Floodplain Risk Management Study

APPENDIX

A

Cardno
Shaping the Future

Tabourie Lake Floodplain Risk Management Study and Plan

Delft 3D Model Verification Report

49913170

Prepared for
Shoalhaven City Council

February 2014

Cardno
Shaping the Future

Document Information

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Executive Summary

Shoalhaven City Council have commissioned Cardno to undertake a Floodplain Risk Management study for the Lake Tabourie Township and its surrounds.

As part of the study, it was required to revise the TUFLOW model used in the Flood Study (WBM, 2010) into the Delft 3D software package as the TUFLOW morphology module used in the assessment:

- Was not currently tested and validated;
- Was identified by TUFLOW as being “under construction”; and,
- BMT WBM have not released it for use by others.

This report details the set-up and validation of the Delft 3D model.

This report will be included as an appendix in the future Floodplain Risk Management Study and Plan report.

Table of Contents

Tables

Figures

* Figures are located in body of report. Other figures are attached separately.

1 Introduction

This report details the works undertaken in developing the Delft 3D model for the assessment of flooding within the Lake Tabourie Catchment.

1.1 Study Context

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

Step 1: Formation of a Floodplain Management Committee

Step 2: Data Collection

Step 3: Flood Study

Step 4: Floodplain Risk Management Study

Step 5: Floodplain Risk Management Plan

Step 6: Implementation of the Floodplain Risk Management Plan

This report addresses revisions to previous investigations undertaken for Step 3 of the Floodplain Management process.

1.2 The Delft3D Model

It was identified during the review of the TUFLOW model used in the flood study (BMT WBM, 2010) that the modelling of the entrance has been undertaken using TUFLOW-MORPH. It is understood that this model is currently not fully tested and validated and is identified by TUFLOW and being "under construction". Further, it only appears to have been utilised by BMT WBM and is not available for wider use.

Consequently, it was decided to convert the TUFLOW model into a Delft3D model for the Floodplain Risk Management Study and Plan.

Delft3D is a flexible integrated modelling suite, which simulates two-dimensional (in either the horizontal or a vertical plane) and three-dimensional flow, sediment transport and morphology, waves, water quality and ecology and is capable of handling the interactions between these processes in time and space. The suite is mostly used for the modelling of natural environments like coastal, river and estuarine areas, but it is equally suitable for more artificial environments like harbours, locks, etc. Delft3D consists of a number of well-tested and validated programmes, which are linked to and integrated with one-another.

1.3 Following Tasks

The validated hydraulic model will subsequently be used to model the design flood events, which will form the basis of the damages assessment and the floodplain risk management options assessment.

2 Available Data

2.1 Survey

A number of survey data sources were available from Council, namely:

- Hydrographic survey data of Tabourie Lake and Tabourie Creek, surveyed in 1993;
- Photogrammetric survey data of the Tabourie Lake Township, taken in 2005;
- Topographic survey data of the Tabourie Lake Tourist Park, surveyed in 2007;
- Topographic survey data of the closed lake entrance, surveyed in 2008; and,
- 10m contours digitised from Geoscience Australia topographic map sheets.

2.2 Water Level Gauge

There is one water level gauge within the catchment area, located on Tabourie Lake, 1km upstream of the entrance. The gauge has been in operation since September 1992. There have been no significant floods in the catchment since this gauge was installed.

The recorded time series of the gauge is shown below in **Figure 2-1**.

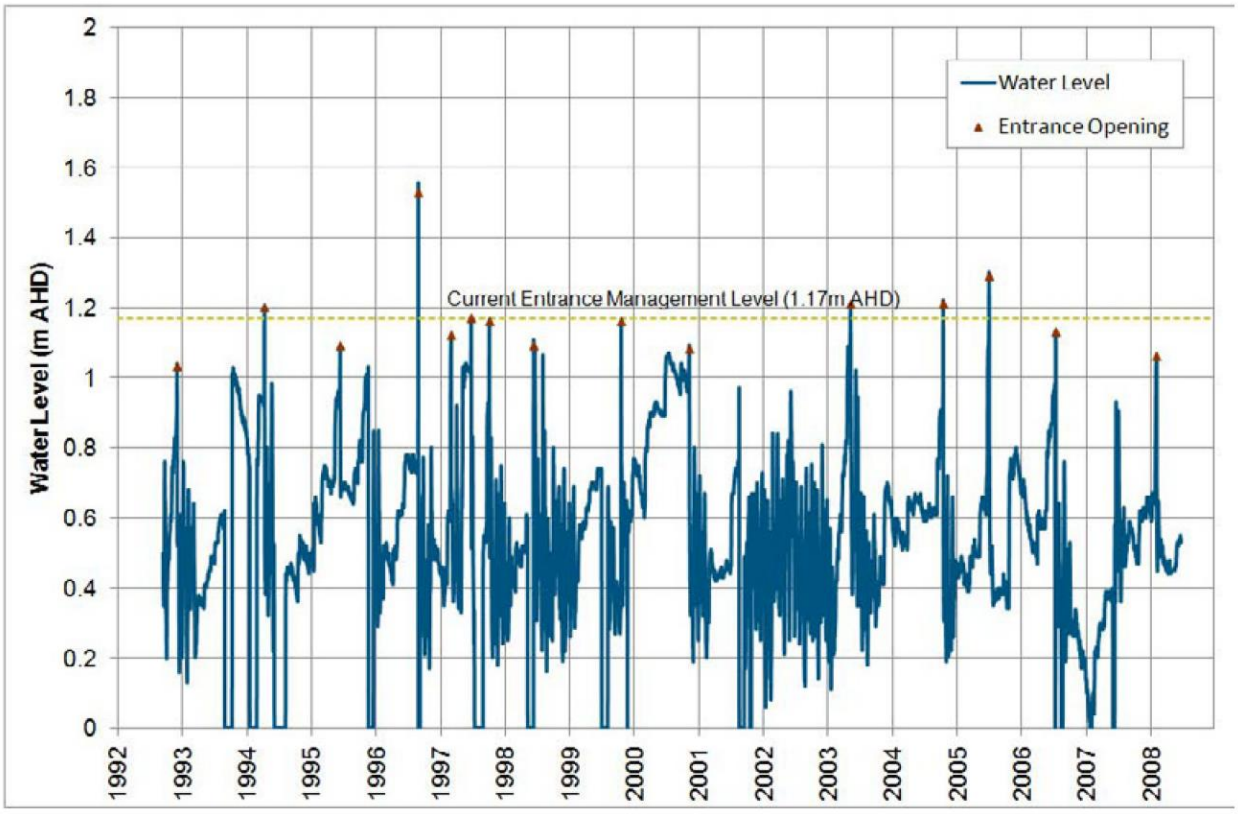

Figure 2-1 Recorded peak daily water levels from the Tabourie Lake gauge (BMT WBM, 2010)

2.3 Previous Modelling

2.3.1 RAFTS Hydrological Model

A RAFTS model for the study area was constructed in 2010 as part of the Tabourie Lake Flood Study. The hydrological model was reviewed, and found to be suitable for the Floodplain Risk Management Study and Plan.

As such, the hydrology from the flood study was adopted, and no changes were undertaken to the RAFTS-XP model.

2.3.2 TUFLOW Hydraulic Model

A 2D TUFLOW model constructed for the study area as part of the Tabourie Lake Flood Study.

The model extended from the Tabourie Lake to the Tabourie Creek entrance, and included the tributaries of Branderee Creek and Saltwater Creek, extending up Branderee Creek 2.3km and up Saltwater Creek 1.5km. The model area was approximately 7km^2 and was represented by a 4m grid.

The model was calibrated to three historical events. Data for these events was scarce however; limited to a small number of peak levels recorded by the community around the Township. A water level gauge is located within the study area, but has only been active since 1992, and no significant events have occurred in this time.

A review of the model found that the parameters adopted for the modelling were suitable, and the model construction generally appropriate. However, it was identified that the modelling of the entrance has been undertaken using TUFLOW-MORPH. It is understood that this model is currently not fully tested and validated and is identified by TUFLOW and being “under construction”. Further, it only appears to have been utilised by BMT WBM and is not available for wider use.

As a result, it was decided to convert the TUFLOW model to a Delft3D model. The development of the Delft3D model is discussed in **Section 3**, and the validation of the model in **Section 4**.

3 Hydraulic Model Development

The hydraulic modelling of the study area was undertaken using the Delft3D modelling software. The set-up of the hydraulic model is discussed below, and the validation of the model in **Section 4**.

3.1 2D Terrain

The model terrain was constructed from the DTM prepared for the flood study. The model was created using a curvilinear grid. This enabled the areas of interest such as the berm and along the river mouth to be finer than areas of storages, such as Lake Tabourie and land areas. The model ranged in grid size from 3m at the berm to 30m in the northern sections of the study area. The majority of the area is covered by a grid size of 4 – 8m.

The model terrain is shown in **Figure 3-1**.

3.2 Entrance Berm

The entrance berm was incorporated in the model based on the information provided for the design event modelling from the previous flood study (BMT WBM, 2010), namely:

- Berm saddle height of 2.0m;
- Berm crest height of 2.2m;
- A lake side gradient of 1 in 50; and,
- An ocean side gradient of 1 in 15.

These parameters were determined in flood study from a probabilistic assessment of berm heights, and site topographic survey (BMT WBM, 2010).

3.2.1 Failure and Erosion of the Entrance Berm

The Delft3D model is capable of modelling the failure and consequent erosion of the entrance berm during flood events. The rate and extent of the berm erosion is controlled by the velocity of the flow passing through the entrance, and the particle properties of the entrance material. The material properties adopted for the entrance berm were extracted from the flood study, and are shown in **Table 3-1**.

Table 3-1 Entrance Berm Material Properties

Parameter	Value
Specific Density	2650 kg/m^3
Dry Bed Density	1600 kg/m^3
Median sediment diameter (D50)	100 µm
Initial sediment thickness	0.05 m

As per the flood study, only the berm and the surrounding area were subject to sediment transfer. Outside of this region, the terrain remained fixed during the flood event. The modification of the berm was modelled using van Rijn 2004 sediment transport model, van Rijn (2006).

The extent of terrain subject to sediment transport is shown in **Figure 3-1**.

3.2.2 Structures

Three structures were included in the hydraulic model:

- The Tabourie Creek bridge on the Princes Highway;
- The Saltwater Creek bridge on Centre Road; and,
- A culvert on an unnamed tributary on the Princes Highway.

These structures are shown in **Figure 3-1**.

The details of these structures were taken from the survey conducted as part of the flood study (BMT WBM, 2010).

3.2.3 2.2.3 Roughness

The roughness values and regions were adopted from the flood study. The roughness layout is shown in **Figure 3-2**. The roughness values adopted for each zone are listed in **Table 3-2** below.

Table 3-2 2D Roughness Values

Zone / Landuse	Manning's 'n' roughness value
Channel – low roughness	0.025
Channel – low to medium roughness	0.035
Channel – medium to high roughness	0.045
Channel – high roughness	0.055
Roadways	0.030
Suburban lots	0.050
Pastureland	0.050
Light vegetation	0.070
Dense vegetation	0.120
Buildings	0.200

3.2.4 Inflows

Model inflows were extracted from the TUFLOW model, and applied at identical locations on the boundary of the 2D model area.

3.2.5 Downstream Boundary

The downstream boundary data was extracted from the TUFLOW model. The adopted boundary was the 1% AEP Ocean Boundary with a peak water level of 2.51 mAHD as specified by BMT WBM (2010), with the peak of the tide timed to coincide with the peak of the catchment flows.

The adopted boundary is shown in **Figure 3-6** below.

