Kangaroo Valley

Floodplain Risk Management Plan

W4960

Prepared for
Shoalhaven City Council

April 2016

Shoalhaven City Council

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Executive Summary

Cardno were commissioned by Shoalhaven City Council to undertake the Floodplain Risk Management Study and Plan for Kangaroo Valley. This document forms the Floodplain Risk Management Plan, and should be read in conjunction with the Floodplain Risk Management Study (Cardno, 2015).

Flooding in Kangaroo Valley can pose a hazard to some residents and properties near rivers, creeks and overland flowpaths. The purpose of this study is to identify and examine options for the management of flooding and make recommendations for actions to be adopted as part of the Floodplain Risk Management Plan.

The land use of the catchment is predominately forest and pasture, with isolated areas of urban development. The terrain is varied; steep ranges surround the catchment on the northern, eastern and southern sides, formed by the eastern escarpment. In the centre of these ranges are open alluvial flats.

The township is located on the southern side of the Kangaroo River, with most development located on the high ground at the foot of the adjacent ranges. Commercial areas are predominately along Moss Vale Road, with residential properties located on the hills to the south. A number of dairy farms are located across the central alluvial plain.

Flooding in the study are is primarily driven by the Kangaroo River and Barrengarry Creek, with local creeks causing some overland flows and nuisance flooding.

The township has experienced historical flooding, with significant events occurring in 2005, 1999, 1991, 1990, 1978 and 1975. Roads have been reported cut during flood events, in some instances by depths of over 2m.

Full details of the flood behaviour of the catchment can be sourced from the Kangaroo Valley Floodplain Risk Management Study (Cardno, 2014).

An assessment was undertaken on the number of properties to be affected under different frequency storm events and the appropriate economic damage for that event. The following table summarises these results.

Table i Flood affected properties and damages under existing conditions

Flood Event	Properties with Over-floor Flooding	Properties with Over-ground Flooding	Flood Damage
PMF	115	94	$26,827,083
0.5% AEP	54	36	$7,091,455
1% AEP	34	31	$4,317,781
2% AEP	14	21	$1,805,705
10% AEP	-	-	-
20% AEP	-	-	-
Average Annual Damage			$216,165

The Floodplain Risk Management Study investigated what could be done to reduce or manage the effects of flooding in the catchment, and recommended a mix of strategies to manage the risks of flooding.

Under the merits-based approach advocated in the NSW State Government's Floodplain Development Manual (NSW Government, 2005), and in consultation with the community, Council and state agency stakeholders, a number of potential options for the management of flooding were identified.

These options included:

- Flood modification measures
- Property modification measures
- Emergency response measures

An extensive list of options was assessed against a range of criteria (technical, economic, environmental and social). The assessment found, of the options investigated (including flood, property and emergency measures), the top three identified by the multi-criteria analysis were:

1. P 3 Building and Development Control Plans
2. EM 4 Public Awareness and Education
3. EM 3 Flood Warning System

Of the structural options assessed, the top option identified by the multi-criteria analysis was:

- FM1.3 Caravan Park Levee

Property modification measures considered and recommended for the floodplain include:

- P3 Building and development control plans
- P7 Flood proofing

Emergency response modifications for the floodplain include:

- EM 1 Information transfer to SES
- EM 2 Flood warning system
- EM 3 Public awareness and education
- EM 4 Flood warning signs at critical locations

Data collection strategies proposed for the floodplain include:

- DC 1 Data collection following a flood event

The above listed flood, emergency and property modification measures ranked highly using a multi-criteria matrix assessment and have been selected for inclusion in the Draft Floodplain Risk Management Plan.

Those options selected for inclusion in the Draft Plan are based upon both their likely benefit and the funding available from Council and the State Government.

Based on the multi-criteria assessment of the options, the cost of implementing the Plan for the existing catchment would be an estimated capital cost of approximately $566,700 and an annual recurrent cost of approximately $23,700.

