Australian Government
Department of Transport and Regional Services

Department of
Infrastructure, Planning and Natural Resources

COFFS CREEK FLOODPLAIN RISK MANAGEMENT PLAN

Aerial view of the lower reaches of the Coffs Creek catchment

Draft Report

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Bewsher Consulting Pty Ltd

Coffs Harbour City Council

COFFS CREEK
FLOODPLAIN RISK MANAGEMENT PLAN

DRAFT REPORT

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EXECUTIVE SUMMARY

Reasons for the Study and Plan

There is a long history of flooding on Coffs Creek. The most recent event, which occurred in November 1996, was the most severe flood ever recorded on Coffs Creek. Some 260 residential homes and 200 commercial buildings were flooded above floor level during this flood.

The 1996 flood prompted Coffs Harbour Council to commission a revised Flood Study to further investigate the cause and severity of this flood. The review indicated that the magnitude of flood problems within the catchment was greater than had previously been thought. Council subsequently commissioned a floodplain risk management study to investigate and recommend measures to reduce flooding problems within the catchment. The recommended measures from the Study form the Coffs Creek Floodplain Risk Management Plan.

The Study and Plan have been produced as separate documents.

Responsibilities

The prime responsibility for planning and management of flood prone lands in New South Wales rests with local government. The NSW Government provides assistance on state-wide policy issues and technical support. Financial assistance is also provided to undertake flood and floodplain risk management studies and for the implementation of works identified in the subsequent floodplain risk management plan.

A project team was assembled for the preparation of the study. Members of the project team include:

(i) *Coffs Harbour Council* – Council has overall responsibility for the management of flood liable land.

(ii) *The Department of Infrastructure, Planning & Natural Resources (formerly Department of Land and Water Conservation (DLWC))* – The Department provides technical assistance and financial support for the study and for the implementation of measures in the recommended plan.

(iii) *The University of New England (CEEWPR)* – The University's Centre for Ecological Economics & Water Policy Research (CEEWPR) has facilitated community participation in the study, and assisted in the evaluation of floodplain management measures.

(iv) *Bewsher Consulting* – Bewsher Consulting has undertaken the technical assessments and prepared the study report and plan, with the assistance of other members of the project team. Don Fox Planning has also assisted Bewsher Consulting on town planning issues.

The Study Area

Coffs Creek is a relatively small, but highly populated catchment on the mid north coast of New South Wales. The creek is approximately 12km long, and has a catchment area (excluding its northern tributaries) of 24 square kilometres.

The study area includes the main Coffs Creek catchment area. The northern tributaries of Coffs Creek is not included in the study area, as a separate investigation [*Paterson Consultants, 1997*] was undertaken for this part of the catchment. The main CBD area has also been the subject of separate drainage investigations.

Objectives of the Study and Plan

The objective of the study is to prepare a floodplain risk management plan that will minimise the effects of flooding. Specific objectives of the study include:

< quantification of the flood problem within the Coffs Creek study area;

< an assessment of potential floodplain management measures to reduce the risks of flooding, including flood mitigation works and other catchment-wide measures such as flood warning, emergency management and planning controls;

< a consultation program that involves the community through the progress of the study and in the consideration of potential flood mitigation works and other measures;

< the development of a recommended floodplain risk management plan for the study area outlining the best measures to reduce flood risks, based on consideration of environmental, social, economic and engineering issues.

Consultation

Community consultation has been an important component of the current study. The Centre for Ecological Economics and Water Policy Research at the University of New England had a major role in coordinating consultation activities across a broad range of community members and other stakeholders for this study. The consultation process has diverged from the usual process of “telling the community about predetermined options” to involving the community in the preliminary identification of options; consideration of the implications of those options; and in the selection of the final options recommended for the floodplain management plan.

Key elements of the consultation process include:

< advertising the study through local papers, distributing newsletters, and providing details on the Internet;

< distribution of a questionnaire to residents and business owners within the study area;

< distribution of a questionnaire to relevant Agencies and Interest Groups;

< a number of community workshops, through the Coffs Creek Flood Working Party, to determine the direction of the study and to consider potential floodplain management measures; and

< public exhibition of the floodplain risk management study during June/July 2005, prior to formal consideration by Council.

The Flood Problem

A flood damages database of potentially flood affected buildings and properties has been prepared for the study area. The database provides details of those properties likely to be inundated in different sized floods and allows the quantification of potential flood damages. Key results from the database indicate that:

< 1,464 residential homes and 424 commercial buildings would be flooded above floor level in a probable maximum flood (PMF);

< 308 residential homes and 111 commercial buildings would be flooded above floor level in a 100 year flood;

< the majority of homes (68%) flooded in a 100 year flood would be inundated by less than 0.5m;

< predicted flood damage in the 100 year flood is $28M, whilst the average annual flood damage is estimated at $2.2M and the present value of all future flood damages is estimated at $24M.

Flood Risk Mapping & Development Controls

The Coffs Creek floodplain has been divided into three flood risk areas (high, medium and low). Different development controls are proposed for the catchment, depending on the type of development and the flood risk area that the development is located. The proposed development controls are included in Appendix B.

The high flood risk area is where high flood damages, potential risk to life, or evacuation problems are anticipated. It is recommended that most development is restricted within this area.

The medium flood risk area is where there is still a significant risk of flood damage, but where these damages can be minimised by the application of appropriate development controls.

The low flood risk area is that area where the risk of flood damage is low. Most land uses would be permitted within this area (subject to other considerations).

In addition to the three flood risk areas listed above, a high flow corridor has been delineated within the high risk area of the floodplain. This corridor conveys a significant proportion of the flood flow and where most development is clearly undesirable due to its high risks and its potential impact on flooding.

Potential Floodplain Management Measures

A range of floodplain management measures has been assessed as part of the Coffs Creek Floodplain Risk Management Study. These include:

< potential flood mitigation works in the lower creek (enlarging bridges, dredging and clearing mangroves);

< potential flood mitigation works in the upper catchment (four different detention basins);

< potential flood mitigation works in other areas (site specific works); and

< catchment-wide measures (development controls, emergency management, flood awareness, creek maintenance etc).

