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Incorporating Ecological Enhancements into the Cooma Flood Mitigation Scheme

John Paul Bucinskas [1], Richard David Evans [2] and Neil Benning [3]

ABSTRACT: Historically, a poor understanding of flood behaviour has led to the existence of flood prone urban development. Local authorities are faced with the challenging task of reducing the impacts of flooding on this development. Traditionally flood mitigation works have been undertaken to reduce these flood impacts by increasing the hydraulic capacity of the stream channel with limited consideration given to ecological impacts.

The town of Cooma is located at the confluence of Cooma and Cooma Back Creeks and existing development in areas adjacent to the creeks is prone to flooding. To address this problem, Cooma-Monaro Shire Council has prepared a Floodplain Management Plan. The Plan aims to reduce the risks to existing development by, amongst other means, increasing the hydraulic capacity of the floodway and the construction of levees to contain floods up to the 5% Annual Exceedance Probability event. Council's Floodplain Management Committee has recently reviewed the balance of social, economic and ecological issues associated with the Floodplain Management Plan particularly with respect to the treatment of the low flow channel. As a result of this review, Council has decided to adopt natural channel design principals to enhance the ecological values of the low flow channel in preference to the initial hard lining proposal. This paper outlines the process and decision support tools used to balance the flood mitigation issue with the relevant social, economic and ecological issues for a major urban flood mitigation project.

MAIN POINTS:

- Urban floodplain management requires balancing social, economic and ecological issues in addition to the primary objective of reducing flood risk;
- A multi-objective assessment process is a useful decision support tool to facilitate a balance between social, economic and ecological issues;
- Ecological enhancements can be achieved in urban streams when preparing and implementing a Floodplain Management Plan;
- The Cooma Flood Mitigation Scheme provides a working example of incorporating natural channel design techniques into the treatment of the low flow channel as part of a major flood mitigation project.

1. INTRODUCTION

The town of Cooma is situated 400 kilometres to the south-west of Sydney at an elevation of 800 metres above sea level in the Southern Tablelands region of New South Wales. The location of the town is shown in Figure 1. The town has a population of about 8000. Since the foundation of the town, urban development adjacent to Cooma Creek and Cooma Back Creek has experienced flooding. Major floods occurred in 1956, 1961, 1969 and 1991 with extensive inundation of the business district and residential areas by high velocity floodwaters.

In 1993, Cooma-Monaro Council engaged the Snowy Mountains Engineering Corporation (SMEC) to complete the Cooma Floodplain Management Study (SMEC, 1994). This study provides a Floodplain Management Plan (FPMP) generally consistent with the intent of State Government's Flood Prone Land Policy as set out in the Floodplain Development Manual (NSW Government, 1986). The key elements of the FPMP include floodway enlargement, levees, a flood warning system, a comprehensive development control plan and a community awareness strategy.

Prior to implementing the structural components of the FPMP, the Cooma-Monaro Floodplain Management Committee (FPMC) decided to reassess the balance between the social, economic and ecological issues with particular respect to the treatment of the low flow channel. The original proposal, to hard line the low flow channel, was considered to be inconsistent with ecological sustainable development principals encouraged by relevant Government legislation and policies. A multi-criteria evaluation analysis was undertaken by the FPMC to facilitate consideration of these issues with alternative options. Reconsideration of the available treatment options resulted in a decision by Council to provide ecological enhancements to the low flow channel using natural channel design techniques

[1] NSW Department of Land & Water Conservation (DLWC), Telephone: (02) 4226 8174 Fax: (02) 4226 8592
PO Box 867, WOLLONGONG EAST NSW 2520 jbucinskas@dlwc.nsw.gov.au

[2] Snowy Mountains Engineering Corporation (SMEC) Telephone: (02) 6452 0222 Fax: (02) 6452 0390
220-226 Sharp Street, COOMA NSW 2630 richard.evans@smec.com.au

[3] NSW Department of Land & Water Conservation (DLWC) , Telephone: (02) 9895 5012 Fax: (02) 9895 5080
PO Box 3720, PARRAMATTA NSW 2124 nbenning@dlwc.nsw.gov.au

rather than the initial proposal to hard line the channel.