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Glossary

Annual Exceedence Probability (AEP)	Refers to the probability or risk of a flood of a given size occurring or being exceeded in any given year. A 90% AEP flood has a high probability of occurring or being exceeded each year; it would occur quite often and would be relatively small. A 1%AEP flood has a low probability of occurrence or being exceeded each year; it would be fairly rare but it would be relatively large.
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Average Recurrence Interval (ARI)	The average or expected value of the periods between exceedances of a given rainfall total accumulated over a given duration. It is implicit in this definition that periods between exceedances are generally random
Cadastre, cadastral base	Information in map or digital form showing the extent and usage of land, including streets, lot boundaries, water courses etc.
Catchment	The area draining to a site. It always relates to a particular location and may include the catchments of tributary streams as well as the main stream.
Creek Rehabilitation	Rehabilitating the natural 'biophysical' (i.e. geomorphic and ecological) functions of the creek.
Design flood	A significant event to be considered in the design process; various works within the floodplain may have different design events. E.g. some roads may be designed to be overtopped in the 1 in 1 year or 100%AEP flood event.
Development	The erection of a building or the carrying out of work; or the use of land or of a building or work; or the subdivision of land.
Discharge	The rate of flow of water measured in terms of volume over time. It is to be distinguished from the speed or velocity of flow, which is a measure of how fast the water is moving rather than how much is moving.
Flash flooding	Flooding which is sudden and often unexpected because it is caused by sudden local heavy rainfall or rainfall in another area. Often defined as flooding which occurs within 6 hours of the rain which causes it.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or overland runoff before entering a watercourse and/or coastal inundation resulting from super elevated sea levels and/or waves overtopping coastline defences.
Flood fringe	The remaining area of flood-prone land after floodway and flood storage areas have been defined.

Flood hazard	Potential risk to life and limb caused by flooding.
Flood-prone land	Land susceptible to inundation by the probable maximum flood (PMF) event, i.e. the maximum extent of flood liable land. Floodplain Risk Management Plans encompass all flood-prone land, rather than being restricted to land subject to designated flood events.
Floodplain	Area of land which is subject to inundation by floods up to the probable maximum flood event, i.e. flood prone land.
Floodplain management measures	The full range of techniques available to floodplain managers.
Floodplain management options	The measures which might be feasible for the management of a particular area.
Flood planning area	The area of land below the flood planning level and thus subject to flood related development controls.
Flood planning levels	Flood levels selected for planning purposes, as determined in floodplain management studies and incorporated in floodplain management plans. Selection should be based on an understanding of the full range of flood behaviour and the associated flood risk. It should also take into account the social, economic and ecological consequences associated with floods of different severities. Different FPLs may be appropriate for different categories of land use and for different flood plains. The concept of FPLs supersedes the "Standard flood event" of the first edition of the Manual. As FPLs do not necessarily extend to the limits of flood prone land (as defined by the probable maximum flood), floodplain management plans may apply to flood prone land beyond the defined FPLs.
Flood storages	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood.
Floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often, but not always, aligned with naturally defined channels. Floodways are areas which, even if only partially blocked, would cause a significant redistribution of flood flow, or significant increase in flood levels. Floodways are often, but not necessarily, areas of deeper flow or areas where higher velocities occur. As for flood storage areas, the extent and behaviour of floodways may change with flood severity. Areas that are benign for small floods may cater for much greater and more hazardous flows during larger floods. Hence, it is necessary to investigate a range of flood sizes before adopting a design flood event to define floodway areas.
Geographical Information Systems (GIS)	A system of software and procedures designed to support the management, manipulation, analysis and display of spatially referenced data.
High hazard	Flood conditions that pose a possible danger to personal safety; evacuation by trucks difficult; able-bodied adults would have difficulty wading to safety; potential for significant structural damage to buildings.

Hydraulics	The term given to the study of water flow in a river, channel or pipe, in particular, the evaluation of flow parameters such as stage and velocity.
Hydrograph	A graph that shows how the discharge changes with time at any particular location.
Hydrology	The term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs for given floods.
Low hazard	Flood conditions such that should it be necessary, people and their possessions could be evacuated by trucks; able-bodied adults would have little difficulty wading to safety.
Mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of the principal watercourses in a catchment. Mainstream flooding generally excludes watercourses constructed with pipes or artificial channels considered as stormwater channels.
Management plan	A document including, as appropriate, both written and diagrammatic information describing how a particular area of land is to be used and managed to achieve defined objectives. It may also include description and discussion of various issues, special features and values of the area, the specific management measures which are to apply and the means and timing by which the plan will be implemented.
Mathematical/computer models	The mathematical representation of the physical processes involved in runoff and stream flow. These models are often run on computers due to the complexity of the mathematical relationships. In this report, the models referred to are mainly involved with rainfall, runoff, pipe and overland stream flow.
Overland Flow	The term overland flow is used interchangeably in this report with “flooding”.
Peak discharge	The maximum discharge occurring during a flood event.
Probable maximum flood	The flood calculated to be the maximum that is likely to occur.
Probability	A statistical measure of the expected frequency or occurrence of flooding. For a fuller explanation see Annual Exceedance Probability.
Risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. For this study, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
Runoff	The amount of rainfall that actually ends up as stream or pipe flow, also known as rainfall excess.
Stage	Equivalent to 'water level'. Both are measured with reference to a specified datum.
Stage hydrograph	A graph that shows how the water level changes with time. It must be referenced to a particular location and datum.