The measures have been assessed in terms of impacts on flooding, environmental implications, economic considerations and other social issues.

The Recommended Floodplain Management Measures

The recommended measures have been included in the Coffs Creek Floodplain Risk Management Plan. The principal recommendations are as follows:

< construction of up to four detention basins in the upper catchment (total estimated cost for all four basins, including land acquisition, $8.5M);

< construction of a low-level floodway and other channel improvements adjacent to Ann Street (estimated cost $200,000);

< review of the Loaders Lane Levee, including further survey and investigation into extending the levee closer to Shephards Lane (estimated cost $10,000);

< continued improvements to the Central Business District Drainage Scheme, which is the subject of separate investigations (costs not available);

< implementation of planning & development controls, including amendments to the Coffs Harbour LEP, adoption of a new *Flood Risk Management DCP or Flood Prone Land Information Sheet*" and a review of other development control plans for consistency (no costs);

< improved emergency management measures, including the update of the SES Local Flood Plan for Coffs Creek with information provided in the floodplain risk management study (no costs);

< encourage flood proofing of individual buildings where there is a high potential for flood damage and/or the development of flood action plans to reduce potential risks and damages (costs borne by individuals);

< the development and implementation of a public awareness program, including the issue of flood certificates and the establishment of one or more flood markers in the catchment, preparation of an information sheet on flooding and an SES flood awareness brochure (estimated cost $35,000);

< development of a vegetation management plan (estimated cost $50,000) that provides a coordinated program of creek maintenance, including the removal of exotic vegetation and other debris from the creek corridor;

< further survey/review (estimated cost $10,000) of potential properties in the high flow corridor for possible inclusion in a voluntary purchase scheme (nominal allowance $300,000)

< Further monitoring and assessment of any works proposed in the floodplain using the flood models developed during the Flood Study (nominal allowance of $10,000).

Timing and Funding

The total cost of implementing all the recommended measures is approximately $9.3M, plus additional expenditure for the CBD drainage improvements (subject to separate investigations) and for on-going maintenance of the creek corridors (subject to the outcome from the vegetation management plan).

The flood benefits of the project are estimated to be about $17.7M in a 100 year flood event, which represents a net present value of flood benefits (from all floods) of $7.4M, and an overall benefit/cost ratio of 0.8.

The timing of the proposed works will depend on Council's overall budgetary commitments and the availability of funds from other sources (eg State and Commonwealth flood mitigation funding and potential Section 94 contributions).

1. OVERVIEW

A number of works that attempt to modify flood behaviour have been considered in the Coffs Creek Floodplain Risk Management Study. Many of these measures were suggested by community members through either the Coffs Creek Working Party Meetings or the community questionnaire. Other measures were suggested by members from the Coffs Creek Project Team.

The measures considered, and recommendations from the study, are summarised in Table 1. Further information concerning the basis of these recommendations can be found in the Coffs Creek Floodplain Risk Management Study.

Further details concerning implementation of the recommended measures are provided in the remainder of this report. The recommended floodplain risk management plan for Coffs Creek is shown on Figure 1 and outlined in Table 3.

Table 1
Floodplain Management Recommendations

Description	Recommendation
1. Potential Works in the Lower Creek	
Widen Orlando Street and Railway Bridges	Not Recommended
Widen Grafton Street Bridge	Not Recommended
Dredge the lower estuary	Not Recommended
Dredge from the Ocean to Grafton Street	Not Recommended
Reduce the density of Mangroves between the Ocean and Grafton Street	Not Recommended
2. Potential Works in the Upper Catchment	
Bakers Road Basin	Recommended
Spagnolos Road Basin	Recommended
Bennetts Road Basin	Recommended
Upper Shephards Lane Basin	Recommended
3. Other Potential Works	
Ann Street Floodway	Recommended
Scarba Street Levee	Not Recommended
Gundagai Street Levee	Not Recommended
Adelines Way Levee	Not Recommended
Review Loaders Lane Levee	Recommended
CBD Drainage Improvements	Recommended
4. Catchment Wide Measures	
Zoning and Development Controls	Recommended
Flood Warning Measures	Not Recommended
Emergency Management Measures	Recommended
Flood Proofing Measures and Flood Action Plans	Recommended
Public Awareness	Recommended
Creek Maintenance	Recommended
Voluntary Purchase Schemes	Further Investigation
Voluntary House Raising Schemes	Not Recommended
Cumulative Development and Flood Model Review	Recommended

2. RECOMMENDED MEASURES

2.1 Construction of Upstream Detention Basins

Priority: *Various*
Estimated Cost: *$8.5M (4 basins)*
Maintenance Cost: *$20,000 per annum (4 basins)*

Detention basins act to temporarily store floodwater from the upper catchment areas during floods, releasing the water at a controlled rate. As a result, peak flows downstream of the basin sites are reduced and flood levels are lowered.

Four potential detention basin sites were identified in the upper catchment area, and investigated with a view to reducing downstream flood problems. The location of each site is shown on Figure 1. Preliminary layouts for each basin site are also included on Figures 4 to 7. A summary of the size, costs and benefits of each of the four basins is provided in Table 2.

TABLE 2
Basin Summary

Basin	Storage Volume	Area occupied by 100yr TWL				Costs $Mill	Benefits from Basin			B/C Ratio
		1A	2A	7A	Total		Houses	Comm. Bldgs	NPV $Mill	
Bakers Rd	270,000	-	5.0	7.1	12.1	$2.3	94	33	$3.8	1.7
Spagnolos Rd	150,000	6.9	-	0.7	7.6	$1.9	72	21	$2.5	1.3
Bennetts Rd	130,000	2.7	-	1.7	4.4	$2.1	79	23	$2.8	1.3
U. Shephards	100,000	-	1.6	0.8	2.4	$2.2	72	21	$2.5	1.1
ALL 4 Basins	650,000	9.6	6.6	10.3	26.5	$8.5	194	82	$7.2	0.8

All four basins have individual economic benefit/cost ratios greater than 1.0. There are no significant environmental concerns for any of the basins, particularly as no excavation within the basin site is proposed other than for the formation of the basin embankment, spillway and outlet works. Each of the basins provides attractive benefits and can be economically justified. The most attractive is the Bakers Road Basin, and the least attractive the Upper Shephards Lane Basin.