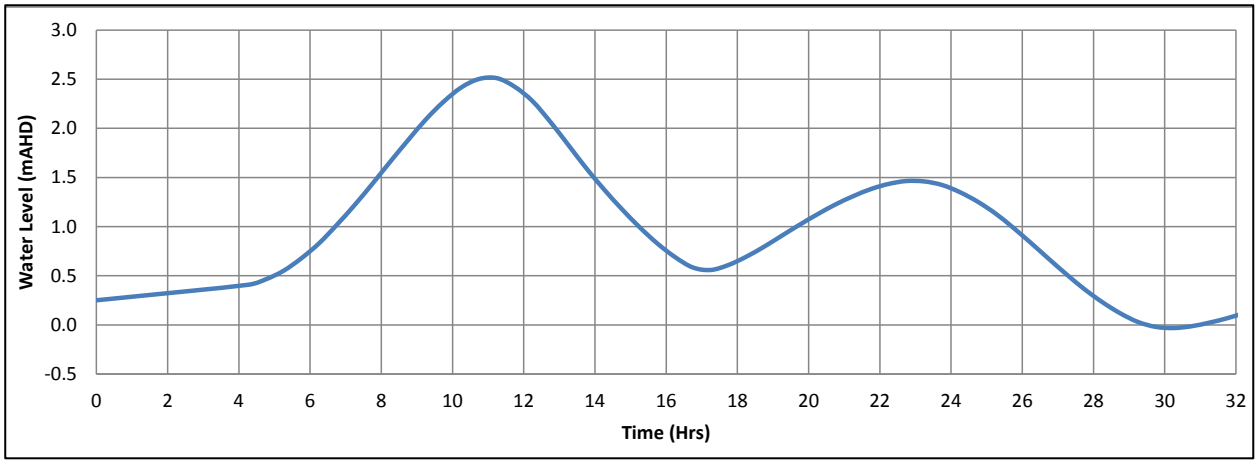

Figure 3-3 Design Ocean Boundary (BMT WBM, 2010)

4 Validation

In order to determine if the Delft3D model was successfully replicating the previous TUFLOW flood behaviour, a comparison was made between three key model outputs:

- Predicted peak water levels;
- Flow through structures; and,
- Behaviour of the berm failure (both timing and extent).

The results of these comparisons are discussed below.

4.1 Validation Comparisons

4.1.1 Peak Water Levels

As the validation of the morphology of the Tuflow model is unknown and was still "under construction" when the initial modelling was conducted by BMT WBM the validation / comparison of the Delft 3D model was initially undertaken using the fixed berm scenario. In this scenario the berm across the entrance of the creek does not break, thus the morphological component of the model is not included. The results of the fixed model will therefore be representative of the differences in the Delft and Tuflow modelling regimes.

A comparison between Delft3D and Tuflow from the 1% AEP model at select locations (as reported in Table 8.1, BMT WBM 2010) and Delft 3D are shown in **Table 4-1**.

The results show a close match between models throughout the study area, indicating that the Delft3D model is replicating the hydraulic behaviour of the Tuflow model.

Table 4-1 Comparison of peak 1% levels between Tuflow and Delft3D Models with the berm fixed

Location	Tuflow Model (mAHD)	Delft3D (mAHD)	Difference (m)
Entrance (Tabourie Creek)	2.75	2.73	-0.02
MHL Recorder (Tabourie Creek)	2.85	2.84	-0.01
Downstream Princes Highway (Tabourie Creek)	3.04	3.05	0.01
Upstream Princes Highway (Tabourie Creek)	3.09	3.08	-0.01
Tabourie Lake	3.10	3.10	0.00
Centre Street (Lemon Tree Creek)	2.86	2.85	-0.01
South Street (Lemon Tree Creek)	2.89	2.91	0.02

The models were then compared incorporating the failure of the entrance berm. A comparison at the same locations for the berm failure models are shown in **Table 4-2**.

The results show a close match between the models at the entrance, along Lemon Tree Creek, and through the Township. Upstream of the Princes Highway, the Delft3D model is showing peak levels 0.09m lower than the Tuflow model, suggesting that in the Delft3D model, the lake is draining quicker than in the Tuflow model.

Given the close match observed throughout the model region when the berm was fixed, it is therefore likely that these minor differences are due to difference in the berm failure between models.

Table 4-2 Comparison of peak 1% levels between Tuflow and Delft3D Models with berm failure

Location	Tuflow Model (mAHD)	Delft3D (mAHD)	Difference (m)
Entrance (Tabourie Creek)	2.53	2.55	0.02
MHL Recorder (Tabourie Creek)	2.63	2.64	0.01
Downstream Princes Highway (Tabourie Creek)	2.91	2.86	-0.05
Upstream Princes Highway (Tabourie Creek)	3.01	2.92	-0.09
Tabourie Lake	3.02	2.94	-0.08
Centre Street (Lemon Tree Creek)	2.66	2.65	-0.01
South Street (Lemon Tree Creek)	2.78	2.76	-0.02

4.1.2 Structure and Entrance Flow

A summary of peak flow rates at key locations within the model are provided in **Table 4-3**. The results show that similar peak flows are observed in both models, as would be expected given the similarity of the peak water levels.

Table 4-3 Comparison of peak flow between models

Location	Tuflow (cumecs)	Delft3D (cumecs)
Tabourie Creek Entrance	309	320
Princes Highway Bridge	247	238
Centre Street Bridge	49	47

4.1.3 Berm Failure

It was reported in the flood study that the berm required an overtopping depth of 0.3m before failure began to occur (BMT WBM, 2010, Section 8.1.1). In the Delft3D model, berm failure commences when the water level in the creek reaches 2.5mAHD; an overtopping depth of 0.3m, given the berm crest height of 2.2mAHD. Further details on the berm failure in the Tuflow model were not provided.

4.2 Outcomes of Model Validation

The above validation assessments were undertaken in order to determine that the hydraulic model accurately representing flood behaviour within the Lake Tabourie Township.

The results of the above assessment show that the Delft3D hydraulic model has been successfully validated to the 1% AEP flood results documented in the previous flood study (BMT WBM, 2010).

Only minor differences were observed between the models for both the fixed berm and berm failure models. The fixed berm comparison showed a particularly close comparison, suggesting that the Delft3D model is accurately replicating the hydraulic behaviour of the Tuflow model.

Peak flow rates through key locations were also closely matched between the Deflt3D and Tuflow models.

The point at which the berm begins to fail is identical in both models.

As such, the Delft3D model can be used with confidence in assessing design flood behaviour within the study area.

5 Conclusion & Next Steps

The results of the above assessment show that the hydraulic model has been successfully validated to the 1% AEP event. As such, the models can be used with confidence in assessing design flood behaviour.

The next stage of the study will use the validated models to define the flooding for the 20%, 5%, 2%, and 1% AEP events and the PMF event. This will provide a comprehensive understanding of existing catchment flood behaviour.

Following this, the flood damages will be calculated for the existing scenario, and an assessment will be made of potential property, response and flood modification mitigation measures within the study area.

6 Qualifications

This report has been prepared by Cardno for Shoalhaven 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.

7 References

BMT WBM, 2010, Tabourie Lake Flood Study, prepared for Shoalhaven City Council, BMT WBM, Broadmeadow

VAN RIJN, L., 2006, *Principles of Sediment Tranoprt in Rivers, Estuaries and Coastal Seas*. Part II: Supplement 2006. Aqua Publications.2006.

Delft 3D Model Verification Report

FIGURES

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Princes Highway Bridge

Princes Highway Culvert

Lemon Tree Creek Bridge

0 1,000
metres
Scale: 1:20,000

Figure 3-1

Delft3D Model Details

TABOURIE LAKE
FRMSP

Cadastre
Model Area
Sediment Transport Region

Elevation (mAHD)

-10
-5
0
1
2
5
10
15
20
25
30
35
40
50

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Map Produced by Cardno NSW/ACT Pty Ltd
Date: December 2013
Coordinate System: MGA Zone 56

Figure 3-2

Roughness Zones

TABOURIE LAKE
FRMSP

- Cadastre
- Model Area
- Buildings
- Suburban Lots
- Roadways
- Pastureland
- Light Vegetation
- Dense Vegetation
- Channel - low
- Channel - low to med
- Channel - med to high
- Channel - high

%

0 1,000
metres
Scale: 1:20,000

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Map Produced by Cardno NSW/ACT Pty Ltd
Date: December 2013
Coordinate System: MGA Zone 56

Floodplain Risk Management Study

APPENDIX

B

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Existing Flooding Issues

As identified in the Flood Study (WBM, 2010), the study area is subject to flooding from both catchment rainfall and lake / ocean surges.

The lake outlet condition plays a large role in catchment flood behaviour. Initial lake levels however, do not significantly affect flood behaviour.

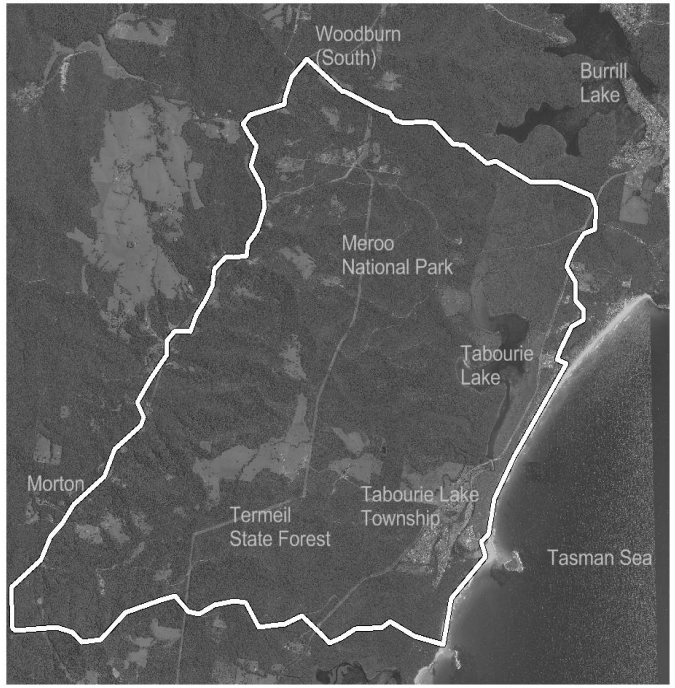
The probable maximum flood extent (extreme flood) for the Tabourie Lake catchment is shown below.

Princes Highway
1 in 5 year flood extent
1 in 100 year flood extent
Probable maximum flood extent

Study Area

The study area comprises the Tabourie Lake catchment, incorporating the Tabourie Lake Township and surrounding areas. The Tabourie Lake catchment area covers approximately 48 square kilometres (see below). The Tabourie Lake Broadwater is fed primarily by Lucy Kings Creek and Munno Creek. Other tributaries include Branderee Creek, Tabourie Creek and Lemon Tree Creek. The Lake has an outlet, adjacent to the Tabourie Lake Township to the Tasman Sea.

Catchment Area



Floodplain Management Process

Council's Shoalhaven River Natural Resource and Floodplain Risk Management Committee (the Committee) oversees the Floodplain Management process. The Committee meets regularly and includes representatives from Council, Office of Environment and Heritage (OEH), State Emergency Service (SES), NSW Department of Primary Industries (DPI), and representatives of the local community.

Floodplain Risk Management Study and Plan Objectives

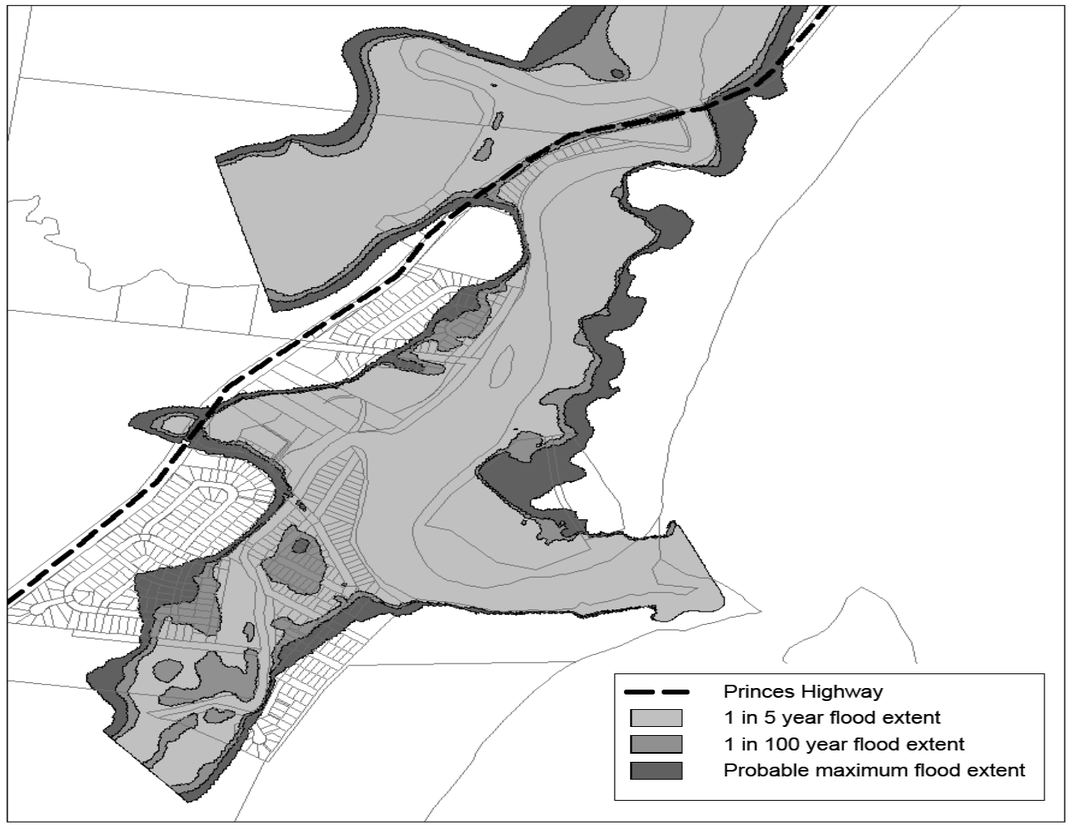
The objectives of the study and plan are:

Floodplain Risk Management Study

Find an appropriate mix of management measures and strategies to effectively manage the full range of flood risk in accordance with the NSW Government Floodplain Development Manual (2005) through an effective public participation and community consultation program. The information from this study will enable Council to formulate a Floodplain Risk Management Plan for the study area.