Stormwater flooding	Inundation by local runoff. Stormwater flooding can be caused by local runoff exceeding the capacity of an urban stormwater drainage system or by the backwater effects of mainstream flooding causing the urban stormwater drainage system to overflow.
Topography	A surface which defines the ground level of a chosen area.

* Terminology in this Glossary have been derived or adapted from the NSW Government Floodplain Development Manual, 2005, where available.

Abbreviations

AAD	Average Annual Damage
AEP	Annual Exceedance Probability
ARI	Average Recurrence Intervals
BoM	Bureau of Meteorology
DCP	Development Control Plan
FPL	Flood Planning Levels
FRMP	Floodplain Risk Management Plan
FRMS	Floodplain Risk Management Study
GIS	Geographic Information System
ha	Hectare
IFD	Intensity Frequency Duration
km	Kilometres
km^2	Square kilometres
LEP	Local Environment Plan
LGA	Local Government Area
m	Metre
m^2	Square metre
m^3	Cubic Metre
mAHD	Metres to Australian Height Datum
mm	Millimetre
m/s	Metres per second
NSW	New South Wales
OEH	Office of Environment & Heritage
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
SES	State Emergency Service

1 Introduction

Cardno were commissioned by Shoalhaven City Council to undertake the Floodplain Risk Management Study and Plan for the Kangaroo Valley catchment.

The study has been undertaken to define the existing flooding behaviour and associated hazards of the study area, and to investigate possible mitigation options to reduce flood damage and risk. The tasks were undertaken alongside community consultation to ensure that community concerns were addressed.

This report details the flood damages assessment, the environmental, social and policy review, and the investigations undertaken into potential flood mitigation options. The findings of this report will be incorporated into the subsequent Floodplain Risk Management Study and Plan.

1.1 Study Context

The NSW Floodplain Management process progresses through 6 steps in an iterative process:

1. Formation of a Floodplain Management Committee
2. Data Collection
3. Flood Study
4. Floodplain Risk Management Study
5. Floodplain Risk Management Plan
6. Implementation of the Overland Flow / Floodplain Risk Management Plan

This document addresses aspects of Stage 4 of the process.

1.2 Study Objectives

The overall objective of this study is to develop a Floodplain Risk Management Study where management issues are assessed, management options are investigated, and recommendations are made and a Floodplain Flood Risk Management Plan developed detailing how flood prone land within the study area is to be managed.

The specific objectives of the Floodplain Risk Management Plan are:

- Describe an appropriate mix of measures that addresses existing, future and continuing flood risks
- To protect and where possible enhance the creek and floodplain environment.
- To be consistent with the objectives of relevant State policies, in particular, the Government's Flood Prone Lands and State Rivers and Estuaries Policies, and to satisfy the objectives and requirements of the Environmental Planning and Assessment Act, 1979.

- To integrate the floodplain risk management plan with the local emergency management plan (flood plan), other relevant catchment management plans, Council's existing corporate, business and strategic plans, existing and proposed environmental planning instruments and policies, and to meet Council's obligations under the Local Government Act, 1993.
- To have the support of the local community.
- To ensure actions arising out of the management plan are sustainable in social, environmental, ecological and economic terms, including the timely adaptation to climate change impacts as they manifest.
- To establish a program for implementation that should include priorities, staging, responsibilities, funding mechanism, constraints and monitoring.

2 Existing Flood Behaviour

The following provides an overview of the existing flooding behaviour within the Kangaroo Valley region. A more detailed assessment can be found in the Floodplain Risk Management Study (Cardno, 2014).

2.1 Background

The Kangaroo River is a tributary of the Shoalhaven River, on the south coast of New South Wales. The river originates from within the Budderoo National Park, from where it flows across the western escarpment, through the township of Kangaroo Valley, and discharges into Lake Yarrunga. Lake Yarrunga is formed by Tallowa Dam, constructed immediately downstream of the confluence of the Kangaroo River and the Shoalhaven River.

The land use of the catchment is predominately forest and pasture, with isolated areas of urban development. The terrain is varied; steep ranges surround the catchment on the northern, eastern and southern sides, formed by the eastern escarpment. In the centre of these ranges are open alluvial flats.

The study area of the Kangaroo Valley Floodplain Risk Management Study and Plan is located mid-way along the Kangaroo River on the central flats, comprising the area of the Kangaroo Valley Township and surrounds.

