings Inundated and Tangible Damages

Design Flood	Building Floors Inundated	Tangible Damages
PMF	22	$890,000
0.5% AEP	6	$105,000
1% AEP	4	$80,000
2% AEP	3	$55,000
5% AEP	3	$40,000
10% AEP	2	$25,000
20% AEP	2	$15,000

Note: The values shown are assuming 100% blockage at Noble Road bridge and Fraser Road culverts. All the buildings affected are residential as there are no commercial or industrial buildings.
These values have changed slightly from those provided in the Flood Study due to re development of 2 Noble Road.

Based on the above values the average annual damages are $15,000.

Proposed Management Measures: A range of floodplain management measures was analysed in the Mudflat Creek Floodplain Risk Management Study (2008) and from this the proposed measures (Table ii) were developed.

Table ii): Measures included in Mudflat Creek Floodplain Risk Management Plan

Measure (refer Figure 1 where appropriate)	Cost	Funding/Responsibility
High Priority:		
Improve Evacuation Planning	Minor	Local Residents/SES
Improve Public Awareness	Minor	Local Residents/SES/Council
Review Development Controls (Figure 2)	Minor	Council
Undertake Channel Maintenance	$5,000/annum	Council
Monitor Rate of Sedimentation		Local Residents/Council/CMA
Design Study to reduce overflows along Fraser Road North	Unknown	Council
Design Study to Control Sheet Flow across Fraser Road secondary flow path	Unknown	Council
Medium Priority:		
Farm Dam No. 3 to be removed	Unknown	Council/Landowner
Review Policies on Farm Dams	Nil	Council/CMA
Undertake Channel Works from Fraser Road to Noble Road	$850,000 excl. Noble Road crossing	Council/CMA
Provide Siltation Control	Unknown	Council
Reduce blockage at Culverts	$30,000/culvert	Council/DECC
Low Priority:		
On-site Detention associated with re-development	Nil cost to Council	Landowner
Establish Database for Local Drainage Issues	Nil cost to Council	Council
Mitigate Wave Runup (considered as part of Brisbane Water Flood Study)	Unknown	Council
Wards Hill Road Basin Review Legal Ramifications	Unknown	Council/RTA

Note: Measures are not in any particular order within each category.

The Plan is shown as Figures 1 and 2.

1. INTRODUCTION

Mudflat Creek is a 123 hectare catchment which drains to Hardys Bay through the lower Killcare district (refer Figure 1). The lower section of the catchment is predominantly occupied by urban residential development. A natural escarpment divides the lower section of the catchment from the upper plateau area. This upper plateau is predominantly natural or rural land type with some residential development around Stewart Street, The Scenic Road and Wards Hill Road.

In light of reported flooding incidents in the study area, Gosford City Council engaged Webb, McKeown & Associates to undertake a Flood Study (Reference 1) and Floodplain Risk Management Study (Reference 2).

Webb McKeown & Associates were subsequently engaged by Gosford City Council to undertake the next stage in the floodplain risk management process, namely the preparation of the Mudflat Creek Floodplain Risk Management Plan.

1.1 Floodplain Risk Management Process

As described in the Floodplain Development Manual (Reference 3), the Floodplain Risk Management Process entails six sequential stages:

Stage 1: Formation of Floodplain Risk Management Committee.
Stage 2: Data Collection.
Stage 3: Flood Study.
Stage 4: Floodplain Risk Management Study.
Stage 5: Floodplain Risk Management Plan.
Stage 6: Implementation of the Plan.

The Mudflat Creek Floodplain Risk Management Plan constitutes the fifth stage in the process and follows from the Floodplain Risk Management Study stage which was completed in 2008.

1.2 Catchment Description

The Mudflat Creek catchment is characterised by a distinct upper and lower section. The upper section of the catchment is located in the plateau area of Killcare Heights. This section of the catchment comprises of residential development around Wards Hill Road, The Scenic Road and Stewart Street together with a large proportion of natural bushland or rural type land.

From the plateau the catchment slopes very steeply down undeveloped, densely forested slopes to the area bounded by Fraser Road and Hardys Bay. This lower section is relatively flat and low lying. Runoff from the plateau area drains to Fraser Road via two natural gullies. Pipe and overland flow systems convey flows from these natural gullies, through the residential areas to Mudflat

Creek. Mudflat Creek then travels through the rear of properties 37-63 Fraser Road before reaching the bridge in Noble Road and its outlet to Hardys Bay.