Floodplain Risk Management Plan:

Formulate a cost effective plan for the study area based on the findings of the Floodplain Risk Management Study and provide a priority program for implementation of the recommended works and measures in accordance with the Floodplain Development Manual. The plan will detail how the existing and future flood risk within the study area will be managed.



If you have any further comments that relate to the Tabourie Lake Floodplain Risk Management Study and Plan, please express them in the space below. Please feel free to attach additional pages if necessary.

YOUR PERSONAL INFORMATION WILL REMAIN CONFIDENTIAL

If you have any queries, please contact:

Ailsa Schofield
Shoalhaven City Council
P: (02) 4429 3145
F: (02) 4422 1816
E: schofielda@shoalhaven.nsw.gov.au

Thank you for providing the above information. Please remember to put the pages back in the reply paid envelope by 20 September 2013. A representative from Cardno may contact you in the near future to discuss your response.

AUGUST 2013

TABOURIE LAKE
Floodplain Risk Management Study & Plan

Local Resident/Land Owner Survey

*Note: information supplied will remain completely confidential.

Q1. Could you please provide us with the following details? We may wish to contact you to discuss some of the information you have provided us.

Name: .....
Address: .....
.....
Daytime Ph: .....
Email: .....

Q2. Is your property (please tick)?

☐ Owner occupied ☐ Occupied by a tenant
☐ A business ☐ Farmland

Q3. How long have you lived, worked and/or owned your property? .....Years .....Months

Q4. How long have you lived in Tabourie Lake? .....Years .....Months

Q5. How many people occupy your property? .....

Q6. Please indicate the number of permanent residents at this address aged:

☐ 0 - 4 years ☐ 5 - 24 years
☐ 25 - 64 years ☐ 65+ years

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prepared by Cardno Shaping the Future

Our team appreciates the diverse effects of flooding – from its dynamic shaping of the environment through to its potential negative social and economic impact. With this knowledge we analyse and develop comprehensive plans.

Q 7. Have you ever experienced flooding since living/working/ owning your property? (please tick relevant boxes)

- ☐ Yes, floodwaters entered my house/business
- ☐ Yes, floodwaters entered my yard/surrounding property
- ☐ Yes, the road was flooded and I couldn't drive my car
- ☐ Yes, the creek / lake broke its banks
- ☐ Yes, other parts of my neighbourhood were flooded
- ☐ No, I haven't experienced a flood (go to Q.9)
- ☐ Other (specify).....

Q 8. If you have experienced a flood, how did the flooding affect you and your family/business? (please tick relevant boxes)

- ☐ Parts of my house/business building were damaged
- ☐ The contents of my house/business were damaged
- ☐ My garden, yard, and/or surrounding property were damaged
- ☐ My car(s) were damaged
- ☐ Other property was damaged (specify) .....
- ☐ I couldn't leave the house/business
- ☐ Family members/work mates couldn't leave/return to the house/business
- ☐ My family had to evacuate the house/business
- ☐ The flood disrupted my daily routine
- ☐ The flood affected me in other ways (specify) .....
- ☐ The flood didn't affect me

Q 9. Do you think your property be flooded sometime in the future? (please tick relevant boxes)

- ☐ No
- ☐ Yes, but only a small part of my yard
- ☐ Yes, most of my yard/outdoor areas of business could be flooded
- ☐ Yes, my house/office/business could flood over the floor

Q10. Have you looked for information about flooding on your property? (please tick relevant boxes)

- ☐ Council's customer service centre
- ☐ Other information from Council (specify).....
- ☐ Viewed a Property Planning (Section 149) Certificate
- ☐ Information from a real estate agent
- ☐ Information from relatives, friends, neighbours, or the previous owner
- ☐ Other information (specify).....
- ☐ No information has been sought
- ☐ I do not believe my property is affected by flooding
- ☐ Council's website

If you answered yes to having looked for information on Council's website:

- ☐ What information have you looked for? (Please specify) .....
  .....
- ☐ Where were you able to find information? (Please specify) .....
  .....

Q11. In you opinion, what is the greatest flood risk in the Tabourie Lake floodplain?

- ☐ Risk to property
- ☐ Risk to life
- ☐ Inconvenience
- ☐ Other (please specify)
  .....

Q12. What do you think are the best ways to get input and feedback from the local community about the options being considered to manage flooding and the results of this project? (please tick relevant boxes)

- ☐ Council's website
- ☐ Emails from Council
- ☐ Council's Floodplain Management Committee
- ☐ Formal Council meetings
- ☐ Council's information page in the local paper
- ☐ Other articles in the local paper
- ☐ Information days in the local area
- ☐ Community meetings
- ☐ Mail outs to all residents/business owners in the study area
- ☐ Other (specify).....

Q13. What is the main language spoken at home?

- ☐ English
- ☐ Other (specify).....

Q14. As a local resident who may have witnessed flooding/drainage problems, you may have your own ideas on how to reduce flood risks. Which of the following management options would you prefer for the Tabourie Lake catchment (1=least preferred, 5=most preferred)? Please also provide comments as to the location where you think the option might be suitable.

Proposed Option	Preference (please circle)	Location/Other Comments?
Management of the entrance of Tabourie Lake to the ocean.	1 2 3 4 5	
Improved flood flow paths.	1 2 3 4 5	
Retarding or detention basins; these temporarily hold water and reduce peak flood flows.	1 2 3 4 5	
Culvert/ bridge/pipe enlarging.	1 2 3 4 5	
Levee banks.	1 2 3 4 5	
Dredging of Tabourie Lake.	1 2 3 4 5	
Environmental channel improvements, including removal of weeds & bank stabilisation.	1 2 3 4 5	
Planning and flood-related development controls.	1 2 3 4 5	
Education of community, providing greater awareness of potential hazards.	1 2 3 4 5	
Flood forecasting, flood warning, evacuation planning and emergency response.	1 2 3 4 5	
Other (please specify any options you believe are suitable). Please attach extra pages for other suggestions.	1 2 3 4 5	

Floodplain Risk Management Options

The following list of Floodplain Risk Management options presents some strategies that could be considered to minimise the risk and reduce the impact of flooding throughout the Tabourie Lake floodplain. These options will be considered in further detail during the preparation of the Management Study and Plan.

Examples of Flood Management Options

	Description
Flood Modification Options	• Construction of levees where properties are most at risk. • Upgrading of drainage systems. • Revision of entrance management procedures.
Property Modification and Planning Control Options	• Building and development controls • Voluntary house raising program (for selected properties) • Voluntary house rebuilding subsidy scheme (for selected properties) • Voluntary property purchase program (for selected properties).
Emergency Response Modification Options	• Revision of the Local Disaster Plan (DISPLAN) • Public awareness and education—locality based flooding information for residents • Public awareness and education—flooding information for schools • Flood depth markers at major (flood affected) road crossings • Continuation of existing public awareness and education campaigns • Data collection strategies for future floods

Property Level Survey

As part of the study, a survey team from Rygate and West Surveyors will be collecting flood levels and ground levels for properties within the Tabourie Lake floodplain. This data is being collected to enable us to accurately determine how properties are affected by flooding. The levels will also be used to calculate damages resulting from flood events and to assess the effectiveness of proposed flood mitigation options. The survey will be conducted between 30/09/2013 and 08/11/2013. Please contact Council if you have any questions regarding this survey.

Consultation

During the Floodplain Risk Management Study and Plan process, consultation will be undertaken with the community in order to establish a comprehensive list of management options.

In addition to the accompanying Questionnaire, which can also be found on Council's website, you will have further opportunities to comment on the direction of the project during the public exhibition periods of the Draft Risk Management Study and Plan, as well as a series of community workshops conducted by Council and Cardno.

The first of these workshops will be held on Wednesday 30th October at the Tabourie Rural Fire Service shed, commencing at 6.30pm. The workshop will introduce the study, and discuss potential mitigation strategies with the community

Any comments received during the workshop will be taken into account before finalisation of the study and plan. For further information regarding this project please see Council's website www.shoalhaven.nsw.gov.au, or contact Shoalhaven City Council via the details below.

Contact Us

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36 Bridge Road, Nowra
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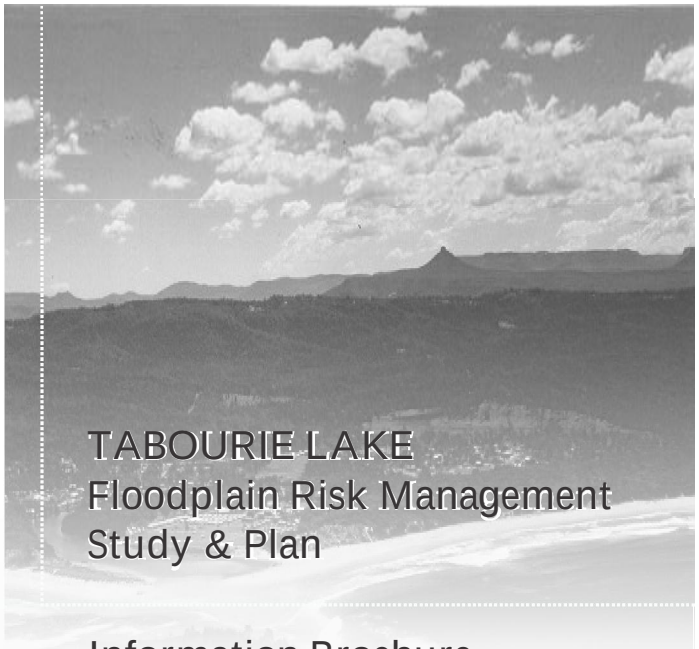
F: (02) 4422 1816
E: schofielda@shoalhaven.nsw.gov.au



TABOURIE LAKE Floodplain Risk Management Study & Plan

Information Brochure

Shoalhaven City Council has engaged Cardno to assist with the preparation of the Tabourie Lake Floodplain Risk Management Study and Plan.

The Risk Management Study and Plan follows from the Flood Study, completed in 2010, which identified the existing flooding behaviour in the Tabourie Lake catchment. The purpose of this Risk Management Study and Plan is to identify and recommend appropriate actions to manage flood risks in the Tabourie Lake catchment.

This brochure provides an introduction to the Risk Management Study and Plan and informs you of its objectives.

Your feedback on the accompanying questionnaire will play an important role in the project.

prepared for Shoalhaven City Council

prepared by Cardno Shaping the Future

Floodplain Risk Management Study

APPENDIX

C

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The following sections set out the methodology for the determination of damages within the Tabourie Lake catchment.

C.1 Residential Damage Curves

The draft DNR (now OEH) Floodplain Management Guideline No. 4 Residential Flood Damage Calculation (NSW Government, 2005) was used in the creation of the residential damage curves. These guidelines include a template spreadsheet program that determines damage curves for three types of residential buildings, namely:

- Single story, slab on ground,
- Two story, slab on ground,
- Single story, high set.

Damages are generally incurred on a property prior to any over floor flooding. The OEH curves allow for a damage of $10,988 (June 2014 dollars) to be incurred when the water level reaches the base of the house, with the base of the house assumed to be 0.3m below the floor level for slab on ground. We have assumed that this remains constant until over floor flooding occurs. A nominal $3,000 has been allowed to represent damage to gardens where the ground level of the property is overtopped by more than 0.3m of depth but only up to 0.3m below the floor of the house. This may occur on steeper properties and larger properties where the garden and fences may be impacted, but the flood waters do not reach the house.

There are a number of input parameters required for the OEH curves, such as floor area and level of flood awareness. The following parameters were adopted:

- A value of 150m^2 was adopted as a conservative estimate of the floor area for residential dwellings in the floodplain based on an analysis of aerial photographs. With a floor area of 150m^2, the default contents value is $61,500 (June 2014 dollars),
- The effective warning time has been assumed to be zero due to the absence of any flood warning systems in the catchment. A long effective warning time allows residents to prepare for flooding by moving valuable household contents and hence reduce the potential damages of household contents,
- The Tabourie Lake catchment is a small part of the regional area, and as such is not likely to cause any post flood inflation. These inflation costs are generally experienced in regional areas where re-construction resources are limited and large floods can cause a strain on these resources.