Should all four basins be constructed, then flood levels could reduce by up to 0.42m at Grafton Street. This would then reduce the number of houses flooded above floor level in the 100 year flood from 308 to 114, and the number of commercial/industrial buildings from 111 to 29. It is important to note that the benefits from each individual basin are not cumulative if more than one are constructed.

The total costs of constructing all four basins is estimated at $8.5M (includes $1.8M acquisition costs), with an estimated benefit/cost ratio of 0.8. Whilst the costs of constructing all four basins slightly outweigh the expected flood benefits, the number of houses and other buildings that benefit are increased. When social benefits are also accounted for, it is considered that this option is also attractive.

The proposed Pacific Highway Upgrade through the Coffs Creek catchment could impact on the Bennett's Road and Spagnolos Road basins. Joint planning is required to ensure that the proposed highway route does not unduly reduce the capacity of the proposed basins. There may even be some opportunity to incorporate the basin embankment within the proposed highway embankment, reducing construction costs of the basin and reduced highway costs through smaller culverts on these watercourses.

2.2 Ann Street Floodway Improvements

Priority: *Low*
Estimated Cost: *$200,000*
Maintenance Cost: *$2,000 per annum*

Previous flood mitigation works undertaken on Coffs Creek in the early 1990's included the excavation of several floodway benches on the inside of creek meanders to improve the waterway capacity and lower flood levels. A similar measure is recommended for the inside bend of a creek meander at the end of Ann Street, about 200m upstream of Grafton Street.

The proposal involves excavation to lower the inside bank of the creek by approximately 1m to form a defined floodway path. This would have the effect of lowering the 100 year flood level by up to 0.2m over a distance of several hundred metres upstream.

The proposal would help to reduce flooding problems experienced by homes in Moonee Street, Korff Street, and Eugourie Close. Whilst flood level reductions of up to 0.2m can be expected in the 100 year flood for up to 37 homes, only 5 of these would no longer be inundated in such a flood.

The estimated quantity of material to be excavated and removed is of the order of 3,000m^3. Removal of some vegetation, re-topsoiling, grassing and establishment of light vegetation is estimated to cost $200,000. The estimated net present value of flood benefits is $160,000, providing an economic benefit/cost ratio of 0.8.

2.3 Loaders Lane Levee Review

Priority: *High*
Estimated Cost: *$10,000*
Maintenance Cost: *Nil*

A levee was previously built behind Loaders Lane to reduce the frequency of flooding in this area. The levee surrounds the development on two sides, restricting floodwater spilling across the development from the upstream reach of the creek. Flooding is still possible, at a lower level, from the back-up of floodwater further downstream, at Shephards Lane.

It is normal practice to build such levees at the estimated 100 year flood level plus 0.5m freeboard. However, the levee was built prior to the Coffs Creek Flood Study Review [Webb McKeown, 2001], and it appears that the levee may actually be

providing a level of protection that is lower than originally intended. A review of survey data available for the floodplain management study indicates that the levee may be close to the revised 100 year flood level (with no freeboard).

It is recommended that the performance of this levee be further reviewed by undertaking a detailed survey along the crest of the levee, and investigating any opportunity to increase its height, if necessary. The estimated cost of the review is $10,000.

2.4 CBD Drainage Improvements

Priority: *On-going*
Estimated Cost: *Subject to separate investigations*
Maintenance Cost: *Nil*

The CBD suffered significant flooding in the 1996 flood. This was due to a combination of mainstream flood problems from the creek and also the failure of the stormwater drainage system above and through the CBD area to cater for local catchment runoff.

Flood mitigation measures considered in the upper catchment areas will help to reduce mainstream flooding problems from the creek, but will do little to alleviate stormwater flooding from the local catchment area above the CBD.

A strategy to alleviate stormwater flooding through the CBD has been investigated in a separate study [Coffs Harbour City Council, 1994]. The strategy was divided into three stages, which involve the construction of two basins in the local catchment area, drainage diversions and amplification of other drainage lines. The first two stages of the scheme are now complete with only the final stage of works remaining.

It is understood that Council is currently reviewing works for the final stage of the strategy, and that some fine-tuning of the original strategy is now under consideration. On completion of this review, it is recommended that works necessary to complete the CBD drainage strategy be incorporated in the Coffs Creek Floodplain Risk Management Plan. This will allow Council to prioritise these works against other proposed measures in the flood risk management plan, and to seek government funds for their implementation.

2.5 Planning & Development Controls

Priority: *High*
Estimated Cost: *Current Council responsibility*
Maintenance Cost: *Current Council responsibility*

Land use planning and development controls are key mechanisms by which Council can manage flood-affected areas within the Coffs Harbour study area. Such mechanisms will influence future development (and redevelopment) and therefore the benefits will accrue gradually over time. Without comprehensive floodplain planning, existing problems may be exacerbated and opportunities to reduce flood risks may be lost.

A review of flood related planning controls for Coffs Harbour was provided in the Coffs Creek Floodplain Risk Management Study. Specific amendments to existing planning controls were proposed, with recommendations that the planning controls be incorporated within a performance-based DCP (or alternatively an information sheet tied to relevant DCPs).

The proposed planning controls recognise that different parts of the floodplain are subject to different flood risks, and that development controls should consider both the flood risk of the area and the proposed landuse activity. For this purpose, the floodplain was divided into three flood risk areas: *High*, *Medium* or *Low*. These different risk areas are shown on Figures 2 and 3 for the Coffs Creek catchment.

The *high flood risk* area is where high flood damages, potential risk to life, or evacuation problems are anticipated, and where most development should be restricted with stringent development controls. The *medium flood risk* area is where there is still a significant risk of flood damage, but where these damages can be minimised by the application of appropriate development controls. The *low flood risk* area is that area above the 100 year flood, where the risk of damage is low and most land uses would normally be permitted.