1.3 Creek Description

The following provides a descriptive overview of the key characteristics of the Mudflat Creek floodplain. Some of the significant features of the creek are illustrated in Photographs 1 to 4.

Photo 1: Noble Road Bridge looking upstream.

Photo 2: Twin 900 mm diameter pipe outlet into Mudflat Creek at rear of 57 Fraser Road. Note siltation covering half of pipes at the outlet.

Photo 3: Looking upstream at rear of 53, 55 and 57 Fraser Road.

Photo 4: Fraser Road culvert looking upstream.

The outlet of the creek into Brisbane Water is a wide mudflat that is dominated by mangroves. Immediately upstream of the outlet a bridge crosses the creek at Noble Road.

Between Noble Road and Fraser Road the creek runs through the rear of residential properties 37-63 Fraser Road and consequently the extent of the overbank area is variable with fences, gardens and sheds representing significant impediments to the overbank flow area. The degree of maintenance varies, with some sections of the creek heavily vegetated while other sections are mowed and maintained by residents. In many cases the same landholders own land on both sides

of the creek and a number of footbridges have been constructed for access purposes (refer Photograph 3).

Runoff from the southern section of Wards Hill Road, Stewart Street and The Scenic Road in the plateau area of Killcare Heights is conveyed via a natural gully which drains to Mudflat Creek via a twin 900 mm diameter stormwater pipe before ultimately discharging into the creek at the rear of 57 Fraser Road (Figure 1).

Flows along the main channel are conveyed under Fraser Road (north-south alignment) via a 1950 mm diameter pipe culvert. Immediately downstream of Fraser Road (north-south alignment) the creek is heavily vegetated with a variety of native and introduced plant species. Rock lining of the embankments upstream and downstream of the 1950 mm culvert has been carried out to reduce erosion.

Upstream of Fraser Road along the main channel the creek is markedly deeper and is fringed by natural bushland. The creek forms into a natural gully that drains the area referred to by local residents as "The Triangle". This is the area bounded by Maitland Bay Drive, Wards Hill Road (northern section) and The Scenic Road.

1.4 Land Use Activities

The floodplain of Mudflat Creek downstream of Fraser Road is occupied entirely by approximately 23 detached residential developments with a mix of one/two storey, old/new and brick and non-brick buildings.

Upstream of Fraser Road the buildings are on the northern (high) bank of the creek and thus are not inundated. However their access to Fraser Road will be affected. There is one "cabin" immediately upstream of Fraser Road that will be inundated.

The creek channel runs through private property and residents have constructed fences, bridges and other flow obstructions in their yards (Photograph 3). The bridges are required to obtain access to their property on the other side of the creek.

1.5 Flooding Mechanism

Flooding within the Mudflat Creek catchment may occur due to a combination of factors including:

- an elevated water level in Brisbane Water due to tidal influences, rainfall and storm surge,
- elevated water levels within Mudflat Creek as a result of intense rain over the Mudflat Creek catchment. The levels in the creek may also be affected by constrictions along its length (e.g. culverts, blockages, bridges, vegetation),
- local runoff over a small area accumulating (ponding) in low spots. Generally this occurs in areas which are relatively flat with limited potential for drainage. This type of flooding

may be exacerbated by inadequate local drainage provisions and elevated water levels at the downstream outlet of the urban drainage (pipe, road drainage) system.

These factors may occur in isolation or in combination with each other. Generally the peak water level in Brisbane Water will occur several hours after the flood peak in Mudflat Creek itself. This is because the peak levels in the Mudflat Creek catchment are typically the result of short duration storms of up to two hours duration. In contrast, the peak levels in Brisbane Water would typically result from longer duration storms of say 6 hours or longer.

Design flood levels were derived in the Flood Study.

1.6 Community Consultation

The Floodplain Risk Management Study and Plan were placed on public exhibition in 2008.

2. OVERVIEW OF FLOODPLAIN RISK MANAGEMENT STUDY

A list of all possible floodplain risk management measures which could be applied in the study area were initially developed. A matrix was prepared to assess them in terms of their suitability and effectiveness for reducing social, ecological, environmental, cultural and economic impacts. As part of this process a number of measures were identified as not being worthy of further consideration. A more detailed assessment of the remaining measures were then undertaken and the results are summarised in Tables 1 and 2. Table 1 provides an overview of the management measures considered in Reference 2 and Table 2 provides a matrix of results from the analysis of these management measures.