The township of Kangaroo Valley is located on the southern side of Kangaroo River. The main road, Moss Vale Road, crosses the Kangaroo River at Hampden Bridge, west of the township.

The township is located on the southern side of the Kangaroo River, with most development located on the high ground at the foot of the adjacent ranges. Commercial areas are predominately along Moss Vale Road, with residential properties located on the hills to the south. A number of dairy farms are located across the central alluvial plain.

The township has experienced historical flooding, with significant events occurring in 2005, 1999, 1991, 1990, 1978 and 1975. Roads have been reported cut during flood events, in some instances by depths of over 2m.

2.2 Revision of Flood Study

A flood study was previously undertaken that identified the flood behaviour in the study area (SMEC, 2009). An update has subsequently been undertaken in this study as part of the Floodplain Risk Management Study (Cardno, 2014) to improve the definition of the flood behaviour in the Kangaroo Valley Township.

Information from the updated flood study was applied to assess potential flood management measures as detailed in the Floodplain Risk Management Report.

2.3 Flood Behaviour

Peak flood depths modelled in the study area are shown in **Figure 2.1** and **Figure 2.2** for the 10% AEP event and the 1% AEP event respectively. A full presentation and discussion on the existing flood behaviour is in the Floodplain Risk Management Study Report.

2.4 Damage Analysis

A flood damage assessment for the existing catchment conditions and several flood management options has been completed and is detailed in the Floodplain Risk Management Study.

The results from the damage analysis are shown in **Table 2.1**. Based on the analysis described in the Floodplain Risk Management Study, the average annual damage for the Kangaroo Valley Township under existing conditions is $216,165.

Table 2-1 Kangaroo Valley Existing Damage Analysis Results

	Properties with overfloor flooding	Average Overfloor Flooding Depth (m)	Maximum Overfloor Flooding Depth (m)	Properties with overground flooding	Total Damages ($Sep 2013)
PMF					
Residential	66	5.24	9.80	71	$ 12,045,634
Commercial	23	2.53	6.56	23	$ 11,921,448
Caravan Park	26	6.53	8.11	0	$ 2,860,000
PMF Total	115			94	$ 26,827,083
200 Year ARI					
Residential	31	2.24	3.88	34	$ 4,496,052
Commercial	2	1.02	0.74	2	$ 296,403
Caravan Park	21	1.13	2.31	0	$ 2,299,000
0.5% AEP Total	54			36	$ 7,091,455
100 Year ARI					
Residential	22	1.19	2.97	29	$ 3,097,781
Commercial	0			2	$ -
Caravan Park	12	0.95	1.46	0	$ 1,220,000
1% AEP Total	34			31	$ 4,317,781
50 Year ARI					
Residential	12	0.81	2.00	20	$ 1,684,705
Commercial	0			1	$ -
Caravan Park	2	0.56	0.58	0	$ 121,000
2% AEP Total	14			21	$ 1,805,705
10 Year ARI					
Residential	0			0	$ -
Commercial	0			0	$ -
Caravan Park	0			0	$ -
10% AEP	0			0	$ -
5 Year ARI					
Residential	0			0	$ -
Commercial	0			0	$ -
Caravan Park	0			0	$ -
20% AEP Total	0			0	$ -

3 Floodplain Risk Management Options

Flood risk can be categorised as existing, future or residual risk:

- **Existing Flood Risk** – existing buildings and developments on flood prone land. Such buildings and developments by virtue of their presence and location are exposed to an 'existing' risk of flooding
- **Future Flood Risk** – buildings and developments that may be built on flood prone land, or on land that may become flood affected in the future. Such buildings and developments would be exposed to a flood risk when they are built
- **Residual Flood Risk** – buildings and development that would be at risk if a flood were to exceed management measures already in place. Unless a floodplain management measure is designed to withstand the PMF, it will be exceeded by a sufficiently large event at some time in the future.

The alternate approaches to managing risk are outlined in **Table 3-1**.

Table 3-1 Flood Risk Management Alternatives (SCARM, 2000)

Alternative	Examples
Preventing / Avoiding risk	Appropriate development within the flood extent, setting suitable planning levels
Reducing likelihood of risk	Structural measures to reduce flooding risk such as drainage augmentation, levees, and detention
Reducing consequences of risk	Development controls to ensure structures are built to withstand flooding
Transferring risk	Via insurance – may be applicable in some areas depending on insurer
Financing risk	Natural disaster funding
Accepting risk	Accepting the risk of flooding as a consequence of having the structure where it is

A range of options were considered as part of the floodplain risk management plan. These are discussed in detail in the Floodplain Risk Management Study, and are summarised below.

