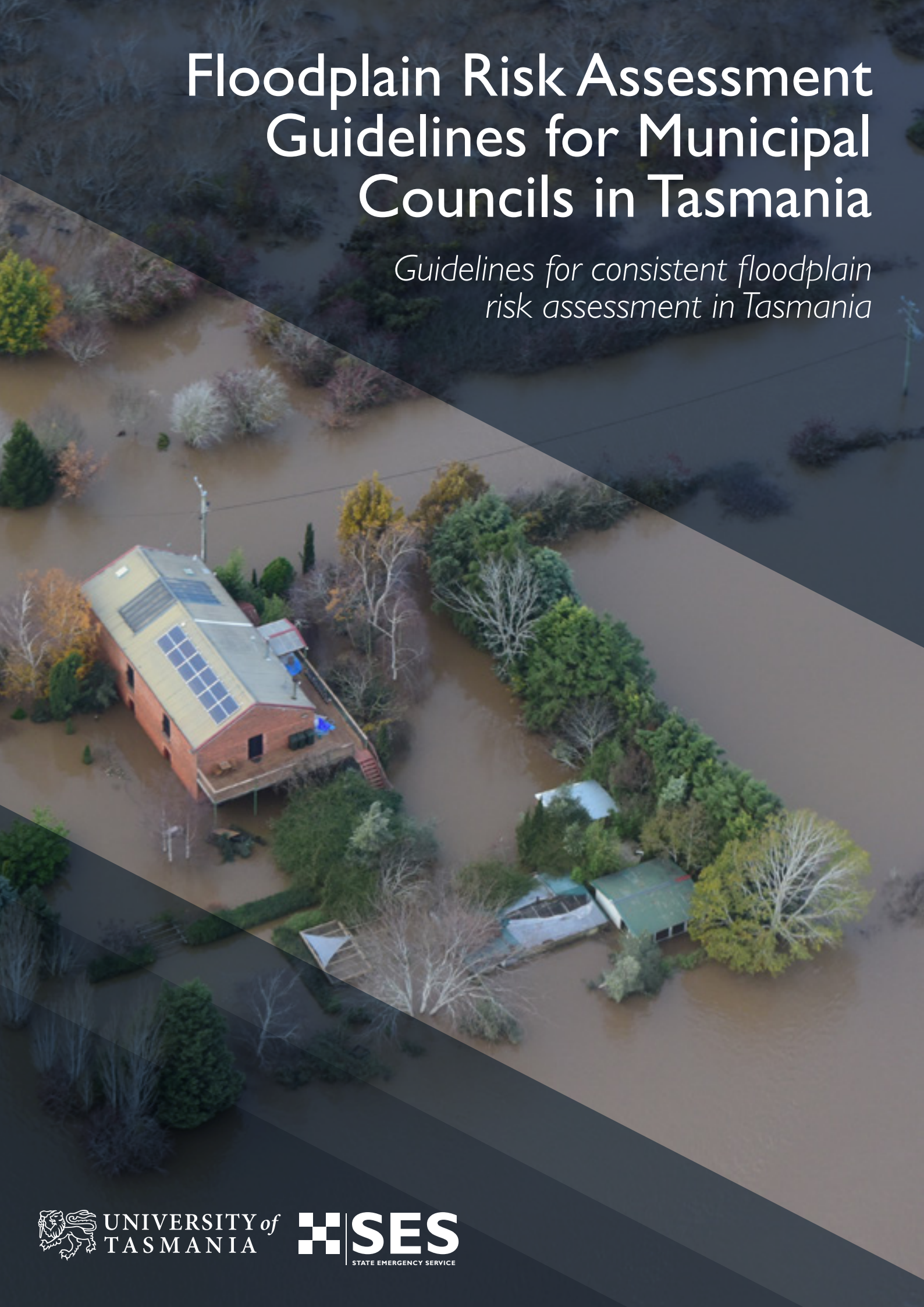
Floodplain Risk Assessment Guidelines for Municipal Councils in Tasmania

Guidelines for consistent floodplain risk assessment in Tasmania



UNIVERSITY of TASMANIA

SES STATE EMERGENCY SERVICE

Guidelines for consistent floodplain risk assessment in Tasmania

Floodplain risk assessments in Tasmania

Flooding in a natural process. Many towns are located within the floodplain and derive social, economic and environmental benefits from occupying these areas. However, floods can impose significant costs on these communities if flood risk is inadequately managed. Flooding is one of the highest risk natural hazards that pose a threat to Tasmania[1]. Flooding was the second most costly natural hazard between 1967 and 2005, with the average annual cost of flooding in Tasmania estimated to be $6.9million[2]. Although many Councils will have their own risk management framework for managing natural hazards, the use of flood study information in local flood risk management decision-making is "…generally inconsistent and limited in some instances"[3].