Following the latest information from the Intergovernmental Panel on Climate Change it is prudent to make an allowance for an increase in design flood levels due to a sea level climate change. This will be determined in the upcoming Brisbane Water Floodplain Risk Management Study.

A multi-criteria matrix assessment of the available measures was undertaken and this was then reviewed by the Committee and Council. Following the public exhibition period, public submissions were also incorporated where applicable.

Table 1: Floodplain Management Measures Considered in Reference 2

Description	Section in FRMS Report	To be Considered for Inclusion in Plan (References to FRMS)
Flood Mitigation Dams	4.2.1	No due to high economic and environmental cost
Construct new Retarding Basins	4.2.2	No due to high economic and environmental cost
On Site Detention	4.2.3	Provides minimal reduction in flood level but will be considered to mitigate the impacts of future development.
Modify Existing Farm Dams	4.2.4	Not practical to use existing farm dams but basin at Wards Hill Road discussed in Section 5.2.5. Dam No. 3 to be removed or modified. DECC/Council to review policies on potential hazard of failure of unregulated farm dams.
Channel Modifications	4.3	Individual measures discussed in Section 5
Levees, Flood Gates, Pumps	4.4	Diversion levees discussed in Section 5.2.3
Local Drainage Issues	4.5	Yes but only in order to identify the problem
Measures to Mitigate Wave Runup	4.6	Considered as part of Brisbane Water Flood/Foreshore Study
Flood Warning	4.7	No too short a warning to be of value
Evacuation Planning	4.8	Yes evaluated by the SES
Public Information and Raising Awareness	4.9	Yes Minimal cost and assumed high benefit cost ratio
Development Control and Flood Planning Levels	4.10	Yes will provide additions to existing Policies
House Raising	4.11	No only suitable house now re developed
Voluntary Purchase of a Property	4.12	No as local residents are unlikely to support this measure

FRMS = Mudflat Creek Floodplain Risk Management Study (FRMS)