C.1.1 Average Weekly Earnings

The OEH curves are derived for late 2001 and were updated to represent June 2014 dollars (refer **Table C-1**). General recommendations by OEH are to adjust the values in residential damage curves by Average Weekly Earnings (AWE) rather than by the inflation rate as measured by the Consumer Price Index (CPI). OEH proposes that AWE is a better representation of societal wealth, and hence an indirect measure of the building and contents value of a home. The most recent data from the Australian Bureau of Statistics at the time of this study was for June 2014. Therefore, all ordinates in the residential flood damage curves were updated to June 2014 dollars. In addition, all damage curves include GST as per OEH recommendations.

The OEH guidelines were derived in November 2001, which allows us to use the November 2001 AWE statistics (issued quarterly) for comparison purposes. June 2014 AWE values were taken from the Australian Bureau of Statistics website (ABS, 2011).

Consequently, damages have been increased by 64% and GST has been included compared to 2001 values.

Table C-1 Average Weekly Earnings (AWE) Statistics for Residential Damage Curves

Month	Year	AWE

November	2001	$673.60
June	2014	$1,104.70

C.2 Commercial Damage Curves

Commercial damage curves were adopted from the FLDamage Manual (Water Studies Pty Ltd, 1992). FLDamage allows for three types of commercial properties:

- Low value commercial,
- Medium value commercial,
- High value commercial.

In determining these damage curves, it has been assumed that the effective warning time is approximately zero, and the loss of trading days as a result of the flooding has been taken as 10.

These curves are determined based on the floor area of the property. The floor level survey provides an estimate of the floor area of the individual commercial properties. These have been used to factor these curves.

The Consumer Price Index (CPI) was used to bring the 1990 data to June 2014 dollars, using data from the Australian Bureau of Statistics (ABS, 2011). It was assumed that the FLDamage data was in June 1990 dollars. The CPI data is shown in **Table C-2**.

Consequently, commercial damages have been increased by 81.8% and GST has been included compared to 1990 values.

Table C-2 CPI Statistics for Commercial Damage Curves

Month	Year	CPI
June	1990	$102.50
June	2014	$204.93

C.3 Industrial Damage Curves

There were no industrial properties in the study. Consequently, the industrial damage curves were not used in this assessment.

C.4 Caravan Park Damage Curves

There are no typical damage curves available for caravans and caravan parks. For estimating the damages the following was assumed for damages occurring to caravans:

- No damage up to 0.25m (a typical axel height)
- Linearly increasing damages up to 0.5m to a nominal $10,000 (minor damages to undercarriage)
- A sharp rise to full damages at 0.6m of $75,000. Caravans have shown to become mobile in flood depths of >0.6m. At this point, it was assumed that the caravan would require replacement. The replacement costs were determined for a mid-range caravan.
- Caravan locations were determined from aerial imagery

C.5 Adopted Damage Curves

The adopted damage curves are shown in **Figure C-1**. For purposes of illustration, the residential and commercial damage curves are shown for a property with a floor area of 150m^2, although the size will be individually determined for each residential and commercial property when calculating catchment damages.

C.6 Average Annual Damage

Average Annual Damage (AAD) is calculated using a probability approach based on the flood damages calculated for each design event.

Flood damages (for a design event) are calculated by using the damage curves described above. These damage curves attempt to define the damage experienced on a property for varying depths of flooding. The total damage for a design event is determined by adding all the individual property damages for that event.

The AAD value attempts to quantify the flood damage that a floodplain would receive on average during a single year. It does this using a probability approach. A probability curve is drawn, based on the flood damages calculated for each design event. For example, the 1% AEP design event has a probability of occurring of 1% in any given year, and as such the 1% AEP flood damage is plotted at this point (0.01) on the AAD curve. AAD is then calculated by determining the area under the plotted curve. Further information of the calculation of AAD can be found in Appendix M of the Floodplain Development Manual (NSW Government, 2005).

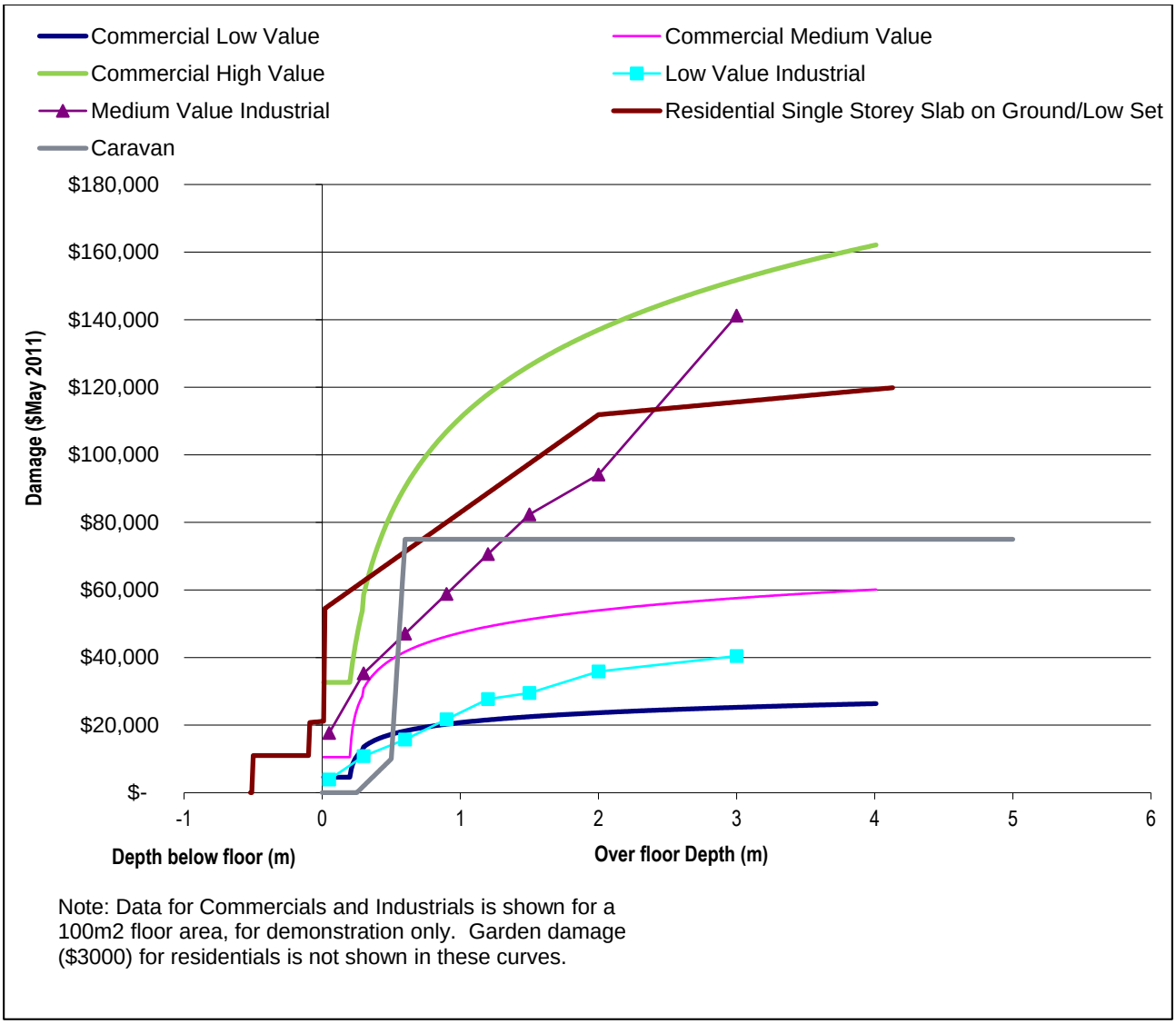

Figure C-2 Adopted Damage Curves

(Damage data sourced from FLDamage, and plotted for a 100m^2 property. Refer Section C.1 and Section C.2 for further details)

Floodplain Risk Management Study

APPENDIX

D

ENVIRONMENTAL & SOCIAL ASSESSMENT

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The following details the environmental and social assessments undertaken for Tabourie Lake.

D.1 Social Characteristics

A knowledge of the demographic character of people living within the catchment assists in the preparation and evaluation of flood management options which are appropriate for the local community. For example, the data is relevant in the consideration of emergency response or evacuation procedures as information may need to be presented in a range of languages or special arrangements made for less mobile members of the community.

The demographic characteristics of the Tabourie Lake catchment presented in this report are based on the suburb of Lake Tabourie. Population data for Lake Tabourie was sourced primarily from the Australian Bureau of Statistics (ABS) 2011 Census.

In summary, the data revealed that:

- Almost a third of the residents of Lake Tabourie are over 60, which is significantly higher than the NSW average. The region also had a lower proportion of people aged between 20 and 39 years of age (**Table D-1**). This results in a community which may face issues with regards to evacuation during a flood event due to limited mobility, inability to drive or health issues associated with an aged community.
- In Lake Tabourie, 83.8% of people were born in Australia. The most common countries of birth outside of Australia were England 4.2%, Germany 1.3 %, Netherlands 1.3% and New Zealand 1.3%. Indigenous (Aboriginal and Torres Strait Islander) people comprised of 2% of the region's population.
- English was the only language spoken in approximately 96.7% of homes in Lake Tabourie. The remainder of other languages spoken at home was Italian (**Table D-2**).
- The average median weekly income for individuals in the region was $666, compared to the NSW average of $561. This trend of slightly above average income for the region compared to the NSW average was also evident for family and household incomes (**TableD-3**). This may have implications for the economic damages incurred on property contents during a flood event.
- The median property price is $284,000 (www.realestate.com.au, 2013), compared with a median property price for houses in NSW of $460,000 (APM, 2013). All dwellings comprised of single dwellings (detached, semi-detached and terraces) as listed in **Table D-4**. This information has implications for the economic damages incurred on the structure of the building during a flood event.

Table D-1 Age Structure of Lake Tabourie

Age Group (Years)	Persons in Lake Tabourie	% of total persons in Lake Tabourie	% of total persons in NSW
0-9 years	84	14	12.9
10-19 years	74	12	12.7
20-29 years	33	5	13.3
30-39 years	61	10	13.9
40-49 years	90	15	14
50-59 years	88	15	12.9
60-69 years	77	13	10
70+ years	94	16	10.3
TOTAL	601	100	100

Table D-2 Languages Spoken at Home in Lake Tabourie (ABS, 2011)

Languages Spoken at Home	Number of People	% of total number of people	% of total homes in NSW
English Only	579	96.7	72.5
Italian	5	0.8	1.2

Table D-3 Average Median Income of Lake Tabourie Residents (ABS, 2011)

Income (For Population Aged 15 Years and Over)	Lake Tabourie	New South Wales
Average Median Individual Income (weekly)	$390	$561
Average Median Family Income (weekly)	$886	$1,477
Average Median Household Income (weekly)	$741	$1,237

Table D-4 Dwelling Structure in Lake Tabourie (ABS, 2011)

Dwelling Structure (Occupied Private Dwellings)	Lake Tabourie	% of Dwellings in Lake Tabourie	% of Dwellings in NSW
Separate house	237	98.8	69.5
Semi-detached, row or terrace house, townhouse etc.	0	0	10.7
Flat, unit or apartment	0	0	18.8
Other dwelling	3	1.2	0.9

D.2 Environmental Characteristics

D.2.1 Topography

From a high elevation of around 350m AHD at the top of the catchment, the topography grades steeply from the upper slopes to the floodplain areas west of Tabourie Lake. The lower reaches of the major watercourses in the catchment are characterised by low-lying swampy depressions (BMT WBM, 2010).

D.2.2 Geology and Soils

When developing structural floodplain management options it is important to understand the geology of the catchment to ensure appropriate locations for management options are selected and to assist with the planning of suitable foundations and other constructions.

The Ulladulla 1:250,000 Geological Series Sheet (Geoscience Australia, 1966) indicated that the catchment is situated on the Permian aged Nowra Sandstone, which consists primarily of quartz sandstone. This geology forms part of the Shoalhaven group, which is made up of sandstones, siltstones and conglomerates.

Soil data for the Tabourie Lake catchment was obtained from the NSW Natural Resource Atlas (NR Atlas, 2013). This data has been used to present likely soil conditions within the catchment, as shown in **Table D-5**.

The geological and soil constraints on floodplain management depend on the management options selected. However, no significant geological constraints have been identified which would impact the preliminary assessment of options undertaken in this Study. Site-specific geotechnical assessment would need to be undertaken prior any detailed design and/or construction works.