Context of these guidelines

Councils provide leadership at the municipal level for emergency management in Tasmania. This includes chairing Municipal Emergency Management Committees (MEMCs) that undertake municipal level all-hazards risk assessments and coordinate the treatment of these risks at the local level. Many Councils also directly undertake floodplain risk management activities.

These guidelines are aimed at Councils and MEMCs whose risk profile includes significant risks posed by flooding hazards, and are intended to assist with the conduct of detailed flood specific risk assessments that may be required to compliment municipal level all-hazards risk assessments.

These Guidelines summarise a method for the assessment of floodplain risks that is consistent with the revised 2015 National Emergency Risk Assessment Guidelines (NERAG)[4,5] and the Australian Emergency Management floodplain risk management guideline (AEM7)[6]. The NERAG provides a nationally consistent methodology to assess emergency-related risks and supports the improvement of resilience in communities as set out in the National Strategy for Disaster Resilience.

The floodplain risk assessment process in the NERAG and AEM7 were applied at the municipal level using the Huon River at Huonville as a local-scale case study.

$6.9 MILLION:
The estimated average annual cost of flooding in Tasmania

Why should local Government follow these guidelines?

To facilitate coordinated flood risk management methods across Tasmania, there is a need for Councils to apply a consistent approach to floodplain risk management. Application of a consistent risk assessment process between Councils will help improve the identification of state-wide flood risk priorities and mitigation strategies, which can lead to improved, transparent planning and decision-making for flood risk management in Tasmania.

The role of Council in flood risk management?

Councils may have a direct or shared management role in managing flood risk. Councils are often responsible for land-use planning, building controls, maintenance and construction of flood mitigation infrastructure, and promoting general community awareness for flooding within their municipality. Council also works with the State Emergency Service and other authorities in the planning and response to natural hazards within their area. Maintaining a current flood risk management plan is crucial to support planning and decision-making activities within the municipality to achieve the strategic objectives of Council.

The Huonville floodplain risk case study

A local-scale floodplain risk management study was undertaken at Huonville, which included a floodplain risk assessment, identification of risk treatment options and evaluation of residual risks[7]. The town of Huonville is 38km southwest of Hobart. The town is located on the banks of the Huon River and experiences minor flooding on a regular basis.

Outputs from the study enabled the Huon Valley Council to present updated risk information to their MEMC for further consideration in the management of flood risk.

Throughout these guidelines, reference is made to the Huonville case study using blue boxes, referred to as 'The Huonville experience'. These boxes complement the guidelines by providing practical insights from the Huonville case study on how the assessment process was applied.

2,264km²

land within the Huon River catchment between Scotts Peak Dam and Huonville

2,669m³/s

the theoretical peak discharge at Huonville for a 1% AEP flood

0.25m-0.5m

expected depth of flood waters in Main Street Huonville for a 1% AEP flood

20

buildings estimated to be damaged by a 1% AEP flood

$555,000

cost of damage to buildings estimated for a 1% AEP flood at Huonville

Floodplain risk assessment guidelines

The risk assessment process

The municipal floodplain risk assessment process reflected in this guideline follows the process demonstrated in the Huonville Flood Risk Assessment (Fig. 1), drawing upon the methodology documented in NERAG and AEM7.

THE HUONVILLE EXPERIENCE

Facilitated workshops proved to be an effective mechanism to engage with stakeholders throughout the floodplain risk assessment process.

Although the NERAG risk assessment methodology focuses on emergency-related risk management, it aligns to an internationally accepted risk management standard[8]. All risk assessment activities documented in the NERAG methodology are covered in the three workshops (Fig. 1).