Table 2: Matrix of Floodplain Management Measures

Description	Section in FRMS Report	Capital Cost	Recurrent Cost	Reduction in AAD	Benefit Cost Ratio	Reduction in Water Level	Reduction in Tangible Damages	Reduction in Intangible Damages (Risk to Life)	Environmental Impact	Community Acceptance	Value for Money	Total Score	To be Considered for Inclusion in Plan (References to FRMS)
Flood Modification Measures Upstream of Fraser Road Bridge													
Do Nothing	5.2.1				nil	0	0	0	0	0	0	0	This is a viable alternative
Channelisation	5.2.2	$50,000	$2,000	nil *	nil	3	0	2	-1	0	0	4	No on account of the minimal reduction in flood damages unless combined with other measures
Levee	5.2.3	$50,000	nil	nil *	nil	-2	-1	1	-1	-1	0	-4	No on account of the increase in flood level upstream and likely high community impact
Increase size of Fraser Road culverts or construct a bridge	5.2.4	$100,000	nil	nil *	nil	0	1	1	0	2	0	4	If combined with downstream works (Refer Section 5.3.4)
Wards Hill Road retarding basin	5.2.5	$100,000	nil	yes	0.14	1	1	1	0	0	-2	1	Yes raising the wall to be considered - Low Priority. Initially obtain advice on legal ramifications
Farm dams in upper catchment	4.2.4	unknown	nil	nil	nil	0	0	3	0	1	1	5	Yes remove Dam No 3 and review policies on farm dams
Flood Modification Measures Downstream of Fraser Road Bridge													
Do Nothing	5.3.1				0	0	0	0	0	-3	0	-3	No as some channel works are required even if only for aesthetic, social and/or environmental reasons
Pipe the creek	5.3.2	$690,000	nil	significant reduction	high	3	3	3	-3	-1	-1	4	No due to Water Sensitive Urban Design issues
Provide siltation control, monitoring and review of processes - Estuary Management issue	5.3.3	?	$1,000	nil *	nil	0	0	0	2	2	2	6	Yes - monitor rate and provide siltation controls
Channel works to 20m downstream Noble Road. May consider works upstream of Fraser Rd if prevents overtopping of road	5.3.4	$1,100,000 (inc. Bridge)	see below 5.3.6	significant reduction	0.14	2	1	1	-1	2	1	6	Yes
Works from 20m downstream of Noble Road to Hardys Bay	5.3.4	additional $350,000	see below 5.3.6	very small	0.02	0	0	1	-3	0	-3	-5	No as has major environmental concerns plus provides little additional hydraulic benefit
Realign channel to lower hazard	5.3.5	included as part of 5.3.4	nil	nil *	nil	0	0	0	-1	3	3	5	Yes
Undertake regular creek maintenance	5.3.6	nil	$5,000	nil	nil	0	0	0	-1	3	3	5	Yes
Reduce likelihood of blockage at Fraser and Noble Roads	5.3.7	$30,000	$1,000	yes @	high	0	2	1	0	3	3	9	Yes
Establish or widen drainage easements	5.3.8	$30,000	nil	nil	nil	0	0	0	0	-1	3	2	Yes presumed at minimal cost to Council
Control sheet flow across Fraser Road at secondary flow path	5.3.9	unknown	nil	yes @	low	1	0	1	0	2	1	5	Yes a Design Study proposed
Upgrade access along Stanley Street	5.3.10	up to $100,000	nil	nil	nil	1	0	1	-1	1	-2	0	No as provides little benefit in reducing hazard
Overland Flow along Fraser Road North													
Do Nothing	5.3.11				nil	0	0	0	0	-3	0	-3	No as extent of flood problem is unacceptable
Prevent overtopping of Fraser Road - construct a levee, enlarge channel, upgrade Fraser Road culvert	5.3.11	?	nil	none #	nil	1	0	1	-2	-1	-1	-2	Upgrading of Fraser Rd culvert considered under Section 5.3.4. If undertaken further channel works upstream will be considered.
Divert runoff along Fraser Road to creek - pipes, swale to the creek	5.3.11	?	?	none #	nil	2	0	2	0	2	1	7	Yes a Design Study proposed
Provide improved runoff collection system along Fraser Road	5.3.11	unknown	nil	none #	nil	1	0	1	0	2	2	6	Yes a Design Study proposed
Modify east-west alignment of Fraser Road	5.3.11	?	?	none #	nil	2	0	1	0	2	1	6	Yes a Design Study proposed
Voluntary purchase of a property to provide flow path to creek	5.3.11	$800,000	nil	none #	nil	0	0	2	0	-3	-3	-4	No unlikely to be accepted by Community
General Floodplain Management Measures													
Establish database for local drainage issues	4.5	negligible	negligible	nil	nil	0	0	0	0	3	3	6	Yes undertaken by Council
Mitigate wave runup	4.6	unknown	unknown	small	low	0	1	1	0	2	2	6	Yes undertaken by Council
Improve evacuation planning	4.8	negligible	negligible	small	high	0	0	3	0	3	3	9	Yes undertaken by SES
Improve public awareness	4.9	negligible	negligible	medium	high	0	0	3	0	3	3	9	Yes undertaken by SES & Council
Review development controls	4.10	negligible	negligible	nil	high	0	2	1	0	2	3	8	Yes undertaken by Council, include on-site detention

Notes: none # = no house floors inundated
yes @ = cannot quantify the reduction in damages
nil * = unless combined with other works
? = depends on nature of works

3. FLOODPLAIN RISK MANAGEMENT PLAN

3.1 Summary

The recommended floodplain management measures for the Mudflat Creek catchment are summarised in Table ii) in the summary and discussed in the following sections.

The priority ranking is based upon a combination of reduction in flood risk, ease of implementation and cost/funding implications. There is no particular order of the measures within each priority categorisation.

3.2 High Priority

Improve Evacuation Planning: Due to the isolated nature of Mudflat Creek and the short duration of flooding it is expected that most residents will stay in their home. Evacuation is therefore only likely to be necessary for medical reasons. The SES would need to evaluate this risk in their proposed Flood Evacuation Plan.

Improve Public Awareness: For floodplain risk management to be effective it must become the responsibility of the whole community. It is difficult to accurately assess the benefits of an awareness program but it is generally considered that the benefits far outweigh the costs.

Review Development Controls: Updating of Council's planning and development controls will ensure that flood damages to new buildings and contents as well as the risk to life will be limited to an acceptable level. In establishing these controls a balance needs to be achieved between the risk/consequences of a future flood event and the impositions on the landowner/developer. A very restrictive set of controls will inhibit further development and possibly financially disadvantage existing landowners. While less strict controls may produce an unacceptable level of damage/hardship in a future flood.

The controls listed on Figure 2 are proposed for the Mudflat Creek floodplain but Council should give consideration to whether they should be applied (possibly with modifications) to other flood liable areas within the Gosford Council local government area.