In addition to the three flood risk areas, a high flow corridor has been delineated within the high risk area of the floodplain. This corridor conveys a significant proportion of the flood flow and where most development is clearly undesirable due to its high risks and its potential impact on flooding.

Specific planning recommendations include:

i). That the Coffs Harbour City Local Environmental Plan 2000 be amended in accordance with the recommendations provided at Appendix A;

ii). That Council gives force to discouraging building in the high flow corridor by utilising foreshore building line provisions embodied within its LEP, where the foreshore building line setback is not currently equal to or greater than the high flow corridor mapped as part of the Coffs Creek Floodplain Risk Management Study and Plan;

iii). Where the high flow corridor substantially affects individual allotments zoned for urban development, the zoning of these properties should be reviewed having regard to broader planning considerations. This review should take into consideration reduced flood extents and levels arising from the implementation of the recommended measures to reduce flooding (eg the recommended basin strategy);

iv). That Council replaces its current *"Floodplain Development and Management Policy"* and *"Floodprone Land Information Sheet"* with a new Flood Risk Management DCP, or alternatively a Floodprone Land Information Sheet, with objectives, performance standards and prescriptive controls as specified in Appendix B;

v). The West Coffs Information Sheet should be reviewed having regard to current flood levels and to assess the potential cumulative impacts of filling;

vi). That Council reviews all its current DCP's so as to provide consistent definitions of floodprone land (to that proposed within the LEP and information sheet), and to cross-reference to the new Floodprone Land Information Sheet where appropriate considerations in regard to flood risk management are relevant. Recommended definitions of relevant terms is provided in Appendix B;

vii). Consideration be given to the introduction of Section 94 Contributions Plans which relate primarily to providing direct or proportional funding from future urban development towards the implementation of the proposed Basin Strategy;

viii). That Council incorporates notations upon its Section 149(2) Certificates, consistent with the approach discussed above. That is, that Council advises where it has existing information identifying land to be subject to flooding (up to the PMF) and that controls in regard to different land uses depending upon the flood risk applicable to individual properties is available from Council. Advice should also be given that an absence of information regarding flood affectation is not a necessary indication of a property being flood-free, and further investigations are recommended;

ix). that Council makes available a system of providing flood certificates for residents on application, which could include information on estimated flood levels for individual properties.

2.6 Emergency Management Measures

Priority: *High*
Estimated Cost: *Council Staff Costs*
Maintenance Cost: *Council Staff Costs*

The State Emergency Service (SES) has formal responsibility for emergency management operations in response to flooding. Other organisations normally provide assistance, including the Bureau of Meteorology, Coffs Harbour City Council, Department of Infrastructure, Planning & Natural Resources, police, fire brigade, ambulance and community groups.

As many organisations have important roles to play, it is imperative that there is a clear understanding of the role and responsibilities of each organisation. This should be defined, agreed, understood and acted upon in a flood situation according to a predetermined flood action plan. The plan needs to be continually updated, as new information on flood behaviour becomes available and as lessons are learnt from other flood experiences.

Emergency management operations in relation to flooding, and other natural disasters, are outlined in the Coffs Harbour City Council DISPLAN.

The SES flood plan should be updated with additional flood information developed as part of the floodplain risk management study. This includes:

< mapping of the three flood risk areas;

- details of residential and other properties affected by flooding;
- details of inundation depths for houses and other buildings in a 100 year flood;
- other details from the flood damages database developed for Coffs Creek; and
- verification of existing SES flood intelligence information against results from the recent flood models.

It is also recommended that the SES flood plan be updated to clearly identify the responsibilities and response action to be taken when high rainfall intensities are recorded in the upper catchment, or when advice of severe thunderstorms is received from the Bureau of Meteorology.

The above details will assist the SES develop an improved Local Flood Plan for the Coffs Creek area, comprising preparedness measures, the conduct of response operations, and the coordination of immediate recovery measures. The Coffs Harbour Floodplain Management Committee would be an ideal group to help progress the development of the Local Flood Plan and to enlist the support of other authorities.

2.7 Flood Proofing Measures and Flood Action Plans

Priority: *Medium*
Estimated Cost: *Individual's expense*
Maintenance Cost *Nil*

Individual properties can be modified to reduce the impacts of flooding by the construction of flood retaining walls or mounds outside the building (similar to levees in function), waterproofing walls or by placing shutters across doors and other openings. This option could be considered for any flood affected building, but it is most effective for commercial premises where there is a high potential for flood damage, or other strata complexes that share a common entrance.

A further measure that could be considered as a supplement to flood proofing, or as a separate measure by itself, is the development of flood action plans for residents and business owners. These plans comprise instructions for people at individual properties telling them what they should do before, during and after a flood, where they should go and who they should contact if there is a flood. They can be developed for all types of properties, but are particularly well suited to strata complexes (eg units at Gundagai Place and Robin Street). The plans would be simple instructions, similar to those for fire emergencies or first aid, and would be posted at noticeable locations within the building.

Government funding is not usually available for such measures, and individual owners need to be encouraged to implement such measures wherever possible.

2.8 Public Awareness Program

Priority: *Various*
Estimated Cost: *$35,000*
Maintenance Cost *$ 1,000*

Raising and maintaining flood awareness will provide residents with an appreciation of the flood problem and what can be expected during floods. It will provide them with an opportunity to plan what to do to reduce potential flood damage and to avoid personal risk during future floods.

An awareness program, as outlined below, could be implemented for a very low cost. Approximate costs are $35,000 for its development and about $1,000 per annum to maintain.

Update Council's GIS

The update of Council's GIS computer-based system to include flood information contained in the flood damages database is recommended. This could include details of properties potentially affected by flooding, the estimated depth of inundation, and the flood hazard for each property. This will provide a valuable tool to facilitate the issue of Section 149 Certificates and/or flood certificates, and is also likely to be a valuable component in emergency management plans (eg prioritising flood evacuations).