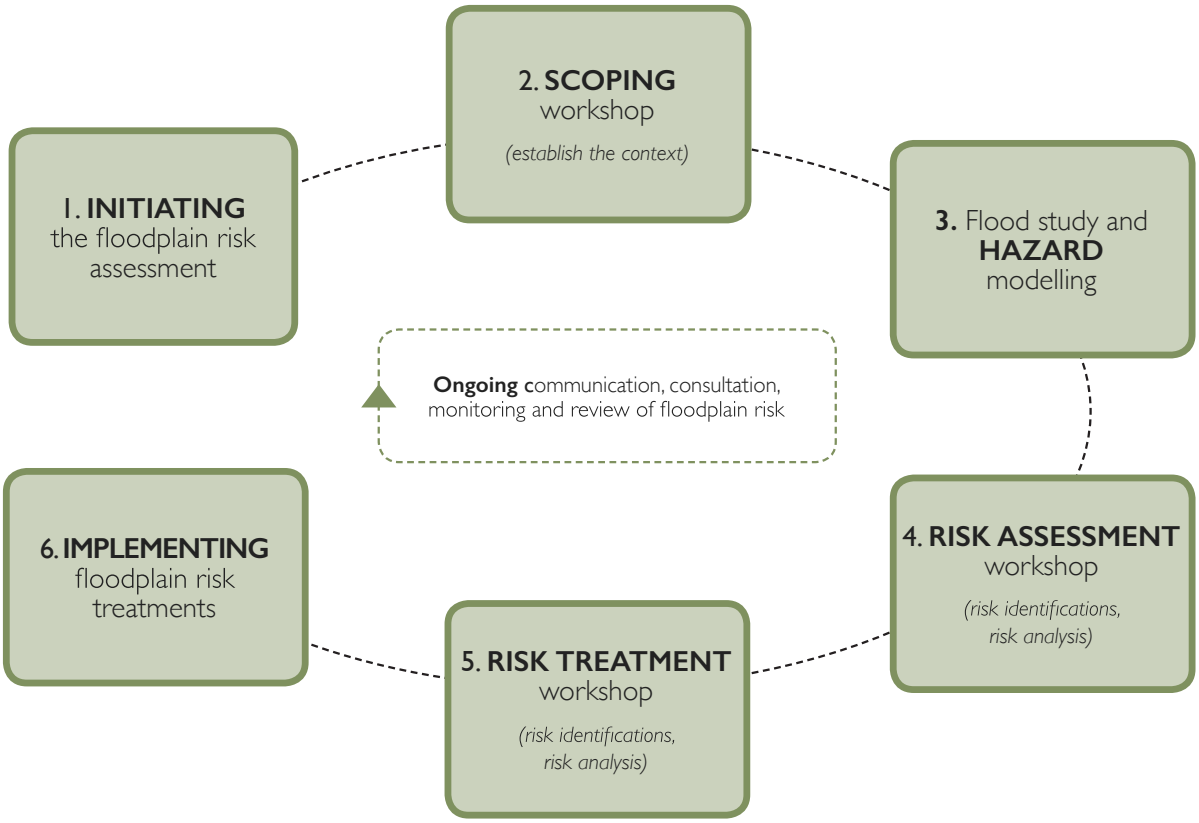


Fig 1. Summary of the municipal floodplain risk assessment stages (1 to 6) presented in these guidelines. The NERAG risk assessment activities done at each workshop are displayed in brackets.

Councils should allow approximately 6-9 months to complete the floodplain risk management process presented in these guidelines (Fig. 2).