Table D-5 General Soil Characteristics in the Tabourie Lake Catchment (NR Atlas, 2013)

Layer	Texture	Colour	pH
1	Fine Sandy Loam	Black	5.5
2	Fine sandy clay loam	Dark greyish brown	5
3	Light medium clay	Greyish brown	4.5
4	Medium heavy clay	Greyish brown	4.5

D.2.3 Contaminated Land and Licensed Discharges

Contaminated land refers to any land which contains a substance at such concentrations as to present a risk of harm to human or environmental health, as defined in the Contaminated Land Management Act 1997. The Office of Environment and Heritage (OEH) is authorised to regulate contaminated land sites and maintains a record of written notices issued by the Environment Protection Authority (EPA) in relation to the investigation or remediation of site contamination.

A search of the OEH Contaminated Land Record on 29 August 2013 showed two known contaminated sites within the Shoalhaven Shire Council LGA. However, neither of these sites are within the Tabourie Lake Catchment. The Contaminated Land Record is not an exhaustive index, and there may be unreported contamination present within the catchment. As such, appropriate investigations should be undertaken prior to any floodplain management works being undertaken which may disturb soils.

A search of the PoEO licensed premises public register on 29 August 2013 identified no licenced premise within the catchment.

D.2.4 Acid Sulfate Soils

Acid Sulfate Soils (ASS) occur when soils containing iron sulfides are exposed to air and the sulfides oxidise producing sulphuric acid (DECC, 2008). This usually occurs when soils are disturbed through excavation of drainage works. The production of sulfuric acid can result in numerous environmental problems. Due to sulphuric acid being a very reactive and corrosive compound, any flora and fauna that is exposed to it could be harmed. It is therefore important to be aware of the distribution of ASS within the catchment, so that potential flood management options are developed and assessed in a manner that is sensitive to the problem of ASS (potential and actual acid sulfate soils).

ASS have been classified based on the likelihood of the soils being present in particular areas and at certain depths. There are five classifications, which are:

- Class 1 – ASS in a Class 1 area are likely to be found on and below the natural ground surface. Any works will trigger the requirement for assessment and may require management (High probability of occurrence).
- Class 2 – ASS in a Class 2 area are likely to be found below the natural ground surface. Any works beneath the natural ground surface, or works which are likely to lower the water table, will trigger the requirement for assessment and may require management (High probability of occurrence).
- Class 3 – ASS in a Class 3 are likely to be found beyond 1 metre below the natural ground surface. Any works that extend beyond 1 metre below the natural ground surface, or works which are likely to lower the water table beyond 1 metre below the natural ground surface, will trigger the requirement for assessment and may require management (Low probability of occurrence).
- Class 4 – ASS in Class 4 are likely to be found beyond 2 metre below the natural ground surface. Any works that extend beyond 2 metre below the natural ground surface, or works which are likely to lower the water table beyond 2 metre below the natural ground surface, will trigger the requirement for assessment and may require management (Low probability of occurrence).
- Class 5 – ASS are not typically found in Class 5 areas. Areas classified as Class 5 are located within 500m of adjacent Class 1, 2, 3 or 4 lands. Works in a Class 5 area that are likely to lower the water

table below 1 metre AHD on adjacent Class 1, 2, 3 or 4 land will trigger the requirement for assessment and may require management (Low probability of occurrence).

Tabourie Lake has a high probability of ASS, and ASS are likely to be found on and below the natural ground surface. There are wetland sites on the fringes of Tabourie Lake with a high probability of potential ASS. These sites are mostly located within the main basin of the lake and in catchment creeks.

If high risk materials were to be disturbed by activities such as shallow drainage, excavation or clearing, there may be a severe environmental risk. The disturbance of ASS in the catchment could have significant consequences for the receiving waters of the estuary. Soil investigations would be necessary to assess these areas for acid sulfate potential should any flood management actions be proposed in these locations and appropriate management response would be required in disturbance of ASS is proposed to occur.

D.2.5 Ground Water

Wetlands that are found within Tabourie Lake are classified as groundwater dependent ecosystems (GDE), which are ecosystems that rely on groundwater for some or all of their water requirements. Such ecosystems can range from highly dependent to opportunistic users of groundwater. Many aquatic habitats also depend on groundwater such as estuarine areas that include mangroves, mudflats, seagrass and saltmarsh; freshwater habitats that include freshwater streams and rivers; and wetlands include coastal lagoons and floodplains, lakes, swamps and bogs (NSW Office of Water, 2012). Not all GDEs draw on groundwater directly and not all are solely reliant on groundwater. However, in many cases groundwater commonly provides an important and reliable source of water to many ecosystems, and can be the main factor controlling the distribution of ecosystem types. In many cases the groundwater provides baseflow in rivers that ecosystems depend on. The impact of changes in groundwater quantity and quality on GDEs is determined by the degree and nature of their groundwater dependency (Geoscience Australia, 2013).

The Coastal Sand Swamp Forest which is associated directly with Tabourie Lake and its catchment is a high probability groundwater dependent wetland community. The NSW Office of Water (2012) has developed risk assessment guidelines to manage land and water use activities that can affect groundwater dependent ecosystems. These guidelines should be considered in regards to any proposed flood modification works.

A search of the NSW Natural Resource Atlas (NR Atlas) identified 14 groundwater bores within close proximity of Tabourie Creek and one alongside Tabourie Lake. Depending on the chosen flood modification option, groundwater may be intercepted during construction. If groundwater extraction/interference is required, an aquifer interference approval would be required for the work under clause 91(3) of the Water Management Act 2000.

D.2.6 Surface Water Quality

Shoalhaven City Council has regularly collected water quality data in Tabourie Lake since 1989. Council and OEH have worked together to develop a Monitoring Evaluation and Reporting (MER) strategy for the health of Shoalhaven estuaries and lakes, linked to a State wide program of water quality and biological “indicators” for assessing and reporting the ecological condition of estuary systems.

A variety of pressure / stressor indicators are monitored in the lake basin to measure changing conditions. These incorporate:

- concentration of forms of nitrogen (µg/L);
- concentration of forms of phosphorus (µg/L);
- dissolved oxygen (mg/L);
- faecal coliform counts (cfu/100mL);
- water acidity (pH);
- water temperature (oC);
- salinity (ppt);

- turbidity (NTUs); and
- Chlorophyll a (µg/L).

The ANZECC guidelines (1992) have been used in order to determine the trigger levels for each of these indicators. Council uses a Water Quality Index (WQI) to rate sites on a scale from 'very poor' to 'excellent'. The WQI for Lake Tabourie over the 2011/12 sampling period rated as 'Medium' (SCC, 2012a). Total Nitrogen levels have been consistently high in Lake Tabourie; however, this is consistent with many independently closing and opening lakes and lagoons (ICOLL) on the south coast.

Processes which affect water quality in an estuary like Tabourie Lake include:

- Catchment inflows – point source pollutants (e.g. urban stormwater discharge) and diffuse source (e.g. sediment, nutrients);
- Water exchange with ocean and from fresh water inputs; and
- Internal lake processes.

The lakes water quality is dependent upon the nature and extent of inflows from the catchment. During dry periods with little if any catchment runoff, oceanic inputs may dominate if the entrance is open, and the lake's water quality may be similar to seawater. However, during prolonged wet periods, the lakes water quality may closely reflect the quality of surface runoff (Peter Spurway & Associates, 2005).

D.2.7 Flora and Fauna

D.2.7.1 Flora

A search of OEH's Atlas of NSW Wildlife on 4 October 2013 revealed 4 species listed as endangered, protected and/or vulnerable. A search of the EPBC Protected Matters Search Tool on 30 August 2013 revealed 16 threatened species and 3 threatened ecological communities listed as endangered or vulnerable.

Details are provided in **Table D-6**.

Vegetation mapping undertaken by AHA Ecological (2008) identified 3 Endangered Ecological Communities (EECs) within the Tabourie Lake Catchment, which are detailed in **Table D-7**.

Any flood management actions will need to recognise the presence of vegetation within the catchment and comply with flora legislative requirements.

Table D-6 Vulnerable and Endangered Flora Species (OEH, 2013)

Scientific Name	Common Name	Legal Status
Caladenia tessellata	Thick Lip Spider Orchid	E1, P
Cryptostylis hunteriana	Leafless Tongue Orchid	V,P,2
Galium australe	Tangled Bedstraw	E1, P
Thesium australe	Austral Toadflax	V,P

Table D-7 Endangered Ecological Communities within the Tabourie Lake Catchment (AHA Ecological, 2008)

Vegetation Community	Description	Condition
Bangalay Sand Forest	This vegetation extends through much of the north-east between Tabourie Lake and the ocean. Dominant canopy species are Bangalay, Old-man Banksia and Sweet Pittosporum with Lomandra, Tree Broom-heath, and Snake Vine in the understorey.	Good.
	There is an extensive stand south of the inlet. Dominated by Bangalay, Blackbutt and Coast Banksia with Coastal Wattle and Lomandra dominating the understorey. Bangalay Sand Forest occurs on deep, freely draining to damp sandy soils on flat to moderate slopes within a few kilometres of the sea. This EEC typically has a dense to open tree canopy, approximately 5 - 20 m tall, depending on exposure and disturbance history. Bangalay Sand Forest is generally under threat from land clearing; degradation and disturbance associated with heavy recreational use; frequent burning; rubbish dumping; and weed invasion.	
Coastal Saltmarsh	This community occurs in a small section in the north-west of the catchment and also along the southern boundary of the northern Council reserve. Dominated by sea-rush and Baumea juncea grading into Swamp Oak.	Fair.
	Located on the south side of the inlet. Dominated by Sea Rush, Isolepis unundatesm Swamp Oak, Hydrocotyle bonariensis.	
Swamp Scleophyll Forest	Area bordering Tabourie Creek adjacent to the Bangalay Forest and at the Southern end of the caravan park are dominated by Bangalay and Swamp oak with a dense cover of Snake Vine and Tall Saw-sedge in the understorey.	Fair.
	Dense stand dominated by Bangalay, Black She-Oak, Gahnia, Common Bracken, Dusky Coral Pea and Dianella with Blackbutt and Tick Bush on the edges.	

D.2.7.2 Fauna

A search of OEH's Atlas of Wildlife on 37 October 2013 revealed 4 species listed as endangered, protected and/or vulnerable. A search of the EPBC Protected Matters Search Tool on 30 August 2013 revealed 46 threatened species and 44 migratory species listed as endangered or vulnerable. **Table D-8** to **Table D-11** provides the details of these species.

The assessment of any proposed flood management works should consider the number and type of species the modification may affect.

Table D-8 Vulnerable and Endangered Flora Species (SEWPAC, 2013)

Scientific Name	Common Name	Legal Status
Boronia deanei	Deane's Boronia	V
Budawangia gnidioides	Budawangs Cliff-heath	V
Caladenia tessellata	Thick-lipped Spider-orchid, Daddy Long-legs	V
Correa baeuerlenii	Chef's Cap	V
Cryptostylis hunteriana	Leafless Tongue-orchid	V

Genoplesium vernale	East Lynne Midge-orchid	V
Leucopogon exolasius	Woronora Beard-heath	V
Melaleuca biconvexa	Biconvex Paperbark	V
Pterostylis gibbosa	Illawarra Greenhood, Rufa Greenhood, Pouched Greenhood	E
Pultenaea baeuerlenii	Budawangs Bush-pea	V
Pultenaea setulosa		V
Streblus pendulinus	Siah's Backbone, Sia's Backbone, Isaac Wood	E
Syzygium paniculatum	Magenta Lilly Pilly, Magenta Cherry, Pocket-less Brush Cherry, Scrub Cherry, Creek Lilly Pilly, Brush Cherry	V
Thesium australe	Austral Toadflax, Toadflax	V
Triplarina nowraensis	Nowra Heath-myrtle	E
Zieria tuberculata	Warty Zieria	V

Table D-9 Vulnerable and Endangered Fauna Species (OEH, 2013)

Scientific Name	Common Name	Legal Status
Birds		
Ptilinopus superbus	Superb Fruit-Dove	V,P
Thalassarche melanophris	Black-browed Albatross	V,P
Macronectes giganteus	Southern Giant Petrel	E1,P
Hieraaetus morphnoides	Little Eagle	V,P
Lophoictinia isura	Square-tailed Kite	V,P,3
Pandion cristatus	Eastern Osprey	V,P,3
Haematopus fuliginosus	Sooty Oystercatcher	V,P
Haematopus longirostris	Pied Oystercatcher	E1,P
Thinornis rubricollis	Hooded Plover	E4A, P
Sternula albifrons	Little Tern	E1, P
Callocephalon fimbriatum	Gang-gang Cockatoo	V,P,3
Calyptorhynchus lathami	Glossy Back Cockatoo	V,P,2
Pezoporus wallicus	Eastern Ground Parrot	V,P,3
Ninox connivens	Barking Owl	V,P,3
Ninox strenua	Powerful Owl	V,P,3
Tyto novaehollandiae	Masked Owl	V,P,3
Tyto tenebricosa	Sooty Owl	V,P,3