Flood Certificates

The provision of flood certificates to residents within the catchment is recommended. The certificates would provide information on the likely depth of flooding at the property for a range of floods. The certificates could be appended to Section 149 Certificates; provided when requests for flood information are made; or provided to all owners, residents, and accommodation houses on a regular basis (say biannually). A sample flood certificate is provided on Figure 8. An information brochure could also accompany the certificate to provide additional explanation and other information to improve flood awareness.

Information Brochures

Preparation and distribution of an Information Sheet of flooding in the Coffs Creek catchment is recommended. The Information sheet could provide clarification of information contained on flood certificates, the 100 year flood and the 1996 flood. An SES flood awareness brochure could also be prepared and distributed.

Establishment of Flood Markers

The construction of one or more flood markers within the Coffs Creek floodplain is recommended. Flood markers can be constructed in parks, reserves or along low points in roads. An appropriate location for Coffs Creek is either adjacent to the creek in the Showground, or on one of the floodway berms upstream of Grafton Street (eg the proposed Ann Street floodway). The height of different probability floods could be shown, along with heights of previous flood events, such as the 1996 flood.

2.9 Creek Maintenance

Priority: *High*
Estimated Cost: *$50,000 (preparation of Vegetation Management Plan)*
Maintenance Cost *To be advised*

The removal and control of debris, weeds and exotic vegetation, such as willows, is an important consideration for Coffs Creek. It will help to reduce localised flood problems where the creek is congested, and will reduce the likelihood of culverts and bridges becoming blocked by debris during floods, which could further exacerbate flooding problems within Coffs Creek. This will also be a vital consideration upstream of proposed detention basins, which must incorporate debris control structures to eliminate the possibility of the basin outlets becoming blocked.

It is recommended that current and future creek maintenance be incorporated within an overall vegetation management plan for Coffs Creek. Such a plan would incorporate:

< the removal of exotic plant species from the creek corridor to improve the hydraulic function of the creek;

< rehabilitation of the creek corridor with endemic plant species that are tolerant of riverine conditions and do not result in an undesirable impediment to the flow of floodwaters;

< the creation of an environment which is sympathetic to the ecology of the creek and, in particular, fauna habitat;

< rehabilitation of the creek corridor to allow for access by the general community for recreation, education and maintenance; and

< ensuring that the potential for soil erosion and destabilisation of the creek banks is addressed by providing for the managed and staged rehabilitation of the creek.

The preparation of a vegetation management plan to provide detailed programs and guidelines for the rehabilitation of the riverine corridor within the study area is recommended. The management plan should include additional information, detailed specifications and a timetable/work program for the implementation of works within definable sections of the riverine corridor. It is critical that monitoring and maintenance be built into the process as part of an overall long-term strategy. The cost of preparing the vegetation management plan is $50,000. Implementation of the plan would be ongoing.

2.10 Voluntary Purchase Schemes

Priority: *Various*
Estimated Cost: *$310,000*
Maintenance Cost *$ 1,000*

Under a voluntary purchase scheme, Council would offer to purchase flood liable properties if and when they became available for purchase, subject to the availability of funds at the time. Voluntary purchase is not compulsory acquisition and affected property owners can expect to receive market values for their property.

Due to the high costs involved with voluntary purchase schemes, only those houses subject to extreme flood hazard are usually considered for voluntary purchase. The extreme flood hazard categorisation recognises the frequency and severity of flooding, the potential damages, the flow impedance of the development and the risk to life.

The mapping of the high flow corridor is based upon the product of flooding depth and velocity. It typically depicts areas of extreme flood hazard.

Although the high flow corridor covers a portion of a number of residential properties, most dwellings are located on that portion of the property outside the corridor, and therefore are of less concern. Notwithstanding, a preliminary review of the mapping indicates that at least one dwelling is within the high flow corridor.

It should be noted that the mapping of the high flow corridor is derived from the hydraulic model and limited topographic mapping over the catchment. As such the depicted boundary of the high flow corridor may need to be checked, particularly in flat areas or where the position of the boundary is critical. Therefore where the mapping indicates that a dwelling may be within the corridor, the actual ground levels should be verified by ground survey. If such survey verifies the adopted contour mapping and the extreme hazard categorisation, the dwelling would be eligible for inclusion in a voluntary purchase scheme.

It is recommended that a ground survey be undertaken for all dwellings shown to be within the high flow corridor and thereby establish a list of dwellings (if any) for inclusion in a voluntary purchase scheme. If more than one dwelling is listed, they should be ranked based upon the degree of hazard.

An indicative cost of the survey and associated investigations is $10,000. It is probable that one dwelling may be included in the scheme at an indicative cost of $300,000.

2.11 Cumulative Development and Flood Model Review

Priority: *High*
Estimated Cost: *$10,000*
Maintenance Cost *$ Nil*

The impact of new or recent development has been assessed in previous studies and reports, prepared as part of individual development proposals submitted to Council. The Coffs Creek Flood Study [Webb McKeown, 2001] also considered the impact of recent development by comparing estimated flood profiles for the 1996 flood under 1974 topographic conditions and under future conditions (based on development identified in the 1998 LEP zoning map). This comparison showed no discernible difference in flood levels for this flood.

It is understood that many of the assessments undertaken as part of various development proposals have been undertaken using relatively simple, steady-state hydraulic models, such as HEC-RAS. These models are satisfactory for analysing the conveyance of the existing and modified creek cross section to determine whether or not there will be any increase in upstream flood levels. However, they are

not suitable for assessing the potential increase in downstream flood levels, due to loss of flood storage from filling of the floodplain or by increasing the conveyance of the creek section. In these circumstances, fully dynamic flood models such as RUBICON, MIKE-11 or TUFLOW are required to properly assess the impact of the development on flood behaviour.

The Coffs Creek Flood Study [Webb McKeown, 2001] used the RUBICON flood model to assess flood behaviour and to assess the impact of development since 1974. Whilst this is considered to be a suitable model for this purpose, the assessment appears to be largely based on the increase in catchment flow from the developing catchment. It is uncertain whether the full extent of floodplain filling that has recently been undertaken, and could potentially occur under the LEP zone map, has been taken into consideration. The assessment was also based on a large flood (the 1996 flood) and more significant impacts could also be expected for smaller floods.