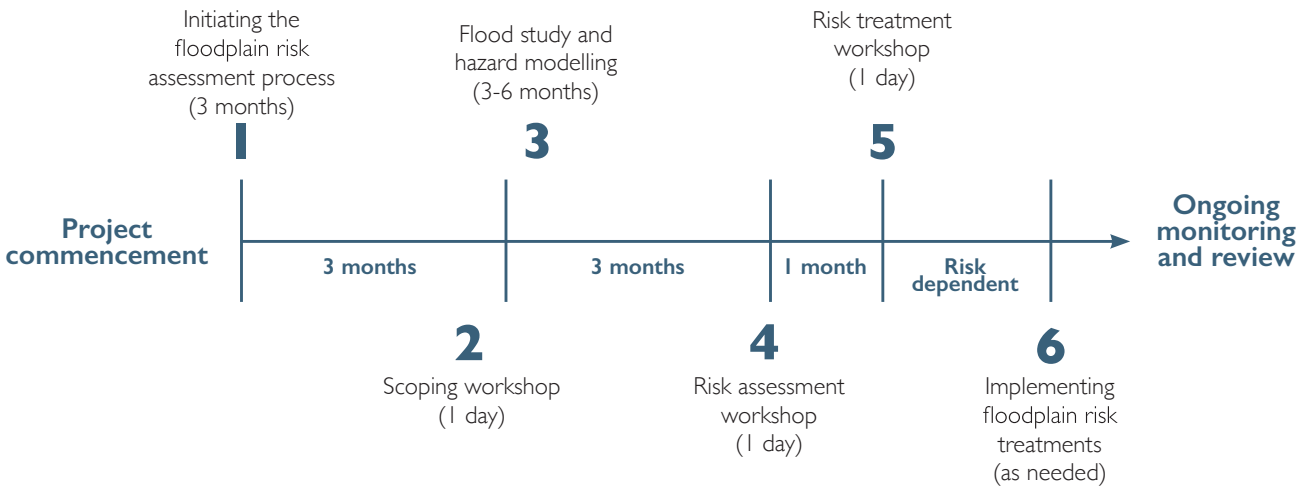


Fig 2. Indicative timeframe for key stages and related activities presented in these guidelines.

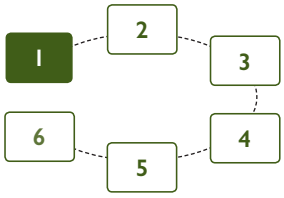
Managing risk and uncertainty

Floodplain risk assessments should assess the current and possible future flood risks to a community. Extreme rainfall predictions are projected to increase in Tasmania in the future[9] and sea levels are projected to rise[10,11], which is likely to impact local flooding regimes. However the influence of climate change on the flood hazard, as well as other factors such as changing catchment characteristics, future land-use, changing demographics, new building controls and the reliability of existing (and new) flood mitigation infrastructure, means it is important to consider the level of uncertainty about future scenarios and the relative confidence that can be assigned within the risk assessment process[12]. This should be considered when discussing future scenarios in the workshops and their impacts. New knowledge, trends and data should also be included into the floodplain risk assessment over time, through ongoing monitoring and review.

THE HUONVILLE EXPERIENCE

Current projections for climate change impacts on the Huon River catchment include a mean sea level rise of 0.8m by the year 2011 and rainfall depth increase of 13% to 15% for the critical storm. These allowances were included in the flood study and future climate hazard scenarios developed.


CARPARK
SKINNER DRIVE
ONE WAY



Stage 1: Initiating the Floodplain Risk Assessment

The floodplain risk assessment process begins with Council initiating the project, establishing governance arrangements and ensuring appropriate project planning and scoping occurs. The project objectives, outcomes and outputs should be documented and business owners identified at this stage. It is critical that appropriate business owners are identified and engaged to ensure the successful acceptance of the project outputs and achievement of the project objectives. Business owners should include those responsible for determining which risk treatment options will be implemented, implementing the treatments, and monitoring their implementation and effectiveness.

Key project team members need to be appointed at this stage (Fig. 3) and other required resources will need to be allocated.

As part of the initiating process, Council should undertake their own desktop review of historical flooding events, flood related technical data and any other relevant documentation that might support the risk assessment process and flood study by the flood modelling consultant.

Stakeholders

The project team will be required to identify and engage closely with stakeholders. Stakeholders are invited to participate in the floodplain risk assessment by identifying groups or individuals responsible for the management of risks or affected by the risks. The Australian Emergency Management Handbook[6]: National Strategy for Disaster Resilience - Community Engagement Framework[13] provides guidelines on effective stakeholder participation in emergency management.

Stakeholders can include representatives from within Council, emergency management organisations, university institutions, the business community and local utilities or authorities (e.g. Bureau of Meteorology, and Parks and Wildlife Service).