The next section of this paper discusses the floodplain management process in NSW as a background to the development of a FPMP for Cooma. In the subsequent section, the use of a multi-objective assessment analysis as a decision support tool to consider various stream treatment options in terms of balancing social, economic and ecological issues is discussed. The technical considerations formulating the design of the low flow channel is also outlined.

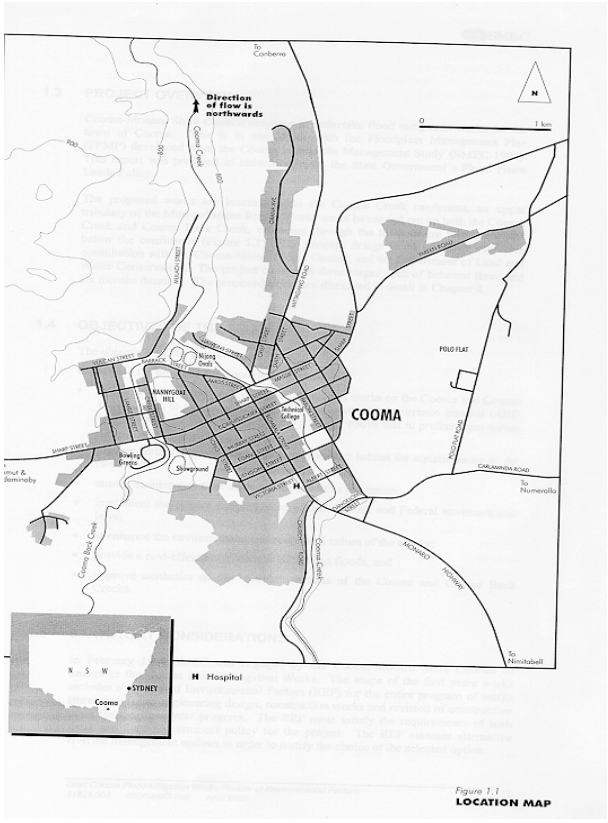

Figure 1 - Location Map for Cooma,
showing extent of urban development (SMEC, 1998)

2. THE DEVELOPMENT OF THE COOMA FLOODPLAIN MANAGEMENT PLAN

2.1 The NSW Floodplain Management Process

The floodplain management process in New South Wales is controlled by the Flood Prone Lands Policy (published in 1984) and detailed in the Floodplain Development Manual (NSW Government, 1986). A process is provided for Floodplain Management Committees to prepare and implement Floodplain Management Plans. A Flood Study is firstly completed which involves establishing hydrologic and hydraulic models to define the nature and extent of the flood problem. A Floodplain Management Study is then prepared which involves determining the optimum FPMP by assessing the full range of flood mitigation options. This includes flood modification, property modification and response modification measures.

The process ensures that solutions are technically sound and have provided for appropriate involvement of stakeholders including the community via the FPMC and consultation. The process also requires that consideration is provided to balance the floodplain management issues with the economic, social and ecological issues.

The NSW State Rivers and Estuaries Policy (SREP) seeks to encourage the sustainable management of riverine environments by promoting activities which rehabilitate degraded riverine environments and their biophysical functions (NSW Government, 1993). The policy is generally satisfied by a demonstrated consideration of a range of treatment options under the given constraints.

In urban environments where existing development is subject to flood risk, solutions to mitigate flood risk can come into conflict with the environmental issues. However, as will be demonstrated with Cooma, there are often opportunities for floodplain managers to promote solutions which seek to address flood risk but also incorporate ecological enhancements as part of the solution.

2.2 The Cooma Floodplain Management Plan

The FPMP for Cooma is documented in SMEC (1994). The flood modification component involves increasing the hydraulic capacity of the creek / floodway system including the construction of levees. Property and response modification measures include flood warning, response planning and development controls.

In March 1998, Cooma-Monaro Council commenced implementation of its FPMP with financial assistance from the State and Commonwealth Governments. The FPMC identified that there was a need to review the ecological issues associated with the FPMP, particularly the proposed treatment of the low flow channel. As with many streams in urban areas, the low flow channel was suffering from degradation with limited and inappropriate riparian vegetation, poor water quality and erosion contributing to a creek system with low ecological values. SMEC, (1994) also details the sedimentation problems at Cooma associated with upstream creek erosion and the impacts this has on flooding. The FPMP provides for the construction of sedimentation traps to address this problem.