3.1 Flood Modification Measures

Flood modification measures are structural options aimed at preventing, avoiding or reducing the likelihood of flood risks. The options are discussed in detail in the Floodplain Risk Management Study, and are summarised in **Table 3-2**. Additional options were also assessed, but they were found not to be suitable for the Kangaroo Valley study area.

3.2 Property Modification Options

A number of property modification options were identified for consideration in the floodplain, and these are summarised in **Table 3-3**. Additional options were also assessed, but they were found to not provide benefits to the Kangaroo Valley study area.

3.3 Emergency Response Modification Options

A number of emergency response modification options are suitable for consideration within the floodplain. These are summarised below in **Table 3-4**.

3.4 Data Collection

In addition to the options discussed above, a data collection strategy is also proposed. This would involve the collection of relevant data such as survey of flood marks and records of property flooding, following a flood event. This data could then be analysed to develop further information about flooding behaviour in the catchment.

Table 3-2 Structural Mitigation Options

Option ID	Option	Option Outline
FM 1.3	Caravan Park Levee	Construction of a levee around the caravan park to the 1% AEP level
FM 2.1	Town Creek Detention Basin	Construction of a detention basin on the eastern branch of Town Creek, upstream of Moss Vale Rd
FM 3.1	Kangaroo River Vegetation Management	Clearing of vegetation within the Kangaroo River upstream and downstream of Hampden Bridge, over a length of approximately 2km.
FM 3.2	Creek Formalisation	Formalise the channels of Jarrets Creek and Town Creek, including diversion of Town Creek 2 into Town Creek 3
FM 3.4	Central Channel - Large	Excavation of overflow channel through central floodplain (100m wide)

Table 3-3 Property Modification Options

Option ID	Option	Option Outline
P2	Building and Development Controls	A number of updates are recommended to Councils building and development controls
P8	Flood Proofing	Incorporating structural and other procedures in order to reduce or eliminate the risk to life and property. This can also include temporary flood protection measures such as flood barriers.

Table 3-4 Emergency Response Modification Options

Option ID	Option	Option Outline
EM1	Information transfer to SES	Transfer of findings from the floodplain risk management study and plan to the SES
EM2	Flood warning system	The critical durations for the Kangaroo Valley catchment may mean the implementation of a flood warning system is feasible.
EM3	Public awareness and education	Improvement of flood awareness in the community to reduce the overall flood risk
EM4	Flood warning signs at critical locations	Flood warning signs placed at public locations where high hazard flooding is experienced.

4 Findings of the Floodplain Risk Management Study

The options identified in the Floodplain Risk Management Study were assessed using a multi-criteria matrix, which incorporated a benefit / cost analysis for the structural options which can be quantitatively assessed. The matrix is attached in **Appendix A**. The multi-criteria matrix utilises a triple bottom line approach to assess the options on their economic, environmental and social suitability.

The Plan consists of a mixture of:

- Flood modification options
- Property modification options
- Emergency modification options

Triple bottom line and economic benefit / cost ratio analysis provide direction in the selection of various options. However, the final selection of options needs to consider other factors relevant to the wider community. For the purposes of selecting a list of options for the Plan, the following criteria have been adopted:

- Overall ranking in the multi-criteria matrix
- Benefits to the wider community, as opposed to localised benefits

The flood management options recommended in the plan, and their implementation is discussed in the following chapter.

5 Implementation Program

The implementation program essentially forms the action list for this Plan.

The benefit of following this sequence is that gradual improvement of the floodplain occurs, as the funds become available for implementation of these options.

Further steps in the floodplain management process from this point forwards are:

1. Floodplain Management Committee to consider and adopt recommendations of this Plan
2. Council to consider the Floodplain Management Committee's recommendations
3. Council to adopt the Plan and submit an application for funding assistance to OEH and other agencies as appropriate
4. As funds become available from OEH, other state government agencies and / or Council's own resources, implement the measures in accordance with the established priorities.

This plan should be regarded as a dynamic instrument requiring review and modification over time. The catalysts for change could include new flood events and experiences, legislative change, alterations in the availability of funding and reviews of Council planning policies. In any event, a review every five years is warranted to ensure the ongoing relevance of the Plan.

The action list for the existing catchment is shown in **Table 5-1**.

The options selected for the plan are based on the ranking of the multi-criteria analysis. The options selected represent a capital outlay of approximately $566,700.