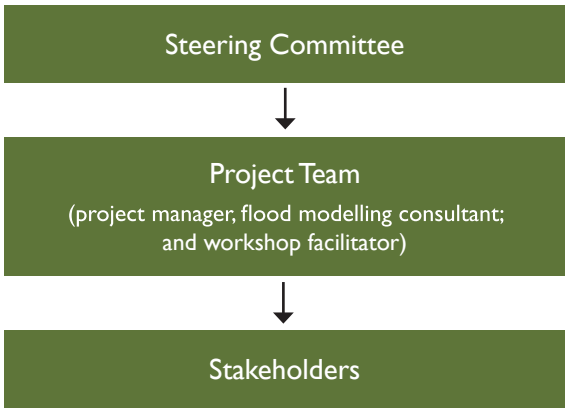


Fig 3. Suggested team structure

THE HUONVILLE EXPERIENCE

Stakeholders were invited to participate in all workshops. Prior to the first workshop, participants were provided with:

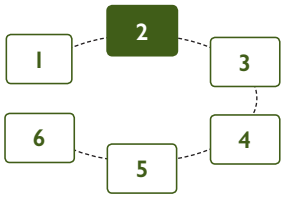
- A document outlining the project, what was expected of them, what influence they would have on the process, the expected outcomes and how the outcomes would be used;
- An ethics information and consent form (from the workshop facilitator) to read, understand and sign.

Outputs at Stage 1 completion:

- ✓ Key team members appointed by Council (project manager, external flood modelling consultant, workshop facilitators)
- ✓ Clear project objectives, documented by Council
- ✓ Stakeholders identified and notified of project
- ✓ Desktop review of existing flood risk documentation

"A number of people attended the Huonville workshops, including Huon Aquaculture, Fruit Growers, and Chamber of Commerce, representing a broad cross-section of key stakeholders. The diversity of the group really helped us to reach a consensus on local data and therefore reach confident conclusions."

Rebecca Bell, Huon Valley Council



Stage 2: Scoping workshop

What is the context?

The scoping workshop aligns to the context setting activities in the risk assessment process. This includes confirmation of the project objectives and any further stakeholder involvement identified by the group, agreeing the risk assessment methodology, risk assessment criteria and stakeholder roles and responsibilities. The workshop provides participants with an opportunity to discuss historic flooding events, their impacts, sources of risks and any assets of concern. The extent of the physical study area to be modelled needs to be agreed at this stage, along with the flooding scenarios to be modelled. It is important to consider possible effects of climate change on the hazard in these scenarios.

THE HUONVILLE EXPERIENCE

The following flood scenarios were developed in the Huon River flood study:

1. **0.5% AEP (1:200 ARI):**
   a. Current climate with HAT tailwater
   a. Future climate (year 2100) with HAT tailwater and 0.8m sea level rise
2. **1% AEP (1:100 ARI):**
   a. Current climate with HAT tailwater
   a. Future climate with HAT tailwater and 0.8m sea level ris
2. **1% AEP (1:100 ARI):**
   a. Current climate with mean sea level tailwater
2. **2% AEP (1:50 ARI):**
   a. Current climate with HAT tailwater
   a. Future climate with HAT tailwater and 0.8m sea level rise
2. **10% AEP (1:10 ARI):**
   a. Current climate with HAT tailwater
   a. Future climate with HAT tailwater and 0.8m sea level rise

AEP = Annual Exceedances Probability: The probability of the river flow exceeding the amount in any given year
ARI = Average Recurrence Interval: 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 the periods between exceedances are generally random.
HAT = Highest Astronomical Tide
MSL = Mean Sea Level
Tailwater = the height of the water at the end of the hydraulic model used to generate the flood maps

Reviewing the risk criteria

The NERAG risk criteria are used to assess exiting controls, the likelihood, consequence and confidence of the identified risk, and should be reviewed in the workshop. In particular, participants should form breakout groups and review the consequence criteria. NERAG identifies five consequence criteria (people, economic, environment, public administration and social setting) that can be used as a starting point in the workshop. The criteria can be scaled for use in a national, regional or local context.