Scientific Name	Common Name	Legal Status
Anthochaera phrygia	Regent Honeyeater	E4A,P
Daphoenositta chrysoptera	Varied Sittella	V,P
Petroica phoenicea	Flame Robin	V,P
Mammals		
Dasyurus maculatus	Spotted-tailed Quoll	V,P
Phascolarctos cinereus	Koala	V,P
Cercartetus nanus	Eastern Pygmy-possum	V,P
Petaurus australis	Yellow-bellied Glider	V,P
Petaurus norfolcensis	Squirrel Glider	V,P
Pteropus poliocephalus	Grey-headed Flying Fox	V,P
Mormopterus norfolkensis	Eastern Freetail-bat	V,P
Chalinolobus dwyeri	Large-eared Pied Bat	V,P
Kerivoula papuensis	Golden-tipped Bat	V,P
Myotis macropus	Southern Myotis	V,P
Scoteanax rueppellii	Greater Broad-nosed Bat	V,P
Vespadelus troughtoni	Eastern Cave Bat	V,P
Arctocephalus pusillus doriferus	Australian Fur-Seal	V,P
Frogs		
Heleioporus australiacus	Giant Burrowing Frog	V,P
Mixophyes balbus	Stuttering Frog	E1,P,2
Litoria aurea	Green and Golden Bell Frog	E1,P
Reptiles		
Chelonia mydas	Green Turtle	V,P

Table D-10 Vulnerable and Endangered Fauna Species (SEWPAC, 2013)

Scientific Name	Common Name	Legal Status
Birds		
Anthochaera phrygia	Regent Honeyeater	E
Botaurus poiciloptilus	Australasian Bittern	E
Dasyornis brachypterus	Eastern Bristlebird	E
Diomedea exulans antipodensis	Antipodean Albatross	V
Diomedea exulans	Tristan Albatross	E
Diomedea exulans gibsoni	Gibson's Albatross	V

Scientific Name	Common Name	Legal Status
Diomedea exulans (sensu lato)	Wandering Albatross	V
Erythrotriorchis radiatus	Red Goshawk	V
Fregetta grallaria	White-bellied Storm-Petrel (Tasman Sea), White-bellied Storm-Petrel	V
Lathamus discolor	Swift Parrot	E
Macronectes giganteus	Southern Giant-Petrel	E
Macronectes halli	Northern Giant-Petrel	V
Neophema chrysogaster	Orange-bellied Parrot	CE
Pterodroma neglecta	Kermadec Petrel (western)	V
Rostratula australis	Australian Painted Snipe	E
Sternula nereis	Australian Fairy Tern	V
Thalassarche bulleri	Buller's Albatross	V
Thalassarche cauta	Shy Albatross, Tasmanian Shy Albatross	V
Thalassarche cauta salvini	Salvin's Albatross	V
Thalassarche cauta steadi	White-capped Albatross	V
Thalassarche melanophris impavida	Campbell Albatross	V
Fish		
Epinephelus daemelii	Black Rockcod, Black Cod, Saddled Rockcod	V
Prototroctes maraena	Australian Grayling	V
Frogs		
Heleioporus australiacus	Giant Burrowing Frog	V
Litoria aurea	Green and Golden Bell Frog	V
Litoria littlejohni	Littlejohn's Tree Frog, Heath Frog	V
Mixophyes balbus	Stuttering Frog	V
Mixophyes iteratus	Giant Barred Frog, Southern Barred Frog	E
Mammals		
Chalinolobus dwyeri	Large-eared Pied Bat, Large Pied Bat	V
Dasyurus maculatus	Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll	E
Eubalaena australis	Southern Right Whale	E
Isoodon obesulus	Southern Brown Bandicoot (Eastern)	E
Megaptera novaeangliae	Humpback Whale	V
Petrogale penicillata	Brush-tailed Rock-wallaby	V
Phascolarctos cinereus	Koala	V

Scientific Name	Common Name	Legal Status
Potorous tridactylus	Long-nosed Potoroo	V
Pseudomys fumeus	Konoom, Smoky Mouse	E
Pseudomys novaehollandiae	New Holland Mouse, Pookila	V
Pteropus poliocephalus	Grey-headed Flying-fox	V
Reptiles		
Caretta	Loggerhead Turtle	E
Chelonia mydas	Green Turtle	V
Dermochelys coriacea	Leatherback Turtle, Leathery Turtle, Luth	E
Eretmochelys imbricata	Hawksbill Turtle	V
Hoplocephalus bungaroides	Broad-headed Snake	V
Natator depressus	Flatback Turtle	V
Sharks		
Carcharias taurus	Grey Nurse Shark	CE
Carcharodon carcharias	Great White Shark	V
Rhincodon typus	Whale Shark	V

Table D-11 Vulnerable and Endangered Migratory Species (SEWPAC, 2013)

Scientific Name	Common Name	Legal Status
Migratory Marine Birds		
Apus pacificus	Fork-tailed Swift	
Diomedea antipodensis	Antipodean Albatross	V
Diomedea dabbenena	Tristan Albatross	E
Diomedea exulans (sensu lato)	Wandering Albatross	V
Diomedea gibsoni	Gibson's Albatross	V
Macronectes giganteus	Southern Giant-Petrel	E
Macronectes halli	Northern Giant-Petrel	V

Scientific Name	Common Name	Legal Status
Puffinus carneipes	Flesh-footed Shearwater, Fleshy-footed Shearwater	
Sterna albifrons	Little Tern	
Thalassarche bulleri	Buller's Albatross	V
Thalassarche cauta (sensu stricto)	Shy Albatross, Tasmanian Shy Albatross	V
Thalassarche impavida	Campbell Albatross	V
Thalassarche salvini	Salvin's Albatross	V
Thalassarche steadi	White-capped Albatross	V
Migratory Marine Species		
Balaenoptera edeni	Bryde's Whale	
Caperea marginata	Pygmy Right Whale	
Carcharodon carcharias	Great White Shark	V
Caretta	Loggerhead Turtle	E
Chelonia mydas	Green Turtle	V
Dermochelys coriacea	Leatherback Turtle, Leathery Turtle, Luth	E
Eretmochelys imbricata	Hawksbill Turtle	V
Eubalaena australis	Southern Right Whale	E
Lagenorhynchus obscurus	Dusky Dolphin	
Lamna nasus	Porbeagle, Mackerel Shark	
Megaptera novaeangliae	Humpback Whale	V
Natator depressus	Flatback Turtle	V
Orcinus orca	Killer Whale, Orca	
Rhincodon typus	Whale Shark	V
Migratory Terrestrial Species		
Haliaeetus leucogaster	White-bellied Sea-Eagle	
Hirundapus caudacutus	White-throated Needletail	
Merops ornatus	Rainbow Bee-eater	
Monarcha melanopsis	Black-faced Monarch	
Monarcha trivirgatus	Spectacled Monarch	
Myiagra cyanoleuca	Satin Flycatcher	
Neophema chrysogaster	Orange-bellied Parrot	CE
Rhipidura rufifrons	Rufous Fantail	
Xanthomyza phrygia	Regent Honeyeater	E

Scientific Name	Common Name	Legal Status
Migratory Wetland Species		
Ardea alba	Great Egret, White Egret	
Ardea ibis	Cattle Egret	
Charadrius bicinctus	Double-banded Plover	
Gallinago hardwickii	Latham's Snipe, Japanese Snipe	
Limosa lapponica	Bar-tailed Godwit	
Numenius madagascariensis	Eastern Curlew	
Rostratula benghalensis (sensu lato)	Painted Snipe	E

D.2.8 Wetlands

Wetlands protected under State Environmental Planning Policy No. 14 (SEPP14) are associated directly with Tabourie Lake and its catchment. A small saltmarsh of Sarcocornia quinqueflora, Selliera radicans, Mimulus repens and Sporobolus virginicus has been found in the wetlands. Biosphere Environmental Consultants (2000) undertook frog and mammal surveys in the wetland which detected the threatened mammal Fishing Bat (Myotis adversus) (SCC, 2012).

Flood modification works within the vicinity of these wetlands should both consider the protection of the wetlands from flood damages and compatibility of the wetlands with the flood works.

D.2.9 Seagrasses

Seagrass communities in Tabourie Lake includes Eel grass (Zostra capricorni) near the estuary entrance, Paddle weed (Halophila ovalis) in the channel further upstream from the entrance and large areas of Sea tassel (Ruppia megacarpa) in the main lake basin (SCC, 2012). The status of seagrasses around the estuary has been reported as ‘very poor’ in the NSW State of the Catchment (SoC) Report for estuaries in the Southern Rivers Region (DECCW, 2010).

Flood modification works within the vicinity of these seagrasses should both consider the protection of the seagrass from flood damages and compatibility with the flood works.

D.2.10 Heritage

D.2.10.1 Aboriginal Heritage

The National Parks and Wildlife Act 1974 provides protection for Aboriginal heritage. The objective of the Act is to conserve heritage items of cultural significance to Aboriginal people and to promote public appreciation of these items. Proposed flood modification actions need to consider any potential impact on identified heritage items.

A preliminary investigation of indigenous heritage was undertaken by searching the NPWS Aboriginal Heritage Information Management System (AHIMS) in September 2013 for known or potential indigenous archaeological or cultural heritage sites within or surrounding the Tabourie Lake Catchment. The items are presented in **Table D-12.**

The following qualifications apply to an AHIMS search:

- AHIMS only includes information on Aboriginal objects and Aboriginal places that have been provided to OEH;
- Large areas of New South Wales have not been the subject of systematic survey or recording of Aboriginal history. These areas may contain Aboriginal objects and other heritage values which are not recorded on AHIMS;
- Recordings are provided from a variety of sources and may be variable in their accuracy. When an AHIMS search identifies Aboriginal objects in or near the area it is recommended that the exact location of the Aboriginal object be determined by re-location on the ground; and
- The criteria used to search AHIMS are derived from the information provided by the client and OEH assumes that this information is accurate.

Table D-12 Items identified under the NPWS Aboriginal Heritage Information Management System for Tabourie Lake (AHIMS, 2013)

Site Type	Number of sites within the Tabourie Lake catchment
Artefact	63
Stone Arrangement	2
Potential Archaeological Deposit (PAD)	5
Shell	30

D.2.10.2 Land Rights and Native Title Claims

Land rights and Native Title are two different forms in which traditional land owners can gain access to land or claim compensation for previous dispossession of their land.

Under the Aboriginal Land Rights Act 1983 local Aboriginal land councils can claim Crown lands provided the lands are vacant and not otherwise required for an essential public purpose. A search on the Land Claims Register maintained by the Office of the Registrar, Aboriginal Land Rights Act 1983 (ORALRA), on 2 September 2013 found one register of Native Title claim which encompasses the whole study area and no Land Use Agreements within the study area.

The Native Title Claim identified for the study area covers a total area of 18,675 km2 and extends from the south of Katoomba to Goulburn. The claim was lodged in 1997 and the tribunal file number is NC97/7. The claim was filed by Gundungurra Tribal Council Aboriginal Corporation and is registered and active.

Before flood management works proceed, any active claims in the development vicinity would need to be confirmed to ensure that an up-to-date evaluation of potential constraints is available and appropriate consultation is undertaken.

D.2.10.3 Non-Aboriginal Heritage

There are three different types of statutory heritage listings of non-Aboriginal origin; local, state or national heritage items. A property is a heritage item if it falls into a listings category. The category of an item depends on whether it is considered to be significant to the nation, state or a local area. The significance of an item is a status determined by assessing its historical, scientific, cultural, social, archaeological, architectural, natural or aesthetic value.

A desktop review of non-Aboriginal heritage was undertaken for the catchment. Searches were undertaken on a number of databases to determine the cultural heritage within this area. Databases searched include:

Australian Heritage Database (incorporates World Heritage List; National Heritage List; Commonwealth Heritage List; Register of the National Estate);

NSW Heritage Office – State Heritage Register; and

Shoalhaven Local Environment Plan (LEP) 1985.

A search of the Australian Heritage Database and the State Heritage Register on 2 September 2013 did not identify any heritage items within or in close proximity to the Tabourie Lake catchment.

There are also no sites of European heritage listed in the Shoalhaven LEP 1985 that have local significance within the catchment.