Undertake Channel Maintenance: These works would provide limited hydraulic benefit but will reduce the likelihood of blockage and enhance the environmental qualities of the creek. Of particular importance is ensuring that mangroves do not invade the creek channel and restrict flood flows. This issue is noted in the Development and Planning Controls on Figure 2.

Monitor Rate of Sedimentation: Sedimentation has occurred in the past causing problems for the creek system. In order to establish the implications of the ongoing sedimentation it is proposed to undertake a regular monitoring program combined with construction of at least one siltation control structure. Ongoing monitoring would include say an annual inspection and provision of a

photographic record. This program would be amended as the needs arise. It would be preferable if the inspection can be undertaken by a local resident group as this would ensure that the "local" issues are addressed.

Design Study to Reduce Overflows along Fraser Road North: The Floodplain Risk Management Study examined a range of possible measures to reduce the overflows including:

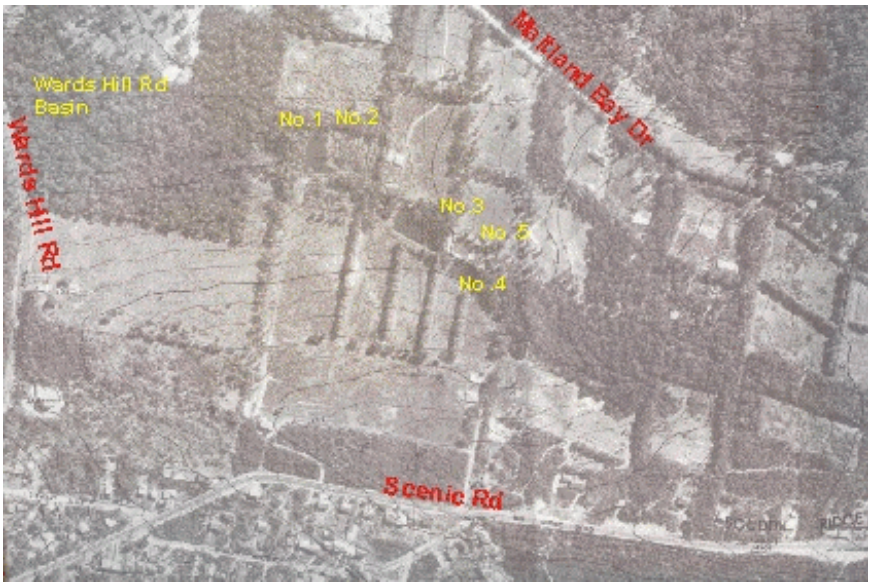
- prevent overtopping from Mudflat Creek (levee, enlarge channel),
- direct runoff into Mudflat Creek (swales, culverts, mounds),
- stormwater collection devices,
- modify east-west alignment of Fraser Road (alter vertical and/or horizontal alignment, swales, easements),
- voluntary purchase of a property to create a drainage reserve.

It is possible that a combination of the above measures will be required as the study will need to evaluate the necessary environmental, hydraulic, social and economic considerations.

Design Study to Control Sheet Flow across Fraser Road at Secondary Flow Path: The north-south alignment of Fraser Road is crossed by upstream runoff during heavy rainfall causing inconvenience, a minor hazard to traffic and some inundation and property damages. The Floodplain Risk Management Study considered a range of measures but a more detailed assessment and survey/detailed design is required.

3.3 Medium Priority

Farm Dam No. 3 to be Removed: The Floodplain Risk Management Study undertook a review of all the farm dams in the upper catchment and determined that this dam (refer figure below) should be removed to eliminate the risk of dam failure and possible catastrophic damages downstream.



Review Policies on Farm Dams: The Floodplain Risk Management Study raised questions regarding the approval, liability for failure and other issues regarding farm dams. These need to be considered by the appropriate authorities.

Undertake Channel Works from Fraser Road to Noble Road: Many residents consider that some form of channel works should be undertaken to provide a reduction in flood level but also to improve the environmental qualities of the creek system. The proposed works included:

- replacing the Fraser Road culvert with twin 2400 mm x 2400 mm RCBCs,
- grade the channel at 1.3% from 1.7 mAHD at Fraser Road to -1.5 mAHD at Noble Road to form a 3 m base width trapezoidal channel (this expands to 10 m wide upstream and downstream of Noble Road) with the final extents to be determined at design stage,
- replace the Noble Road timber bridge with either three 3300 mm x 2100 mm RCBCs or a bridge structure 10 m wide.