The original FPMP (SMEC, 1994) proposed hard lining of the low flow channel with reno mattresses. Although adoption of this proposal may have contributed to improved channel stability, the FPMC recognised that this was not the only option and was not consistent with ecological sustainability principals being promoted by the Government. The FPMC therefore considered it appropriate to reconsider a wider range of treatment options for the low flow channel including those which would provide ecological benefits in addition to stability.

To facilitate consideration of these options the FPMC decided to undertake a multi-objective evaluation analysis. Using this approach the FPMC was satisfied that it could demonstrate that it has fulfilled its environmental obligations under various legislation and policies in addition to addressing its duty of care responsibilities in managing the prevailing flood risk.

3. MULTI-OBJECTIVE EVALUATION ANALYSIS

In order to facilitate consideration of social, economic and ecological issues in the development of floodplain management plans there is an increasing demand on floodplain managers to develop appropriate tools. Multi-objective evaluation analysis is one such tool and was utilised by the FPMC to balance the relevant issues to determine the optimum treatment of the low flow channel for the Cooma Flood Mitigation Scheme. The use of multi criteria evaluation processes is a widely accepted practice; its use in floodplain management is discussed in the NSW Floodplain Development Manual (NSW Government, 1986).

The assessment process for Cooma assumed that each option would have equivalent impacts on flood behaviour as the hydraulic impacts could be accommodated in the final design of the floodway.

3.1 Consideration of the Treatment Options

Five options were considered for the treatment of the low flow channel, as follows:

- **Option 1: Do Nothing**
  - No work on the low flow channel.
- **Option 2: Natural Channel Design (NCD)**
  - Enhance and introduce meanders
  - Enhance pools and riffles in low flow channel
  - Flood compatible native vegetation for ecological enhancements
  - Non-uniform 'natural' channel appearance
- **Option 3: NCD with protection**

Similar to Option 2 but includes:

  - Hard erosion protection such as rocks and geo-fabrics on much of the low flow channel, resulting in a more uniform appearance
- **Option 4: NCD with selected protection**

Similar to option 2 but includes:

  - No change in planform (ie. no meander enhancement)
  - Hard erosion protection (eg. rockfill) at susceptible erosion points (ie outside bends) only
- **Option 5: Engineered Channel – Reno Mattress**
  - No change in planform or in longitudinal section (ie. no meanders, pools or riffles)
  - Reno mattress (eg. rocks encased in mesh) used on low flow channel
  - Uniform channel appearance
  - No vegetation

3.2 Balancing the Issues

To facilitate clarification of the issues the broader social, economic and ecological issues were further sub-divided as follows:

Social Issues

- Aesthetics – the visual amenity of the option
- Community awareness & education – potential to encourage awareness of the environment and use for environmental education
- Safety to public
- Community acceptance – willingness of the community to accept the design
- Community involvement –willingness of the community to maintain the work

Economic Issues

- Construction & design costs – relative costs for each option
- Maintenance
  - Sediment removal – ease and amount of sediment removal
  - Vegetation – frequency of weeding, watering and plant replacement
  - Erosion works – estimated future remediation requirements
  - Monitoring – frequency and ease of monitoring the performance, eg. rates of erosion
- Longevity – how well the design will remain as designed in both the short and long term

Ecological Issues

- Biodiversity – enhancement to the aquatic, riparian and physical habitat
- Hydraulic diversity – simulation of natural stream flow variations
- Consistency with the NSW State Rivers and Estuaries Policy (SREP) – conforming to 'best management practice' for sustainability and restoration of biophysical functions
- Fish passage – continuity principals associated with ease of passage for aquatic organisms and fauna
- Future opportunities – potential to allow further enhancement works (ie ecological sustainability)

3.3 Completing the Evaluation

To obtain the most benefit from the evaluation, it was decided by the FPMC that Council, DLWC and SMEC would each carry out independent scoring and weighting of the treatment options for consideration by the committee. An example of a completed evaluation is

shown as Table 1. The scoring and weighting was undertaken as follows:

3.4 Scoring

Scores were assigned to the treatment options for each criteria using a simple rating system as follows:

Poor	Fair	Good	Very Good	Excellent
1	2	3	4	5

The rated scores were then entered into the matrix for each option against each issue. The best option for each issue could then be compared.