Floodplain Risk Management Study

APPENDIX

E

OPTION COSTINGS

Cardno
Shaping the Future

49913170 - Tabourie Lake FRMSP

Princes Highway Levee
Cost Estimate

v1

ITEM NO.	DESCRIPTION OF WORK	QUANTITY	UNIT	RATE	COST
1.0	**GENERAL AND PRELIMINARIES**				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item		
1.2	Provision of sediment & erosion control	1	item		
1.3	Construction setout & survey	1	item		
1.4	Work as executed survey & documentation	1	item		
1.5	Geotechnical supervision, testing & certification	1	item		
	SUBTOTAL (Assumed as 15% of works cost)				**45,900**
2.0	**DEMOLITION, CLEARING AND GRUBBING**				
2.1	Clearing & grubbing	6,200	sq. m	10	62,000
2.2	Strip topsoil & stockpile for re-use (assuming 150mm depth)	930	cu. m	20	18,600
2.3	Dispose of excess topsoil (nominal 10% allowance)	93	cu. m	50	4,650
	SUBTOTAL				**85,250**
3.0	**EARTHWORKS**				
3.1	Construct levee	3170	cu. m	50	158,500
	SUBTOTAL				**158,500**
4.0	**MINOR LANDSCAPING**				
4.1	Repair disturbed areas in accordance with landscape architects requirements (nominal allowance)	6,200	sq. m	10	62,000
	SUBTOTAL				**62,000**
	CONSTRUCTION SUB-TOTAL				**351,650**
5.0	**CONTINGENCIES**				
5.1	50% construction cost				**175,825**
	CONSTRUCTION TOTAL, excluding GST				**527,475**
	GST				**52,748**
	CONSTRUCTION TOTAL, including GST				**580,223**
	CONSTRUCTION TOTAL, rounded				**580,300**

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NOTES:

1. Estimate does not include Consultant's fees, including design or project management
2. Assume existing drainage at sufficiently deep level to remain undisturbed.
3. Estimate / rates in 2010 dollars and does not allow for inflation

49913170 - Tabourie Lake FRMSP

Portland Way Levee
Cost Estimate

v1

ITEM NO.	DESCRIPTION OF WORK	QUANTITY	UNIT	RATE	COST
1.0	**GENERAL AND PRELIMINARIES**				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item		
1.2	Provision of sediment & erosion control	1	item		
1.3	Construction setout & survey	1	item		
1.4	Work as executed survey & documentation	1	item		
1.5	Geotechnical supervision, testing & certification	1	item		
	SUBTOTAL (Assumed as 15% of works cost)				**13,800**
2.0	**DEMOLITION, CLEARING AND GRUBBING**				
2.1	Clearing & grubbing	2,500	sq. m	10	25,000
2.2	Strip topsoil & stockpile for re-use (assuming 150mm depth)	375	cu. m	20	7,500
2.3	Dispose of excess topsoil (nominal 10% allowance)	37.5	cu. m	50	1,875
	SUBTOTAL				**34,375**
3.0	**EARTHWORKS**				
3.1	Construct levee	650	cu. m	50	32,500
	SUBTOTAL				**32,500**
4.0	**MINOR LANDSCAPING**				
4.1	Repair disturbed areas in accordance with landscape architects requirements (nominal allowance)	2,500	sq. m	10	25,000
	SUBTOTAL				**25,000**
	CONSTRUCTION SUB-TOTAL				**105,675**
5.0	**CONTINGENCIES**				
5.1	50% construction cost				**52,838**
	CONSTRUCTION TOTAL, excluding GST				**158,513**
	GST				**15,851**
	CONSTRUCTION TOTAL, including GST				**174,364**
	CONSTRUCTION TOTAL, rounded				**174,400**

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NOTES:

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3. Estimate / rates in 2010 dollars and does not allow for inflation

49913170 - Tabourie Lake FRMSP

Caravan Road Raising
Cost Estimate

v1

ITEM NO.	DESCRIPTION OF WORK	QUANTITY	UNIT	RATE	COST
1.0	**GENERAL AND PRELIMINARIES**				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item		
1.2	Provision of sediment & erosion control	1	item		
1.3	Construction setout & survey	1	item		
1.4	Work as executed survey & documentation	1	item		
1.5	Geotechnical supervision, testing & certification	1	item		
	SUBTOTAL (Assumed as 15% of works cost)				**32,200**
2.0	**DEMOLITION, CLEARING AND GRUBBING**				
2.1	Clearing & grubbing	3,120	sq. m	10	31,200
2.2	Strip topsoil & stockpile for re-use (assuming 150mm depth)	468	cu. m	20	9,360
2.3	Dispose of excess topsoil (nominal 10% allowance)	46.8	cu. m	50	2,340
2.4	Pull up and dispose existing road surface	2080	sq.m	15	31,200
	SUBTOTAL				**42,900**
3.0	**EARTHWORKS**				
3.1	Raise road base to new levels including compaction of fill	1350	cu. m	50	67,500
	SUBTOTAL				**67,500**
4.0	**Pavements**				
4.1	Reinstate disturbed road pavement, including demolition and disposal of additional material to provide good jointing	2,080	sq. m	35	72,800
	SUBTOTAL				**72,800**
5.0	**MINOR LANDSCAPING**				
5.1	Repair disturbed areas in accordance with landscape architects requirements (nominal allowance)	3,120	sq. m	10	31,200
	SUBTOTAL				**31,200**
	CONSTRUCTION SUB-TOTAL				**246,600**
5.0	**CONTINGENCIES**				
5.1	50% construction cost				**123,300**
	CONSTRUCTION TOTAL, excluding GST				**369,900**
	GST				**36,990**
	CONSTRUCTION TOTAL, including GST				**406,890**
	CONSTRUCTION TOTAL, rounded				**406,900**

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NOTES:

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3. Estimate / rates in 2010 dollars and does not allow for inflation

49913170 - Tabourie Lake FRMSP

River & Lyra Rd Raising
Cost Estimate

v1

ITEM NO.	DESCRIPTION OF WORK	QUANTITY	UNIT	RATE	COST
1.0	**GENERAL AND PRELIMINARIES**				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item		
1.2	Provision of sediment & erosion control	1	item		
1.3	Construction setout & survey	1	item		
1.4	Work as executed survey & documentation	1	item		
1.5	Geotechnical supervision, testing & certification	1	item		
	SUBTOTAL (Assumed as 15% of works cost)				**40,800**
2.0	**DEMOLITION, CLEARING AND GRUBBING**				
2.1	Clearing & grubbing	900	sq. m	10	9,000
2.2	Strip topsoil & stockpile for re-use (assuming 150mm depth)	135	cu. m	20	2,700
2.3	Dispose of excess topsoil (nominal 10% allowance)	13.5	cu. m	50	675
2.4	Pull up and dispose existing road surface	2700	sq.m	35	94,500
	SUBTOTAL				**12,375**
3.0	**EARTHWORKS**				
3.1	Raise road base to new levels including compaction of fill	2300	cu. m	50	115,000
	SUBTOTAL				**115,000**
4.0	**Pavements**				
4.1	Reinstate disturbed road pavement, including demolition and disposal of additional material to provide good jointing	2,700	sq. m	50	135,000
	SUBTOTAL				**135,000**
5.0	**MINOR LANDSCAPING**				
5.1	Repair disturbed areas in accordance with landscape architects requirements (nominal allowance)	900	sq. m	10	9,000
	SUBTOTAL				**9,000**
	CONSTRUCTION SUB-TOTAL				**312,175**
5.0	**CONTINGENCIES**				
5.1	50% construction cost				**156,088**
	CONSTRUCTION TOTAL, excluding GST				**468,263**
	GST				**46,826**
	CONSTRUCTION TOTAL, including GST				**515,089**
	CONSTRUCTION TOTAL, rounded				**515,100**

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NOTES:

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3. Estimate / rates in 2010 dollars and does not allow for inflation

49913170 - Tabourie Lake FRMSP

Beach & Bridge Street Raising
Cost Estimate

v1

ITEM NO.	DESCRIPTION OF WORK	QUANTITY	UNIT	RATE	COST
1.0	**GENERAL AND PRELIMINARIES**				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item		
1.2	Provision of sediment & erosion control	1	item		
1.3	Construction setout & survey	1	item		
1.4	Work as executed survey & documentation	1	item		
1.5	Geotechnical supervision, testing & certification	1	item		
	SUBTOTAL (Assumed as 15% of works cost)				**41,500**
2.0	**DEMOLITION, CLEARING AND GRUBBING**				
2.1	Clearing & grubbing	1,850	sq. m	10	18,500
2.2	Strip topsoil & stockpile for re-use (assuming 150mm depth)	277.5	cu. m	20	5,550
2.3	Dispose of excess topsoil (nominal 10% allowance)	27.75	cu. m	50	1,388
2.4	Pull up and dispose existing road surface	1800	sq.m	35	63,000
	SUBTOTAL				**25,438**
3.0	**EARTHWORKS**				
3.1	Raise road base to new levels including compaction of fill	1730	cu. m	50	86,500
3.2	Construct levee	1120	cu. m	50	56,000
	SUBTOTAL				**142,500**
4.0	**Pavements**				
4.1	Reinstate disturbed road pavement, including demolition and disposal of additional material to provide good jointing	1,800	sq. m	50	90,000
	SUBTOTAL				**90,000**
5.0	**MINOR LANDSCAPING**				
5.1	Repair disturbed areas in accordance with landscape architects requirements (nominal allowance)	1,850	sq. m	10	18,500
	SUBTOTAL				**18,500**
	CONSTRUCTION SUB-TOTAL				**317,938**
5.0	**CONTINGENCIES**				
5.1	50% construction cost				**158,969**
	CONSTRUCTION TOTAL, excluding GST				**476,906**
	GST				**47,691**
	CONSTRUCTION TOTAL, including GST				**524,597**
	CONSTRUCTION TOTAL, rounded				**524,600**

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NOTES:

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3. Estimate / rates in 2010 dollars and does not allow for inflation

49913170 - Tabourie Lake FRMSP

Cardno Shaping the Future

Bridge & Centre St Raising
Cost Estimate

v1

ITEM NO.	DESCRIPTION OF WORK	QUANTITY	UNIT	RATE	COST
1.0	**GENERAL AND PRELIMINARIES**				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item		
1.2	Provision of sediment & erosion control	1	item		
1.3	Construction setout & survey	1	item		
1.4	Work as executed survey & documentation	1	item		
1.5	Geotechnical supervision, testing & certification	1	item		
	SUBTOTAL (Assumed as 15% of works cost)				**73,400**
2.0	**DEMOLITION, CLEARING AND GRUBBING**				
2.1	Clearing & grubbing	4,050	sq. m	10	40,500
2.2	Strip topsoil & stockpile for re-use (assuming 150mm depth)	607.5	cu. m	20	12,150
2.3	Dispose of excess topsoil (nominal 10% allowance)	60.75	cu. m	50	3,038
2.4	Pull up and dispose existing road surface	1800	sq.m	35	63,000
	SUBTOTAL				**55,688**
3.0	**EARTHWORKS**				
3.1	Raise road base to new levels including compaction of fill	1730	cu. m	50	86,500
3.2	Construct levee	4320	cu. m	50	216,000
	SUBTOTAL				**302,500**
4.0	**Pavements**				
4.1	Reinstate disturbed road pavement, including demolition and disposal of additional material to provide good jointing	1,800	sq. m	50	90,000
	SUBTOTAL				**90,000**
5.0	**MINOR LANDSCAPING**				
5.1	Repair disturbed areas in accordance with landscape architects requirements (nominal allowance)	4,050	sq. m	10	40,500
	SUBTOTAL				**40,500**
	CONSTRUCTION SUB-TOTAL				**562,088**
5.0	**CONTINGENCIES**				
5.1	50% construction cost				**281,044**
	CONSTRUCTION TOTAL, excluding GST				**843,131**
	GST				**84,313**
	CONSTRUCTION TOTAL, including GST				**927,444**
	CONSTRUCTION TOTAL, rounded				**927,500**

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3. Estimate / rates in 2010 dollars and does not allow for inflation