Council already has a design for the above works but this would need to be reviewed.

Provide Siltation Control: Siltation is an ongoing process and can be controlled by constructing a "basin" either upstream or downstream of Noble Road to collect the sediment. The basin would need to be cleared at regular intervals.

Reduce Blockage at Culverts: The design flood analysis assumes blockage of the culverts at Fraser and Noble Roads by vegetative or other debris. Blockage control devices (bollards or racks) will significantly reduce the likelihood of total blockage of the structure.

3.4 Low Priority

On-Site Detention: OSD provides a means of reducing the impacts of future urbanisation but would not reduce existing peak flows. Generally it is not applied in rural areas as the density of development is such that it cannot be justified. All development to be in accordance with DCP 165 (Water Cycle Management).

Establish Database for Local Drainage Issues: Some residents have highlighted the issue of runoff ponding in yards or along Fraser Road. Whilst these issues are generally not considered or funded within this type of study it is important that they are identified to ensure they are not exacerbated or can possibly be attenuated with any proposed flood mitigation works.

Mitigate Wave Runup: Wave runup effects can produce flooding in the downstream part of the creek (say within 50 m of Noble Road) but are largely mitigated by the stands of mangroves. Wave runup and its implications should be investigated as part of the Brisbane Water Flood Study.

Wards Hill Road Basin - Review Legal Ramifications: Wards Hill Road presently acts as a retarding basin, reducing peak flows downstream. The basin could be modified to enlarge its capacity by constructing a 1 m high (approximate) embankment on the upstream side. This would

provide some reduction in peak flows downstream. However the legal ramifications of these works should they fail, or not operate as designed, need to be reviewed by Council and the RTA before this measure can be pursued further.

4. ACKNOWLEDGEMENTS

This study was carried out by Webb, McKeown & Associates Pty Ltd and funded by Gosford City Council and the Department of Environment and Climate Change. The assistance of the following in providing data and guidance to the study is gratefully acknowledged:

- Gosford City Council,
- Department of Environment and Climate Change,
- Floodplain Management Committee,
- residents of Mudflat Creek.

5. REFERENCES

1. Gosford City Council
Mudflat Creek Flood Study
Webb, McKeown & Associates, November 2006.

2. Gosford City Council
Mudflat Creek Floodplain Risk Management Study
Webb, McKeown & Associates, March 2008.

3. **Floodplain Development Manual**
NSW Government, April 2005.

FIGURES

FIGURE 1

MUDFLAT CREEK FLOODPLAIN RISK MANAGEMENT PLAN

Measure

High Priority:

Improve Evacuation Planning
Improve Public Awareness
Review Development Controls
Undertake Channel Maintenance
Monitor Rate of Sedimentation
Design Study to reduce overflows along Fraser Road North
Design Study to Control Sheet Flow across Fraser Road secondary flow path

Medium Priority:

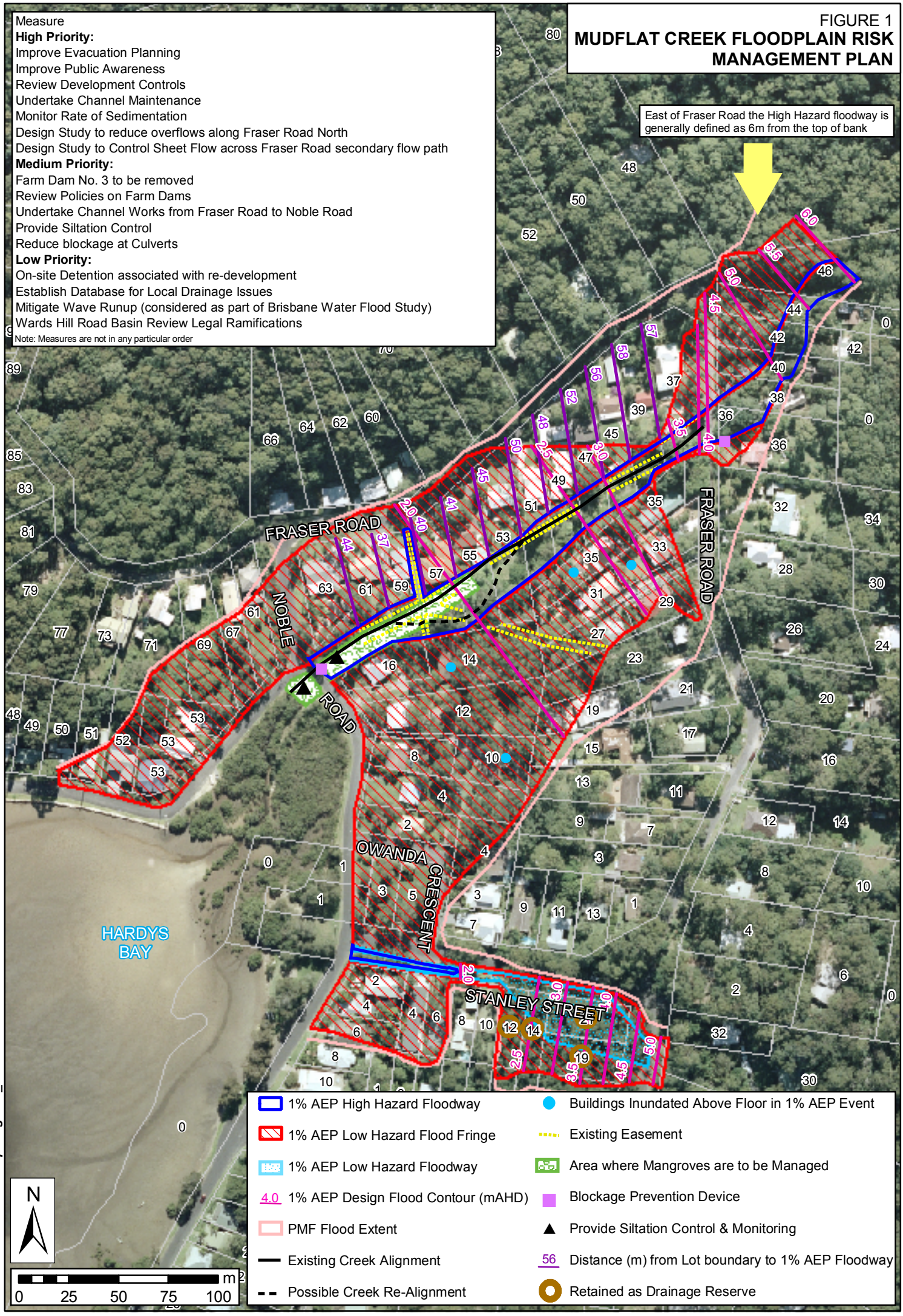
Farm Dam No. 3 to be removed
Review Policies on Farm Dams
Undertake Channel Works from Fraser Road to Noble Road
Provide Siltation Control
Reduce blockage at Culverts

Low Priority:

On-site Detention associated with re-development
Establish Database for Local Drainage Issues
Mitigate Wave Runup (considered as part of Brisbane Water Flood Study)
Wards Hill Road Basin Review Legal Ramifications

Note: Measures are not in any particular order

East of Fraser Road the High Hazard floodway is generally defined as 6m from the top of bank



1% AEP High Hazard Floodway
1% AEP Low Hazard Flood Fringe
1% AEP Low Hazard Floodway
4.0 1% AEP Design Flood Contour (mAHD)
PMF Flood Extent
Existing Creek Alignment
Possible Creek Re-Alignment
Buildings Inundated Above Floor in 1% AEP Event
Existing Easement
Area where Mangroves are to be Managed
Blockage Prevention Device
Provide Siltation Control & Monitoring
56 Distance (m) from Lot boundary to 1% AEP Floodway
Retained as Drainage Reserve

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Flood Planning Levels:
- residential habitable floor level of 1% AEP + 0.5 m,
- residential garage floor at 1% AEP,
- all habitable residential floors must be a minimum of 0.5 m and garages a minimum of 0.3 m above the surrounding finished ground unless it can be demonstrated that there is nil chance of overland flow entering the floor,
- the appropriate FPL for the development is to be based upon the highest 1% AEP flood contour (to the nearest 0.1 m) within the property +0.1 m.

Increase in Number of Residents Living on the Floodplain: There is to be no increase in the number of residents (dual occupancy, subdivision) for properties lying entirely within the floodplain. Consideration will be given to properties lying partially within the floodplain if it can be demonstrated that there is no increase in damages, risk to life or burden on the SES/Council. A minimum requirement will be safe and easy access to/from the building and garages in the 1% AEP event. New developments that reduce the existing flood risk (removing an existing building or risk) are to be promoted.