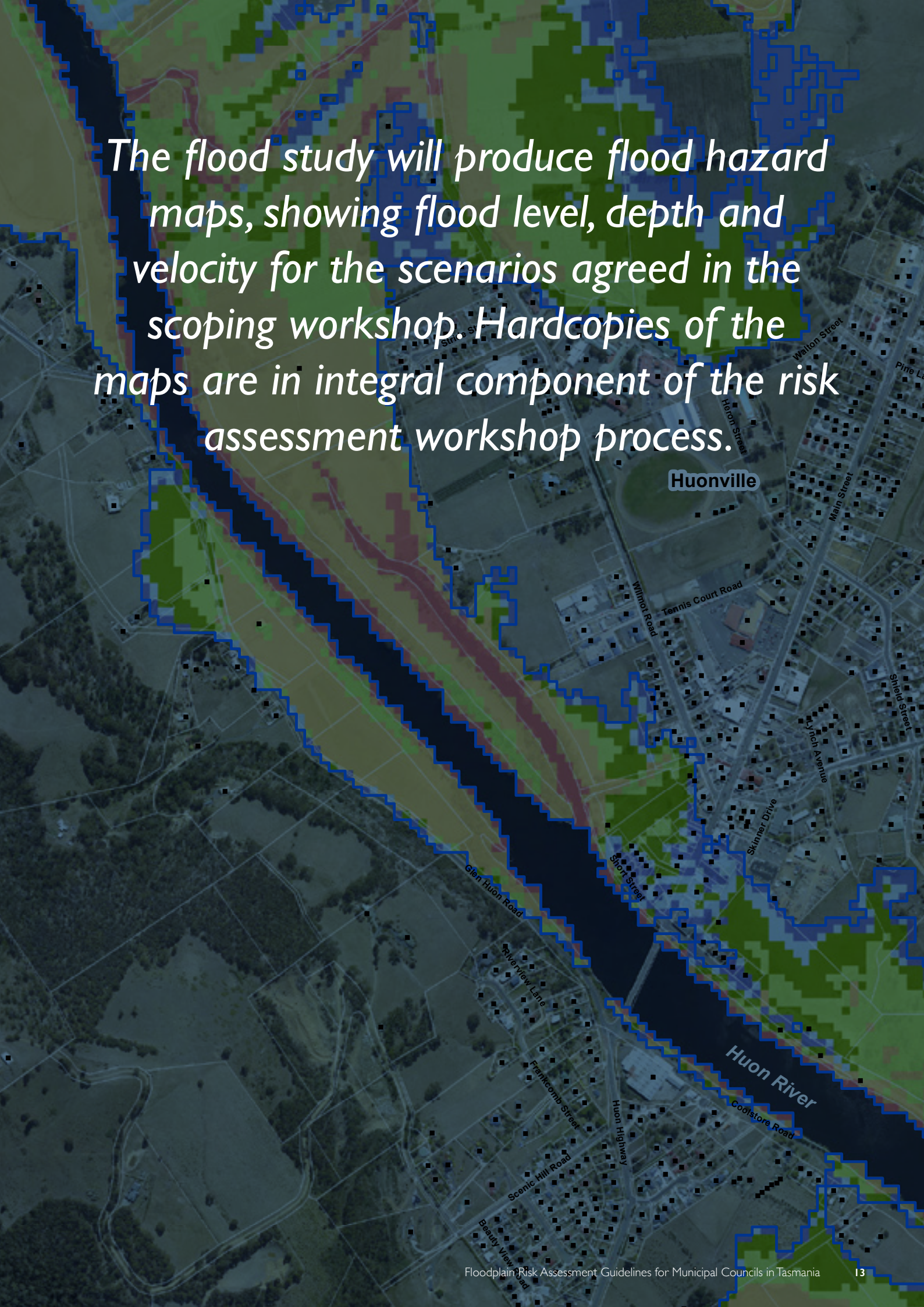
THE HUONVILLE EXPERIENCE

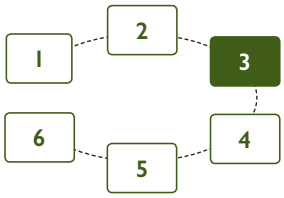
Workshop participants modified the **people** and **economic** consequence rating tables NERAG in the context of Huonville, once these had been downscaled. The consequence to the people criteria was modified on the basis that 1-2 deaths (although tragic) did not represent a catastrophe for the whole town. Similarly the % gross product criteria was adjusted to reflect the magnitude of historical losses experienced in the area and relative size of key industries (in terms of gross product) that are vulnerable to flooding.