49913170 - Tabourie Lake FRMSP

Combination 2-2 + 2-3 + 2-4
Cost Estimate

v1

ITEM NO.	DESCRIPTION OF WORK	QUANTITY	UNIT	RATE	COST
1.0	**GENERAL AND PRELIMINARIES**				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item		
1.2	Provision of sediment & erosion control	1	item		
1.3	Construction setout & survey	1	item		
1.4	Work as executed survey & documentation	1	item		
1.5	Geotechnical supervision, testing & certification	1	item		
	SUBTOTAL (Assumed as 15% of works cost)				**129,000**
2.0	**DEMOLITION, CLEARING AND GRUBBING**				
2.1	Clearing & grubbing	6,800	sq. m	10	68,000
2.2	Strip topsoil & stockpile for re-use (assuming 150mm depth)	1020	cu. m	20	20,400
2.3	Dispose of excess topsoil (nominal 10% allowance)	102	cu. m	50	5,100
2.4	Pull up and dispose existing road surface	4500	sq.m	35	157,500
	SUBTOTAL				**93,500**
3.0	**EARTHWORKS**				
3.1	Raise road base to new levels including compaction of fill	4030	cu. m	50	201,500
3.2	Construct levee	5440	cu. m	50	272,000
	SUBTOTAL				**473,500**
4.0	**Pavements**				
4.1	Reinstate disturbed road pavement, including demolition and disposal of additional material to provide good jointing	4,500	sq. m	50	225,000
	SUBTOTAL				**225,000**
5.0	**MINOR LANDSCAPING**				
5.1	Repair disturbed areas in accordance with landscape architects requirements (nominal allowance)	6,800	sq. m	10	68,000
	SUBTOTAL				**68,000**
	CONSTRUCTION SUB-TOTAL				**989,000**
5.0	**CONTINGENCIES**				
5.1	50% construction cost				**494,500**
	CONSTRUCTION TOTAL, excluding GST				**1,483,500**
	GST				**148,350**
	CONSTRUCTION TOTAL, including GST				**1,631,850**
	CONSTRUCTION TOTAL, rounded				**1,631,900**

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NOTES:

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3. Estimate / rates in 2010 dollars and does not allow for inflation

49913170 - Tabourie Lake FRMSP

Combination 2-2 + 2-3 + 2-4 - 1% AEP Protection
Cost Estimate

v1

ITEM NO.	DESCRIPTION OF WORK	QUANTITY	UNIT	RATE	COST
1.0	**GENERAL AND PRELIMINARIES**				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item		
1.2	Provision of sediment & erosion control	1	item		
1.3	Construction setout & survey	1	item		
1.4	Work as executed survey & documentation	1	item		
1.5	Geotechnical supervision, testing & certification	1	item		
	SUBTOTAL (Assumed as 15% of works cost)				**150,500**
2.0	**DEMOLITION, CLEARING AND GRUBBING**				
2.1	Clearing & grubbing	2,450	sq. m	10	24,500
2.2	Strip topsoil & stockpile for re-use (assuming 150mm depth)	367.5	cu. m	20	7,350
2.3	Dispose of excess topsoil (nominal 10% allowance)	36.75	cu. m	50	1,838
2.4	Pull up and dispose existing road surface	4500	sq.m	35	157,500
	SUBTOTAL				**33,688**
3.0	**Flood walls**				
3.1	Construct flood walls, including pilings, sheeting and footings as required	1890	sq. face m	500	945,000
	SUBTOTAL				**945,000**
5.0	**MINOR LANDSCAPING**				
5.1	Repair disturbed areas in accordance with landscape architects requirements (nominal allowance)	2,450	sq. m	10	24,500
	SUBTOTAL				**24,500**
	CONSTRUCTION SUB-TOTAL				**1,153,688**
5.0	**CONTINGENCIES**				
5.1	50% construction cost				**576,844**
	CONSTRUCTION TOTAL, excluding GST				**1,730,531**
	GST				**173,053**
	CONSTRUCTION TOTAL, including GST				**1,903,584**
	CONSTRUCTION TOTAL, rounded				**1,903,600**

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NOTES:

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3. Estimate / rates in 2010 dollars and does not allow for inflation

49913170 - Tabourie Lake FRMSP

Cardno Shaping the Future

Highway Raising
Cost Estimate

v1

ITEM NO.	DESCRIPTION OF WORK	QUANTITY	UNIT	RATE	COST
1.0	**GENERAL AND PRELIMINARIES**				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item		
1.2	Provision of sediment & erosion control	1	item		
1.3	Construction setout & survey	1	item		
1.4	Work as executed survey & documentation	1	item		
1.5	Geotechnical supervision, testing & certification	1	item		
	SUBTOTAL (Assumed as 15% of works cost)				**32,500**
2.0	**DEMOLITION, CLEARING AND GRUBBING**				
2.1	Clearing & grubbing	3,720	sq. m	10	37,200
2.2	Strip topsoil & stockpile for re-use (assuming 150mm depth)	558	cu. m	20	11,160
2.3	Dispose of excess topsoil (nominal 10% allowance)	55.8	cu. m	50	2,790
2.4	Pull up and dispose existing road surface	2480	sq.m	15	37,200
	SUBTOTAL				**51,150**
3.0	**EARTHWORKS**				
3.1	Raise road base to new levels including compaction of fill	820	cu. m	50	41,000
	SUBTOTAL				**41,000**
4.0	**Pavements**				
4.1	Reinstate disturbed road pavement, including demolition and disposal of additional material to provide good jointing	2,480	sq. m	35	86,800
	SUBTOTAL				**86,800**
5.0	**MINOR LANDSCAPING**				
5.1	Repair disturbed areas in accordance with landscape architects requirements (nominal allowance)	3,720	sq. m	10	37,200
	SUBTOTAL				**37,200**
	CONSTRUCTION SUB-TOTAL				**248,650**
5.0	**CONTINGENCIES**				
5.1	50% construction cost				**124,325**
	CONSTRUCTION TOTAL, excluding GST				**372,975**
	GST				**37,298**
	CONSTRUCTION TOTAL, including GST				**410,273**
	CONSTRUCTION TOTAL, rounded				**410,300**

DISCLAIMER:

1. This estimate of cost is provided in good faith using information available at this stage. This estimate of cost is not guaranteed. Cardno (NSW) will not accept liability in the event that actual costs exceed the estimate.

NOTES:

1. Estimate does not include Consultant's fees, including design or project management
2. Assume existing drainage at sufficiently deep level to remain undisturbed.
3. Estimate / rates in 2010 dollars and does not allow for inflation

Floodplain Risk Management Study

APPENDIX

F

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	Economic Score	Reduction in Risk to Life	Reduction in Social Disruption	Community Criteria	Aesthetic & Lake / Creek Access Impacts	Council Support	Compatible with Policies and Plans	Social Score	Surface Water Quality	Groundwater	Flora / Fauna Impact	Acid Sulfate Soils	Heritage	Environmental Score	TOTAL SCORE	RANK on TOTAL SCORE
1	FM 1.1 *	Flood Modification	Princes Highway Creek Side Levee	$580,300	$2,000	$607,901	$62,333	18.2%	$860,242	1.42	1	-1	2	**0.8**	1	0	-2	-2	0	0	**-0.5**	0	0	0	-2	0	**-0.4**	**0.6**	**17**
2	FM 1.2 *	Flood Modification	Portland Way Levee	$174,400	$2,500	$208,902	$5,393	1.6%	$74,427	0.36	-1	0	1	**-0.3**	0	0	-2	-1	0	0	**-0.5**	0	0	0	-2	-1	**-0.6**	**-1.6**	**19**
6	FM 2.1	Flood Modification	Caravan Park Road Raising	$406,900	$1,000	$420,701	NC	N/A	N/A	N/A	1	0	1	**0.8**	2	1	-1	0	0	0	**0.3**	0	0	0	-1	0	**-0.2**	**1.6**	**14**
7	FM 2.2 *	Flood Modification	River and Lyra Road Raising	$515,100	$1,500	$535,801	$2,387	0.7%	$32,942	0.06	-2	-1	1	**-1.0**	1	0	2	0	0	0	**0.5**	0	0	0	-1	-2	**-0.6**	**-2.1**	**21**
8	FM 2.3 *	Flood Modification	Beach and Bridge Street Raising	$524,600	$2,000	$552,201	$989	0.3%	$13,649	0.02	-2	-1	1	**-1.0**	1	0	-2	-1	0	0	**-0.3**	0	0	0	-1	-1	**-0.4**	**-2.7**	**22**
9	FM 2.4 *	Flood Modification	Bridge and Centre Street Raising and Flood Levee Construction	$927,500	$2,000	$955,101	$77,472	22.6%	$1,069,171	1.12	1	-1	2	**0.8**	1	1	-2	-2	0	0	**-0.3**	0	0	0	-1	-1	**-0.4**	**0.8**	**16**
10	FM 2.5 *	Flood Modification	Local Road Raising Combination	$1,631,900	$5,000	$1,700,904	$78,461	22.9%	$1,082,820	0.64	-1	-1	1	**-0.5**	2	0	-2	-2	0	0	**-0.3**	0	0	0	-1	-2	**-0.6**	**-1.9**	**20**
11	FM 2.5a *	Flood Modification	Local Road Raising Combination - 1% AEP protection	$1,903,600	$5,000	$1,972,604	$204,920	59.9%	$2,828,049	1.43	1	-1	2	**0.8**	2	0	-2	-2	0	0	**-0.3**	0	0	0	-1	-2	**-0.6**	**0.6**	**18**
12	FM 2.6	Flood Modification	Princes Highway Raising	$410,300	$1,000	$424,101	NC	N/A	N/A	N/A	2	0	1	**1.3**	0	0	-2	0	0	0	**-0.3**	0	0	0	-2	0	**-0.4**	**1.8**	**13**
13	FM 3.1	Flood Modification	Lake Dredging	Not viable, refer report																									
14	FM 3.2	Flood Modification	Entrance Dredging	Not viable, refer report																									
15	FM 3.3	Flood Modification	Saltwater Creek Dredging	Not viable, refer report																									
16	FM 4.1	Flood Modification	Saltwater Creek Vegetation Management	Not viable, refer report																									
17	P1	Property Modification	House Raising	Not viable, refer report																									
18	P2	Property Modification	Voluntary Purchase	Not viable, refer report																									
19	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	0	2	0	1	0	**0.8**	0	0	0	0	0	**0.0**	**3.8**	**2**
20	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	$650,000	$1,000	$663,801	NC	N/A	N/A	N/A	1	-1	1	**0.5**	1	0	0	0	1	0	**0.3**	0	0	0	0	0	**0.0**	**1.3**	**15**
23	P7	Property Modification	Flood Proofing Guidelines	$15,000	$1,000	$28,801	NC	N/A	N/A	N/A	1	2	1	**1.3**	1	0	2	0	1	0	**0.7**	0	0	0	0	0	**0.0**	**3.2**	**8**
24	EM1	Emergency Response Modification	Information transfer to the SES	$3,000	$250	$6,450	NC	N/A	N/A	N/A	2	2	0	**1.5**	2	0	2	0	2	0	**1.0**	0	0	0	0	0	**0.0**	**4.0**	**1**
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	1	1	0	**0.8**	2	0	1	0	2	1	**1.0**	0	0	0	0	0	**0.0**	**2.5**	**9**
26	EM3	Emergency Response Modification	Flood warning system	$50,000	$500	$56,900	NC	N/A	N/A	N/A	1	1	1	**1.0**	2	2	2	0	2	0	**1.3**	0	0	0	0	0	**0.0**	**3.3**	**7**
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	0	1	0	**1.0**	0	0	0	0	0	**0.0**	**2.5**	**9**
28	EM5	Emergency Response Modification	Flood warning signs	$5,000	$200	$7,760	NC	N/A	N/A	N/A	2	2	0	**1.5**	1	0	1	0	1	0	**0.5**	0	0	0	0	0	**0.0**	**3.5**	**4**
29	EM6	Emergency Response Modification	Local Evacuation Centres	$5,000	$500	$11,900	NC	N/A	N/A	N/A	2	2	0	**1.5**	2	0	1	0	1	0	**0.7**	0	0	0	0	0	**0.0**	**3.7**	**3**
30	EM7a	Emergency Response Modification	Relocation of the Childcare Facility	$500,000	$0	$500,000	NC	N/A	N/A	N/A	2	-1	0	**0.8**	2	1	1	0	1	0	**0.8**	0	0	0	0	0	**0.0**	**2.3**	**11**
31	EM7b	Emergency Response Modification	Flood Emergency Response Plan for Childcare Centre	$5,000	$250	$8,450	NC	N/A	N/A	N/A	2	2	0	**1.5**	1	0	1	0	1	0	**0.5**	0	0	0	0	0	**0.0**	**3.5**	**4**
32	DC1	Data Collection Strategy	Data collection following a flood event	$5,000	$3,000	$46,402	NC	N/A	N/A	N/A	2	2	0	**1.5**	0	0	1	0	1	0	**0.3**	0	0	0	0	0	**0.0**	**3.3**	**6**
33	EMP	Entrance Management	Review Entrance Management Policy	$50,000	$0	$50,000	NC	N/A	N/A	N/A	1	2	0	**1.0**	0	0	2	0	0	0	**0.3**	0	0	0	0	0	**0.0**	**2.3**	**11**

** Indicates hydraulic model and detailed economic assessment used*

NC - Not Costed