Fill within the Floodplain: Filling within the 1% AEP floodplain (as part of earthworks or a building) is not promoted and each case will be decided on its merits based upon a submission by the proponent. The following are guidelines which should be followed as far as possible:
- achieve fill using cut/fill balance,
- no additional fill if there is an existing building on piers,
- only fill within the existing building footprint to a maximum of 0.5m above the existing natural surface,
- there is a nett increase in temporary floodplain storage,
- there is a reduction in risk to life,
- there is no increase in flood level, velocity or diversion of floodwaters (both overland and mainstream).

Development within 1% AEP High Hazard/Floodway Extent: No residential building (house, garage, home improvements, sheds, bridges, etc.) permitted. Fencing to be removed or modified as far as practicable to allow the passage of flood flows.

Restriction to Overland Flow Path: Overland flow paths are less well defined than the main Mudflat Creek floodway extent and can easily be altered (inadvertently or otherwise) by filling, fencing, driveways, sheds, or re-vegetation by the resident/property owner. Proposals for new developments must consider this aspect in their submission for development approval.

Development in Drainage Easements: As far as possible no development that restricts the flow of floodwaters (building, vegetation, earthworks, fencing) will be permitted within drainage easements. Easements should remain open for the free passage of floodwaters.

Development within 40 m of the Top of Bank: All development within 40 m of the top of bank of Mudflat Creek requires separate approval from the Department of Water and Energy under the Rivers and Foreshores Improvement Act.

Building Materials, Structural Stability, Damage Minimisation: All new buildings subject to Flood Planning Level (FPL) controls must provide certification from a Registered Engineer that the building will be minimum structurally sound in the FPL flood event (1% AEP +0.5 m). As far as possible all services(electricity, telephone, sewerage, water supply, etc.) should be designed so that in the above FPL flood event there is minimal damage within the property. Improvements on the property not already covered by the above must be designed to experience minimal damage and not to increase the flood hazard (i.e. block the flow path if they fail).

Crossings of Mudflat Creek: All existing private bridges should be removed and as part of the proposed channel works, replaced with low level causeways constructed by Council.

Bed or Channel Works to Mudflat Creek: All works (earthworks or re-vegetation) to the bed or channel must be approved by Council and other relevant Government agencies.

Increase in Flood Risk: A development will not be permitted if it increases the flood risk to existing or future residents, the SES or any other emergency agency.

Hydraulic Study: Council may require a developer to undertake a hydraulic study in order to determine the hydraulic impacts of any proposed development.

Risk to Life of Occupants: All new developments or extensions greater than 20% of the existing floor area must either provide flood free access to a “safe” locality outside the PMF extent or within the building (vertical evacuation to a 2nd floor or attic in a single storey building).

Climate Change Increase in Design Flood Levels for Mudflat Creek: A sea level climate change increase will be determined in the subsequent Brisbane Water Floodplain Risk Management Study. A rainfall climate change increase is considered to be within the 0.5m freeboard until such time that a more definitive assessment is obtained.

Mangrove Extent: The present extent and density of mangrove habitat upstream and downstream of Noble Road is to be benchmarked as at 2008 by aerial and oblique digital photographs. Any change in the extent or density that will adversely or beneficially affect flood levels is to be monitored and where appropriate managed by Council (for example removed) in consultation with the relevant State Government Agencies. The two key areas of interest are upstream of Noble Road bridge and immediately downstream of the bridge where a sedimentation basin is proposed.

Underfloor Area: Any proposed underfloor area designed to accommodate the throughflow of floodwaters must:
- not be enclosed in any way and have minimum pier spacings of 2 m with the maximum offsets for rows of piers aligned parallel to flow as 0.1m,
- be designed to experience minimal structural or other damage in a flood.

Subdivision of Land and Dual Occupancies: It is important that no new residential lots or dual occupancies are established within the 1% AEP floodplain that would place the new occupants or rescue personal at risk to life during a flood. Therefore no new lots or dual occupancies are permitted that cannot provide safe pedestrian and vehicular 1% AEP flood free access out of the floodplain.

Redevelopment of Existing Houses and Garages within the 1% AEP Floodplain: All new houses within the 1% AEP floodplain with floors greater than 0.5m above the general ground level are to be elevated on piers. Filling is allowed under garages or carports where the filling will not adversely affect overland stormwater flows and the “blocked” flow width across the property is not greater than 50% of the total. In addition all building structures should be positioned where they would have the least impact on flows across the property.

Existing Development Controls of Council: In addition to the above controls, all developments must comply with Council’s existing flood related development controls.