Outputs at Stage 2 completion:

- ✓ Confirmation of project objectives and stakeholder involvement
- ✓ Clarity on participant roles and responsibilities
- ✓ Agreement on the risk assessment methodology and outputs
- ✓ Agreement on the consequence criteria to be adopted for the study
- ✓ An account of historic flood events and their impacts
- ✓ Definition of the flood hazard scenarios to be modelled (with agreement on mapping outputs)

The flood study will produce flood hazard maps, showing flood level, depth and velocity for the scenarios agreed in the scoping workshop. Hardcopies of the maps are in integral component of the risk assessment workshop process.





Stage 3: Flood study and hazard modelling

What flood events could occur and how might these floods behave?

An important goal of this stage is to undertake a flood study and produce flood hazard maps for the scenarios agreed in the scoping workshop. This study is undertaken by the flood modelling consultant with the study forming an input to the forthcoming floodplain risk assessment workshop. As a minimum, the scope of this stage should follow the guidance and methodology in AEM7 Chapters 11 (Flood study) and 12 (Floodplain management study).

AEM7 provides detailed information about conducting a flood study and floodplain management study

THE HUONVILLE EXPERIENCE

Flood types include riverine flooding, flash flooding and coastal inundation. The Huonville case study focussed primarily on riverine flooding from the Huon River. Flooding associated with dam failure, flash flooding and flooding that could occur from tributaries was not included on the basis that flooding from the Huon River posed the greatest threat to the township.

Flood study

The flood study is a technical investigation into flood behaviour and modelling of flood scenarios. The study should utilise existing flood hydrology and hydraulic models where possible to reduce study costs. The flood modelling is undertaken for the agreed scenarios to produce flood level, depth and velocity results. Mapping produced from the flood study should be contained on a single sheet, with hardcopy maps printed on A3 paper in preparation for the risk assessment workshop. Specifically, the following flood study outputs are helpful to assess flood consequences in the risk assessment process:

- Flood extent and depth
- Flood level
- Flood hazard
- Flood rate of rise map

A XPSWMM hydraulic model was developed for the Huonville case study to produce hazard data

THE HUONVILLE EXPERIENCE

Hydraulic model inputs and outputs, flood study and floodplain study outputs should be provided by consultants in hardcopy and electronic formats (including geospatial and metadata data) to Councils to enable future re-analysis or detailed treatment options analysis (such as cost benefit analysis of structural mitigation treatment options).

Floodplain management study

The floodplain management study builds on the flood study with a focus on understanding existing flood controls, flood impacts and the treatment options available to manage the flood risk. Historic (and existing) information on flooding can be incorporated into this study. A quantitative, or semi-quantitative risk assessment can also be undertaken to:

- Generate data for presentation and use in the qualitative risk assessment workshop
- Compare and validate risk levels with those levels determined in the workshops

Other guidelines exist in the Emergency Management series to support disaster loss assessment[14].

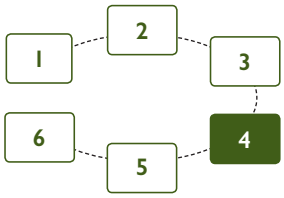
Section 12.2 of AEM 7 provides a detailed list of floodplain management study outputs

Workshop briefing document

Outputs from the flood study and floodplain management study provides participants to the forthcoming risk assessment workshop with background contextual information. A briefing documented should be prepared and distributed to participants ahead of the workshop. This document can also include a description of historical flooding and impacts in the area, the basis for the flood modelling and an overview of existing flood management controls.

Outputs at Stage 3 completion:

- ✓ Flood study report
- ✓ Floodplain management study (included in the flood study report) – refer to Section 12.2 of AEM7 for a list of study outputs
- ✓ Flood hazard mapping for agreed scenarios
- ✓ Desktop review to identify land and assets affected by flooding
- ✓ Workshop briefing document (distributed to participants)



Stage 4: Risk assessment workshop

What are the flood risks and their classification?