3.5 Weighting

It was decided by the committee to weight each of the criteria in order to achieve a balanced total score for each treatment option. The weightings were influenced by the following issues:

- Resources and funding available for implementation
- Minimisation of long term maintenance requirements of the low flow channel.
- Longevity of the design and the need for potential future remediation
- The current condition of the low flow channel
- Potential impacts of the channel on other components of the flood mitigation scheme including levees and residential / commercial properties and assets
- Council's responsibility to the community and the environment
- Desires and expectations of the community
- Concurrence with State and Commonwealth policies and legislation
- Environmental approvals and conditions of funding

Each of the criteria were assigned a weighting, with the total equalling 100%. For Cooma, the committee set weightings for the broader criteria as social 25%, economic 50% and ecological 25%. The high relative weighting of economic issues reflects the importance placed on this issue by the committee. The evaluations by SMEC, DLWC and Council involved independent scoring and weighting of the sub-criteria.

3.6 Final Scores

The total score for each option was obtained by adding each score multiplied by its respective weighting. The final scores were included to promote discussion within the FPMC on the various issues and was not used as the sole basis for decision making. The process of scoring each of the criteria and providing a relative weighting allowed the FPMC to evaluate the relative merit of each of the criteria with respect to each option.

It should be noted that the independent assessments undertaken, generally led to a preference to option 4 in terms of the final score. The independent assessments also provided a means to test the sensitivity of the approach. By comparing the options for each issue, it became clear that the hard engineered solution was preferred on economic grounds but rated extremely poorly on the social and economic issues. Although Option 4 did not score extremely highly on any one particular issue, it had the highest overall score implying that it generally satisfied all the criteria. Following discussions and variations to the scores and weights by the FPMC Option 4 was subsequently adopted as the preferred option. The FPMC considered that this option provided the best overall balance of the issues.

3.7 Discussion

The multi-objective evaluation matrix was found by the FPMC to assist in rationalising the decision making process. On this project, its use was intended to provide a clear basis for discussion rather than pointing to the optimum treatment solution. It proved very useful to the FPMC, a committee largely made up of 'non-technical' members including Councillors and the community. The breakdown, scoring and weighting process assisted in the explanation of the advantages and disadvantages of each option. The multi-criteria evaluation process provides a quick and clearly documented basis to promote discussion and encourage considerations to balance all of the relative issues in an objective manner.

The committee had to ultimately make a considered decision. The matrix approach was not used in Cooma to make the decision, but it did provide a simple framework for identifying and organising the issues in conflict and the trade-offs. It is believed however, that had the FPMC been unable to resolve the decision through the discussion of issues, the weighted multi-objective matrix could have been used by all of the committee members to determine the decision. This would resolve the conflicts usually associated with such matters when they are forced to go to a vote.

4. NATURAL CHANNEL DESIGN CONSIDERATIONS

4.1 General

Natural channel design essentially involves integrating the hydraulic conveyance requirements of a stream with the ecological requirements. The natural channel design philosophy has grown in prominence in recent years and involves restoring the natural biophysical functions of the stream as part of the stabilisation process. It is generally a multi-disciplinary approach integrating river engineering (hydrology, hydraulics and design), fluvial geomorphology and riparian ecology. It usually involves using natural materials to restore channel stability and maximising opportunities for habitat

enhancement. The overriding intent is to achieve ecological sustainability with due consideration to the active hydraulic and geomorphic processes.

The philosophy is inherent in most recent publications on stream management. This paper does not attempt to comprehensively detail natural channel design processes. However some useful references for further reading include Newbury and Gaboury (1993), EPA (1996), Raine and Gardiner (1995) and ID&A (1996).

4.2 Overview of the Design Process in Cooma

The existing low flow channels of Cooma and Cooma Back Creeks are generally in a poor state of repair and suffering from erosion. The channel is sparse of appropriate riparian vegetation and the low flow channel has very few pools remaining, providing little habitat for terrestrial and aquatic fauna.

The existing creek system has undergone various modifications as part of the development of the town including channel and floodway modifications and the removal of vegetation. Other issues in Cooma include siltation resulting from erosion of the upstream creeks and catchment.