5.1 Key Stakeholders

As a part of the implementation of the Plan and the detailed design phase of some of the options, liaison should be undertaken with key stakeholders. These stakeholders should include, but are not limited to:

- Private residents – in particular, those affected by proposed works
- Community groups
- Shoalhaven Water –with regard to any impacts on their assets within the catchment
- RMS – with regard to any impacts on any RMS roads in the study area
- SES – particularly with regards to the emergency management options. Generally, the SES should also be kept informed of changes to the flood behaviour resulting from any of the implemented option
- OEH – as it is likely that funding would be sourced from OEH for a number of the options, they should be consulted as a part of the design process

Table 5-1 Floodplain Risk Management Measures Recommended for Inclusion in the Kangaroo Valley Risk Management Plan

ID	Description	Estimated Capital Cost	Estimated Recurring Cost	Funding Sources / Responsibility	Priority for Implementation
P3	Building and Development Controls	$15,000	$500	Council	High
EM3	Public awareness and education	$20,000	$2,000	Council / SES	High
EM2	Flood warning system	$50,000	$1,500	Council / OEH	High
EM4	Flood warning signs	$5,000	$200	Council / SES	High
EM1	Infomation transfer to the SES	$3,000	$0	Council / SES	High
P7	Flood Proofing Guidelines	$15,000	$1,000	Council	Medium
DC1	Data collection following a flood event	$5,000	$3,000	Council	Medium
FM 1.3	Caravan Park Levee	$300,100	$500	Council / OEH / Park Owner	Low
FM 3.1	Kangaroo River Vegetation Management	$153,600	$15,000	Council / OEH / Local Community	Low
Total Cost of Implementing the Plan (All options)		**$566,700**	**$23,700**		
Total Cost of Implementing the Plan (High and Medium options only)		**$113,000**	**$8,200**		
Total Cost of Implementing the Plan (High options only)		**$93,000**	**$4,200**		
Total Cost of Implementing Non-Structural Options Only		**$113,000**	**$8,200**		
Total Cost of Implementing Structural Options Only		**$453,700**	**$15,500**		

6 Recommendations and Conclusion

This report presents the findings of the Floodplain Risk Management Plan for Kangaroo Valley. The investigations and consultations undertaken as part of the Floodplain Risk Management Study identified a number of issues for the floodplain. Based on these issues, a series of floodplain management measures were developed, and have been recommended in this Floodplain Risk Management Plan.

The assessment of management options provided in the Floodplain Risk Management Study facilitates the identification of the most beneficial options (in terms of hydraulics, economics, environmental and social issues).

7 Qualifications

This report has been prepared by Cardno for Shoalhaven City Council and as such should not be used by a third party without proper reference.

The investigation and modelling procedures adopted for this study follow industry standards and considerable care has been applied to the preparation of the results. However, model set-up and calibration depends on the quality of data available. The flow regime and the flow control structures are complicated and can only be represented by schematised model layouts.

Hence there will be a level of uncertainty in the results and this should be borne in mind in their application.

The report relies on the accuracy of the survey data and pit and pipe date provided.

Study results should not be used for purposes other than those for which they were prepared.

8 References

Cardno. (2015). *Kangaroo Valley Floodplain Risk Management Study*. St Leonards: Cardno

NSW Government. (2005). *Floodplain Development Manual.* Sydney: NSW Government.

NSW Government. (2005). *Floodplain management Guideline No4, Residential Flood Damage Calculation.* Sydney: DIPNR.

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Floodplain Risk Management Plan