During 2004, Council commissioned Webb McKeown & Associates to undertake additional assessments of cumulative development using the RUBICON flood model. Results indicated that filling of the floodplain associated with the development of McCarthy Park Estate and Naranga Gardens has had a notable impact on the 20 year and 100 year flood levels in the vicinity of those developments [Webb McKeown, 2004a]. The maximum increase in flood levels was estimated at 0.18m (20 year flood) and 0.26m (100 year flood). Increases of 0.05 to 0.06m were also reported to persist over a distance of 1.7km downstream. Flood behaviour in this vicinity is relatively complex, being near the junction of two creeks and containing numerous overflow paths, and may in fact warrant a more detailed analysis using a fully 2-dimensional flood model. The impact of other recent development was noted as being no greater than about 0.01m.

It is understood that Council is in the process of liaising with the developers of these two areas to see whether compensatory flood mitigation measures can be implemented that will reduce the impact on flood levels.

Further monitoring and assessment of any works proposed in the floodplain is recommended. A nominal amount of $10,000 is recommended for any further review with the RUBICON flood model. Alternatively, consideration could be given to undertaking a more detailed flood assessment using a 2-dimensional flood model, particularly for the area between Robin Street and Loaders Lane where flood behaviour is relatively complex.

Table 3
Recommended Floodplain Risk Management Plan

Item	Description	Estimated Cost ($)		Funding Sources	Benefit/Cost	Priority
		Capital	Maintenance (pa)			
1	**Bakers Road Detention Basin** a) Detailed Design b) Land Acquisition/Easements c) Construction	 $50,000 $1,000,000 $1,300,000	 $5,000	 Council, DIPNR, S94 Contribution Council, DIPNR, S94 Contribution Council, DIPNR, S94 Contribution	1.7	 High High High
2	**Spagnolos Road Detention Basin** a) Detailed Design b) Land Acquisition/Easements c) Construction	 $50,000 $300,000 $1,600,000	 $5,000	 Council, DIPNR, S94 Contribution Council, DIPNR, S94 Contribution Council, DIPNR, S94 Contribution	1.3	 High High Medium
3	**Bennetts Road Detention Basin** a) Detailed Design b) Land Acquisition/Easements c) Construction	 $50,000 $200,000 $1,900,000	 $5,000	 Council, DIPNR, S94 Contribution Council, DIPNR, S94 Contribution Council, DIPNR, S94 Contribution	1.3	 High High Medium
4	**Upper Shephards Lane Detention Basin** a) Detailed Design b) Land Acquisition c) Construction	 $50,000 $300,000 $1,900,000	 $5,000	 Council, DIPNR, S94 Contribution Council, DIPNR, S94 Contribution Council, DIPNR, S94 Contribution	1.1	 High High High
5	**Ann Street Floodway Improvements** a) Design Drawings b) Floodway/Channel Improvements	 $10,000 $200,000	 $2,000	 Council, DIPNR Council, DIPNR	0.8	 Low Low
6	**Loaders Lane Levee Review** a) Survey & Review b) Upgrade if Appropriate	 $10,000 TBA		 Council, DIPNR Council, DIPNR	-	 High High
7	**CBD Drainage Improvements**	TBA		Council, DIPNR	TBA	On-going
8	**Planning & Development Controls**	Staff Costs		Current Council Responsibility	-	High
9	**Emergency Management Measures** a) Update Local Flood Plan	 Staff costs		 SES, Council	-	 High
10	**Flood Proofing/Flood Management** a) Encourage flood proofing measures b) Encourage development of flood action plans	 N/A N/A		 Individual owners	-	 Medium

TABLE 3 (Cont)
Recommended Floodplain Risk Management Plan

Item	Description	Estimated Cost ($)		Funding Sources	Benefit/Cost	Priority
		Capital	Maintenance (pa)			
11	**Public Awareness Program** a) Update Council GIS b) Issue Flood Certificates c) Information Sheet on Flooding d) SES Flood Awareness Brochure e) Construct one or more Flood Markers	 Staff Costs $5,000 $10,000 $10,000 $10,000	 $1,000	 Council Council Council, DIPNR SES, Council, DIPNR Council, DIPNR	-	 High Medium Medium Medium Low
12	**Creek Maintenance** a) Vegetation Management Plan b) On-going Creek Maintenance	 $50,000 TBA	 TBA	 Council, DIPNR Council, DIPNR, Volunteers, Other	-	 High Medium
13	**Voluntary Purchase Schemes** a) Survey/review potential properties b) Purchase Identified properties (~1)	 $10,000 $300,000	 $1,000	 Council, DIPNR	TBA	Medium
14	**Cumulative Development & Flood Model Review** (Review impacts with Flood Study Model)	 $10,000		 Council, DIPNR	-	High
	TOTAL	**$9,325,000***	**$24,000**	**Various**	**0.8**	

- Costs do not include CBD Drainage Improvements (subject to separate investigations) and on-going maintenance of creek corridors (subject to vegetation management plan)

3. FUNDING AND IMPLEMENTATION

3.1 Estimated Costs

The total cost of implementing the Coffs Creek Floodplain Risk Management Plan is approximately $9.3M. This amount does not include allowance for on-going CBD drainage improvements (subject to separate investigations) or on-going maintenance of the creek corridor, which is a likely outcome of the vegetation management plan.

The total cost allows for the construction of all four of the potential detention basins identified in the upper catchment. The availability of all four basin sites is still to be confirmed by Council. Should one or more of the basins prove impractical, due to land acquisition problems or other unforseen difficulties, then costs would be lowered.

Maintenance costs associated with the Plan are estimated to be approximately $24,000 per annum.

The estimated flood benefits of the project (excluding the CBD drainage improvements and creek maintenance) is estimated to be about $17.7M in a 100 year flood, and represents a net present value of flood benefits (from all floods) of approximately $7.4M. The Plan has an attractive benefit/cost ratio of 0.8.