The FPMP identified that it was only feasible to provide protection up to the 5% Annual Exceedance Probability (AEP) event (or the 1 in 20 year Average Recurrent Interval (ARI)) to existing flood liable development in Cooma. The flood modification component of the Flood Mitigation Scheme therefore involves formalising the "floodway" to ensure a 1 in 20 year ARI capacity with a 0.5 metre freeboard.

The design of the low channel was undertaken by SMEC using the guidelines set out in Newbury and Gaboury (1993). Consideration had to be made to the high tractive stresses in the existing stream. These high stresses are primarily attributed to the steep gradient of the creeks. In some sections, floodwater velocities exceed 3 m/s for the 1 in 20 year ARI flood event.

The location of riffles was controlled by ensuring that they are located primarily on meander inflection points and have been spaced approximately 6-8 times the channel width.

4.3 The Final Design

The current Cooma Flood Mitigation Scheme will achieve ecological enhancements to the creek channel by the construction of a natural low flow channel in preference to hard lining. The construction of riffles in the low flow channel will contribute to increased bed and bank stability by providing grade control. The proposed pool / riffle sequence will provide hydraulic diversity to the low flow channel for in-stream habitat. The banks of the channel will be revegetated with native "flood compatible" vegetation for environmental enhancements and to ensure that the flood mitigation benefits of the overall scheme are achieved. This vegetation will primarily consist of smaller native plants and shrubs but will enhance the stability, habitat, shade and food sources for native fauna. It is envisaged that the riverine enhancement / flood mitigation works will provide an environmental and recreational feature to the town.

5. CONCLUSIONS

Although urban stream management often presents a complex range of issues, particularly when existing adjoining development is flood prone, there is still scope to provide ecological enhancements into flood mitigation schemes. The case study described for the Cooma Flood Mitigation Scheme details both the decision making framework and the design considerations to implement an environmentally sound solution to an urban flooding problem.

The NSW floodplain management process provides a mechanism for local government to facilitate a balance between flood risk reduction and social, economic and ecological issues. The multi-objective evaluation process discussed in this paper demonstrates that tools are available to floodplain managers to facilitate considerations in balancing the pertinent issues.

The intent of the Government's policies is to incorporate ecological sustainable solutions to river and floodplain management problems. The case study presented in this paper demonstrates that environmental enhancements can be incorporated into flood mitigation schemes particularly when the issues are tabled and discussed by all relevant stakeholders.

This project provides a working example to floodplain managers of how to optimise environmental outcomes when balancing the social, economic and ecological issues in the management of flood risk.

6. REFERENCES

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Table 1: Multi-Criteria Evaluation of Options
for the Treatment of the Low Flow Channel as part of the
Cooma Flood Mitigation Scheme
- Copy of Evaluation by SMEC

CRITERIA	OPTION 1 Do Nothing	OPTION 2 Natural Channel Design (NCD)	OPTION 3 NCD with protection (pools/riffles and meanders)	OPTION 4 NCD with selected protection (pools/riffles no meanders)	OPTION 5 Engineered Channel (reno mattress)	WEIGHTING
SOCIAL						
Aesthetics	3	5	4	3	1	7%
Community awareness/education	1	5	5	1	1	4%
Safety to public	3	2	2	3	4	7%
Community Acceptance	2	4	3	4	3	5%
Community Involvement	2	5	4	3	1	2%
ECONOMIC						**25%**
Construction and design cost	5	3	2	4	2	10%
Maintenance						
sediment removal	1	1	1	2	4	10%
vegetation	3	1	1	2	5	8%
erosion works	3	1	3	4	5	5%
monitoring	3	1	2	3	5	2%
Longevity						
short term	3	1	4	4	5	8%
long term	3	2	3	4	4	7%
ECOLOGICAL						**50%**
Biodiversity (habitat)	2	5	5	3	1	7%
Hydraulic diversity	2	4	4	3	1	5%
Consistent with SREP	2	4	4	3	1	5%
Fish passage	1	3	3	2	1	5%
Future opportunities	4	5	4	3	1	3%
						25%
TOTALS	**2.61**	**2.81**	**2.97**	**3.04**	**2.84**	