FIGURES

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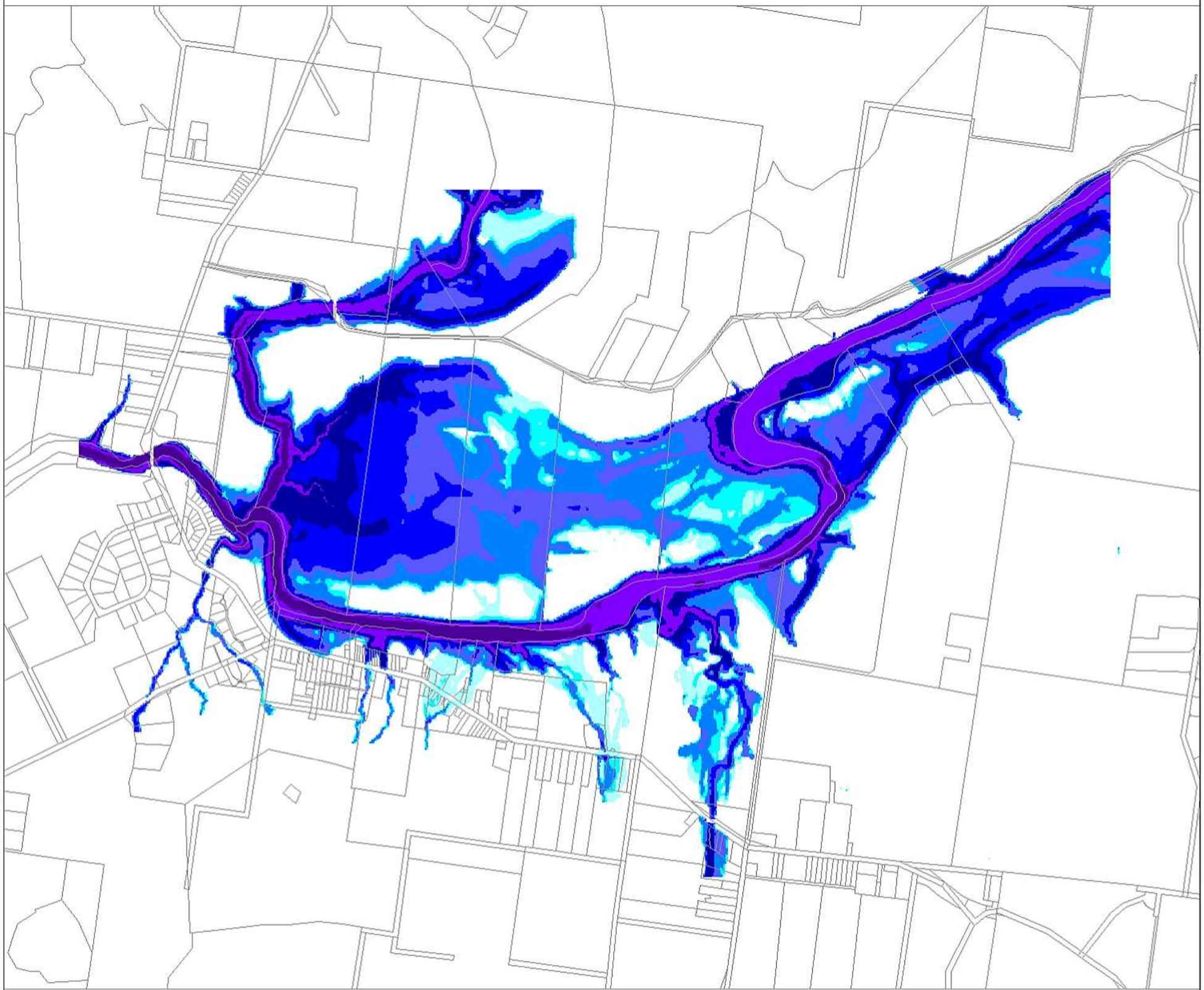

Figure 2-1

10% AEP Flood Depth

Kangaroo Valley FRMSP
Flood Study Revision

Cadastre

Depth (metres)

- 0.0 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- > 10.0

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Map Produced by Cardno NSW/ACT Pty Ltd
Date: June 2014
Project: Kangaroo Valley FRMSP
Coordinate System: MGA Zone 56

Figure 2-2

1% AEP Flood Depth

Kangaroo Valley FRMSP
Flood Study Revision

Cadastre

Depth (metres)

- 0.0 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- > 10.0

N

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0 1,000
metres
Scale: 1:15,000

Map Produced by Cardno NSW/ACT Pty Ltd
Date: June 2014
Project: Kangaroo Valley FRMSP
Coordinate System: MGA Zone 56