3.2 Funding Sources

There are a variety of sources of potential funding that could be considered to implement the Coffs Creek Floodplain Risk Management Plan. These include:

< State and Commonwealth funding for flood risk management measures through the Department of Infrastructure, Planning & Natural Resources;

< Council funds;

< Section 94 Contributions from future development where a nexus can be established between that development and flooding.

< Volunteer labour (eg Community Groups or School Groups that may be able to assist in maintenance of the creek corridors or other flood awareness initiatives);

Council can expect to receive the majority of financial assistance through the Department of Infrastructure, Planning & Natural Resources. These funds are available to implement measures that contribute to reducing existing flood problems. Funding assistance is usually provided on a 1:1:1 basis (Commonwealth:State:Council). Special grant money may also be available in some cases.

Although much of the Plan may be eligible for Government assistance, funding can not be guaranteed. Government funds are allocated on an annual basis to competing projects throughout the State. Measures that receive Government funding must be of significant benefit to the community. Funding of investigation and design activities as well as any works and ongoing programs such as voluntary house raising, is normally available. Maintenance, however, is normally the responsibility of Council.

3.3 The Next Steps

The steps in progressing the floodplain management process are as follows:

< Council determines a program of works, based on overall priority, available Council funds and any other constraints;

< Council submits an application for funding assistance to the Department of Infrastructure, Planning & Natural Resources and negotiates other sources of funding;

< implementation of the Plan proceeds, as funds become available and in accordance with established priorities.

4. ON-GOING REVIEW OF PLAN

The Plan should be regarded as a dynamic instrument requiring review and modification over time. The catalyst for change could include new flood events and experiences, legislative change, alterations in the availability of funding, or changes to the area's planning strategies. In any event, a thorough review every five years is warranted to ensure the ongoing relevance of the Plan.

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6. GLOSSARY

Note that terms shown in bold are described elsewhere in this Glossary.

100 year flood	A **flood** that occurs on average once every 100 years. Also known as a 1% flood. See **annual exceedance probability (AEP)** and **average recurrence interval (ARI)**.
50 year flood	A **flood** that occurs on average once every 50 years. Also known as a 2% flood. See **annual exceedance probability (AEP)** and **average recurrence interval (ARI)**.
20 year flood	A **flood** that occurs on average once every 20 years. Also known as a 5% flood. See **annual exceedance probability (AEP)** and **average recurrence interval (ARI)**.
afflux	The increase in flood level upstream of a constriction of flood flows. A road culvert, a pipe or a narrowing of the stream channel could cause the constriction.
annual exceedance probability (AEP)	AEP (measured as a percentage) is a term used to describe **flood** size. AEP is the long-term probability between floods of a certain magnitude. For example, a 1% AEP flood is a **flood** that occurs on average once every 100 years. It is also referred to as the '100 year flood' or 1 in 100 year flood'. The terms **100 year flood**, **50 year flood**, **20 year flood** etc, have been used in this study. See also **average recurrence interval (ARI)**.
Australian Height Datum (AHD)	A common national plane of level approximately equivalent to the height above sea level. All **flood levels**, floor levels and ground levels in this study have been provided in metres AHD.
average annual damage (AAD)	Average annual damage is the average flood damage per year that would occur in a nominated development situation over a long period of time.
average recurrence interval (ARI)	ARI (measured in years) is a term used to describe **flood** size. It is a means of describing how likely a flood is to occur in a given year. For example, a 100 year ARI flood is a flood that occurs or is exceeded on average once every 100 years. The terms **100 year flood**, **50 year flood**, **20 year flood** etc, have been used in this study. See also **annual exceedance probability (AEP)**.
catchment	The land draining through the main stream, as well as tributary streams.
Development Control Plan (DCP)	A DCP is a plan prepared in accordance with Section 72 of the *Environmental Planning and Assessment Act, 1979* that provides detailed guidelines for the assessment of development applications.
DIPNR	Department of Infrastructure, Planning and Natural Resources. Now incorporates the floodplain management responsibilities of the former Department of Land and Water Conservation and the former Planning NSW.
discharge	The rate of flow of water measured in terms of volume per unit time, for example, **cubic metres per second (m^3/s)**. Discharge is different from the speed or **velocity** of flow, which is a measure of how fast the water is moving.

DLWC	Department of Land and Water Conservation. This was the name given to the Department of Water Resources (DWR), the Department of Conservation and Land Management (CALM) and flood sections of the Public Works Department (PWD) from May 1995. DLWC was incorporated into the Department of Infrastructure, Planning and Natural Resources (DIPNR) from 1 July 2003. DLWC has been used in this report, except for work and/or studies carried out by these departments prior to May 1995.
DUAP	The former Department of Urban Affairs and Planning (NSW). Previously the Department of Planning (NSW). Superseded by Planning NSW, which was incorporated into the Department of Infrastructure, Planning and Natural Resources from 1 July 2003.
DWR	The former Department of Water Resources. This department became a major component of the Department of Land and Water Conservation (DLWC) in May 1995.
ecologically sustainable development (ESD)	Using, conserving and enhancing natural resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be maintained or increased. A more detailed definition is included in the *Local Government Act 1993*.
effective warning time	The time available after receiving advice of an impending **flood** and before the floodwaters prevent appropriate flood response actions being undertaken. The **effective warning time** is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.
emergency management	A range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding.
EP&A Act	*Environmental Planning and Assessment Act, 1979*.
extreme flood	An estimate of the **probable maximum flood (PMF)**, which is the largest flood likely to occur.
flood	A relatively high stream flow that overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
flood awareness	An appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures.
flood hazard	The potential for damage to property or risk to persons during a **flood**. Flood hazard is a key tool used to determine flood severity and is used for assessing the suitability of future types of land use.
flood level	The height of the **flood** described either as a depth of water above a particular location (eg. 1m above a floor, yard or road) or as a depth of water related to a standard level such as **Australian Height Datum** (eg the flood level was 7.8m AHD). Terms also used include **flood stage** and **water level**.

flood liable land	Land susceptible to flooding up to the **probable maximum flood (PMF)**. Also called **flood prone land**. Note that the term flood liable land now covers the whole of the **floodplain**, not just that part below the **flood planning level**, as indicated in the superseded Floodplain Development Manual (NSW Government, 1986).
flood planning levels (FPLs)	The combination of flood levels and **freeboards** selected for planning purposes, as determined in **floodplain management studies** and incorporated in **floodplain management plans**. The concept of flood planning levels supersedes the designated flood or the flood standard used in earlier studies.
flood prone land	Land susceptible to flooding up to the **probable maximum flood (PMF**). Also called **flood liable land**.
flood proofing	A combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate damages during a **flood**.
flood stage	see **flood level**.
Flood Study	A study that investigates flood behaviour, including identification of flood extents, **flood levels** and flood velocities for a range of flood sizes.
floodplain	The area of land that is subject to inundation by floods up to and including the probable maximum flood event, that is, **flood prone land** or **flood liable land**.
Floodplain Risk Management Plan	The outcome of a **Floodplain Management Risk Study**.
Floodplain Risk Management Study	The current study. These studies are carried out in accordance with the *Floodplain Development Manual* (NSW Government, 2005) and assess options for minimising the danger to life and property during **floods**. These measures, referred to as 'floodplain management measures/options', aim to achieve an equitable balance between environmental, social, economic, financial and engineering considerations. The outcome of a Floodplain Risk Management Study is a **Floodplain Risk Management Plan**.
floodway	Those areas of the **floodplain** where a significant discharge of water occurs during **floods**. Floodways are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in **flood levels**.
flow	see **discharge**
foreshore building line	A line fixed by resolution of Council in respect of land fronting any bay, river, creek, lagoon, harbour or ocean, which provides a setback distance where buildings or other structures would normally be prohibited.
freeboard	A factor of safety expressed as the height above the **design flood level**. Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels across the **floodplain**, such and wave action, localised **hydraulic** behaviour and impacts that are specific event related, such as levee and embankment settlement, and other effects such as "greenhouse" and climate change.

high flood hazard	For a particular size **flood**, there would be a possible danger to personal safety, able-bodied adults would have difficulty wading to safety, evacuation by trucks would be difficult and there would be a potential for significant structural damage to buildings.
high flow corridor	The area of the **floodplain** where a significant **discharge** of water occurs during floods. Should the area within this boundary be fully or partially blocked, a significant redistribution of flood flows or increase in **flood levels** would occur. For this study, the high flow corridor has been defined as either the area within the normal creek banks, or where the product of depth and **velocity** exceeds 1.0 in a 100 year flood.
hydraulics	Term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and **velocity**.
hydrology	Term given to the study of the rainfall and runoff process; in particular, the evaluation of **peak discharges**, flow volumes and the derivation of hydrographs (graphs that show how the discharge or stage/flood level at any particular location varies with time during a flood).
km	kilometres. 1km = 1,000m = 0.62 miles.
km^2	square kilometres. $1km^2 = 1,000,000m^2 = 100ha \approx 250$ acres.
Local Environmental Plan (LEP)	A Local Environmental Plan is a plan prepared in accordance with the *Environmental Planning and Assessment Act*, 1979, that defines zones, permissible uses within those zones and specifies development standards and other special matters for consideration with regard to the use or development of land.
low flood hazard	For a particular size flood, able-bodied adults would generally have little difficulty wading and trucks could be used to evacuate people and their possessions should it be necessary.
m	metres. All units used in this report are metric.
m AHD	metres **Australian Height Datum (AHD)**.
m/s	metres per second. Unit used to describe the **velocity** of floodwaters. $10km/h \approx 2.8m/s$.
m^2	square metres. $1m^2 \approx 10.8$ square feet.
m^3/s	Cubic metres per second or 'cumecs'. A unit of measurement for creek flows or **discharges**. It the rate of flow of water measured in terms of volume per unit time.
merit approach	The principles of the merit approach are embodied in the *Floodplain Development Manual* (NSW Government, 2005) and weigh up social, economic, ecological and cultural impacts of land use options for different **flood prone** areas together with flood damage, **hazard** and behaviour implications, and environmental protection and well being of the State's rivers and **floodplains**.
MIKE-11	The software program used to develop a computer model that analyses the **hydraulics** of the waterways within a **catchment** and calculates water levels (flood levels) and flow **velocities**. Known as a hydraulic model.
mm	millimetres. 1m = 1,000mm

overland flow path	The path that floodwaters can follow if they leave the confines of the main flow channel. Overland flow paths can occur through private property or along roads. Floodwaters travelling along overland flow paths, often referred to as 'overland flows', may or may not re-enter the main channel from which they left — they may be diverted to another water course.
peak discharge	The maximum **flow** or **discharge** during a flood.
Planning NSW	Formerly the **Department of Urban Affairs and Planning (NSW)** and the Department of Planning (NSW), at present DIPNR (since 1 July 2003.
present value	In relation to flood damage, is the sum of all future flood damages that can be expected over a fixed period (usually 20 years) expressed as a cost in today's value.
probable maximum flood (PMF)	The largest flood likely to ever occur. The PMF defines the extent of **flood prone land** or **flood liable land**, that is, the **floodplain**. The extent, nature and potential consequences of flooding associated with the PMF event are addressed in the current study.
reliable access	During a **flood**, reliable access means the ability for people to safely evacuate an area subject to imminent flooding within **effective warning time**, having regard to the depth and **velocity** of floodwaters, the suitability of the evacuation route, and other relevant factors.
risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of this study, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
RORB	The software program used to develop a computer model that analyses the **hydrology** (rainfall–**runoff** processes) of the **catchment** and calculates hydrographs and **peak discharges**. Known as a hydrological model.
runoff	The amount of rainfall that ends up as flow in a stream, also known as rainfall excess.
SES	State Emergency Service of New South Wales.
stage–damage curve	A relationship between different water depths and the predicted flood damage at that depth.
velocity	the term used to describe the speed of floodwaters, usually in **m/s** (metres per second). 10km/h = 2.7m/s.
water level	see **flood level**.
water surface profile	A graph showing the height of the **flood** (**flood stage**, **water level** or **flood level**) at any given location along a watercourse at a particular time.

FIGURES