Floodplain Risk Management Plan

APPENDIX A
MULTI-CRITERIA ASSESSMENT MATRIX

Cardno
Shaping the Future

No.	ID	Category of Measure	Description	Estimate of Capital Cost	Estimate of Recurrent Cost	Net Present Value (7%, 50 years)	Reduction in AAD	% reduction in c.f. to base case	NPV of Reduction in AAD	Benefit - Cost Ratio	Score on Benefit Cost Ratio	Capital and Operating Costs	Reduction in Risk to Property	EconomicScore	Reduction in Risk to Life	Reduction in Social Disruption	Community Criteria	Council Support	Compatible with Policies and Plans	Social Score	Water Quality and Flow	Fauna & Flora	Environmental Score	TOTAL SCORE	RANK on TOTAL SCORE
1	FM 1.1	Flood Modification	Cullan Crescent Levee	Not viable, refer report																					
2	FM 1.2	Flood Modification	Tennis Court Levee	Not viable, refer report																					
3	FM 1.3 *	Flood Modification	Caravan Park Levee	$300,100	$500	$307,000	$15,448	7.1%	$213,194	0.69	-1	0	1	**-0.3**	2	0	0	1	1	**0.8**	0	0	**0.0**	**0.3**	**9**
4	FM 1.4 *	Flood Modification	Road Raising (0.2m overtopping limit)		$250	$3,450	$0	0.0%	$0	0.00	-2	2	2	**0.0**	1	0	-2	-1	-2	**-0.8**	0	0	**0.0**	**-0.8**	**12**
5	FM 1.5 *	Flood Modification	Road Raising (flood free in 1% AEP Event)	Not viable, refer report																					
6	FM 2.1 *	Flood Modification	Town Creek Detention Basin	$708,300	$1,000	$722,101	-$3.00	0.0%	-$41	0.00	-2	-1	2	**-0.8**	0	0	0	1	1	**0.4**	0	0	**0.0**	**-1.1**	**13**
7	FM 2.2 *	Flood Modification	Kangaroo River Detention Basin	Not viable, refer report																					
8	FM 3.1 *	Flood Modification	Kangaroo River Vegetation Management	$153,600	$15,000	$360,611	$13,425	6.2%	$185,275	0.51	-1	0	1	**-0.3**	0	0	1	0	0	**0.2**	0	1	**0.5**	**0.2**	**10**
9	FM 3.2 *	Flood Modification	Creek Formalisation	$1,149,100	$2,500	$1,183,602	$303	0.1%	$4,182	0.00	-2	-1	2	**-0.8**	0	0	1	1	1	**0.6**	1	0	**0.5**	**-0.4**	**11**
10	FM 3.3	Flood Modification	Hampden Bridge Widening	Not viable, refer report																					
11	FM 3.4 *	Flood Modification	Central Channel – Large	$60,495,800	$30,000	$60,909,822	$15,727	7.3%	$217,044	0.00	-2	-2	2	**-1.0**	1	1	0	1	1	**0.8**	-1	0	**-0.5**	**-1.7**	**14**
12	FM 3.5 *	Flood Modification	Central Channel – Small	Not viable, refer report																					
13	FM 3.6	Flood Modification	Kangaroo River Widening	Not viable, refer report																					
14	FM 4.1	Flood Modification	Culvert Augmentation	Not viable, refer report																					
18	P1	Property Modification	House Raising	Not viable, refer report																					
20	P2	Property Modification	Voluntary Purchase	Not viable, refer report																					
17	P3	Property Modification	Building and Development Controls	$15,000	$500	$21,900	NC	N/A	N/A	N/A	1	2	2	**1.5**	2	1	1	1	2	**1.4**	0	0	**0.0**	**4.4**	**1**
19	P4	Property Modification	House Rebuilding	Not viable, refer report																					
21	P5	Property Modification	Land Swap	Not viable, refer report																					
22	P6	Property Modification	Council Redevelopment	Not viable, refer report																					
23	P7	Property Modification	Flood Proofing Guidelines	$15,000	$1,000	$28,801	$3,185	1.5%	$43,955	1.53	0	2	1	**0.8**	0	0	1	1	2	**0.8**	0	0	**0.0**	**2.3**	**6**
24	EM1	Emergency Response Modification	Infomation transfer to the SES	$3,000	$0	$3,000	NC	N/A	N/A	N/A	0	2	0	**0.5**	2	0	2	2	2	**1.6**	0	0	**0.0**	**2.6**	**5**
25	EM2	Emergency Response Modification	Preparation of Local Flood Plans and update of DISPLAN	$30,000	$2,000	$57,601	NC	N/A	N/A	N/A	0	1	0	**0.3**	2	0	1	1	2	**1.2**	0	0	**0.0**	**1.7**	**8**
26	EM3	Emergency Response Modification	Flood warning system	$50,000	$1,500	$70,701	NC	N/A	N/A	N/A	0	2	1	**0.8**	2	1	1	1	2	**1.4**	0	0	**0.0**	**2.9**	**3**
27	EM4	Emergency Response Modification	Public awareness and education	$20,000	$2,000	$47,601	NC	N/A	N/A	N/A	0	2	1	**0.8**	2	1	2	1	2	**1.6**	0	0	**0.0**	**3.1**	**2**
28	EM5	Emergency Response Modification	Flood warning signs	$5,000	$200	$7,760	NC	N/A	N/A	N/A	0	2	0	**0.5**	1	2	2	2	2	**1.8**	0	0	**0.0**	**2.8**	**4**
29	DC1	Data Collection Strategy	Data collection following a flood event	$5,000	$3,000	$46,402	NC	N/A	N/A	N/A	0	2	0	**0.5**	0	0	2	2	2	**1.2**	0	0	**0.0**	**2.2**	**7**

** Indicates hydraulic model and detailed economic assessment used*

NC - Not Costed