The risk assessment workshop aims to cover the following steps of the NERAG process:

- Risk identification
- Risk analysis

The *NERAG (Handbook 10)* provides a detailed method for flood risk assessment

THE HUONVILLE EXPERIENCE

There were 9 risk descriptions for each scenario documented in the workshop.

THE HUONVILLE EXPERIENCE

Three of the nine flooding scenarios modelled were chosen for use in the risk assessment workshop. A selection of the three flood scenarios (i.e. flooding of Huonville from the Huon River) was based upon a first-pass analysis from the project team. Those scenarios judged to be most informative to capture flood impacts were selected. The scenarios included:

1. **10% AEP flood; current climate with HAT tailwater;**
2. **10% AEP flood; future climate; HAT tailwater; (equivalent to 1% AEP in the current climate)**
3. **1% AEP flood; future climate; HAT tailwater**

Risk identification

This workshop is focussed around the flood scenarios mapped, with each flood scenario representing an 'emergency event'. Risks can be explained with risk descriptions that link the source, emergency event and consequences together, for example:

there is potential that **HEAVY RAINFALL**
(source)

will result in **RIVERINE FLOODING**
(emergency event)

that will in turn cause **LOSS OF LIFE AND INJURY**
(consequence to people)

Each flooding event is likely to have several risk descriptions because there are multiple consequences; to people, the economy, the environment, public administration and the social setting.

Risk analysis

Workshop participants are divided up into groups, with each group assigned one of the scenarios to analyse the following:

1. Strength and expediency of each existing control
2. The consequences to each criteria under the scenario
3. The likelihood of each risk
4. The overall level of each risk
5. The confidence level in the assessment of each risk

The use of visual aids (e.g. photos and hazard maps for each scenario) is encouraged to effectively communicate the context of the flooding events to stakeholders. Further guidance on risk management techniques may also be reviewed prior to the workshop[15].

Strength and expediency of existing controls

Existing flood risk management controls can include physical (e.g. levees), procedural (e.g. land-use planning) and behavioural (e.g. community knowledge). NERAG categorises existing controls into 'prevention', 'preparedness' or 'response and recovery' and therefore using these categories is encouraged. In groups, participants assessed the effectiveness of the existing flood management controls against their flood scenario. For each flood scenario, the controls are rated in terms of strength (i.e. how well does the control reduce the risk) and expediency (i.e. how easily can the control be activated and used). The highest rating score is taken at the end to capture the individual group assessments in their scenario.

Section 6.2 of *NERAG (Handbook 10)* provides tables to assess the strength and expediency of existing controls

THE HUONVILLE EXPERIENCE

The flood management study identified 2 'prevention and mitigation controls', 8 'preparedness' controls, 4 'response' controls and 1 'recovery' control currently in place.

Consequence of a scenario

The consequences to each criteria (people, economic, environment, public administration and social setting) are then assessed by breakout groups for their assigned scenario. Each group should have a mix of stakeholders with knowledge to collectively assess each criteria. The assessment of consequences is often either qualitative (with input from experts) and may draw upon quantitative information obtained in the floodplain management study. Such information might include number of buildings impacted or area of land use inundated for each scenario.

Section 6.4 of *NERAG (Handbook 10)* provides tables to assess consequences of each risk description

Likelihood of the risk occurring

For each risk, the likelihood level can be determined based on the probability of the scenario and the probability of the estimated consequences from the event. The annual exceedance probability (AEP) is adopted by NERAG to describe the chance of an event occurring. Using the likelihood of the scenario as a starting point, adjustments can be made to the overall likelihood of the risk based on level of current controls in place, temporal factors (e.g. time of day) and future changes projected (e.g. population growth).

Section 6.5 of *NERAG (Handbook 10)* provides tables to assess the likelihood of each risk description

The risk level

The consequence and likelihood information produced for each risk can be used to determine the level of the risk by using a qualitative risk matrix.

Section 6.6 of *NERAG (Handbook 10)* provides tables to assess risk level

THE HUONVILLE EXPERIENCE

The future climate change scenario had a higher level of risk, partially attributable to the increased uncertainty of impacts and future controls.

The confidence level

The level of confidence (or uncertainty) in the risk level is important to assess to avoid misleading risk assessment. NERAG describes the level of confidence as either being highest, high, moderate, low or lowest.

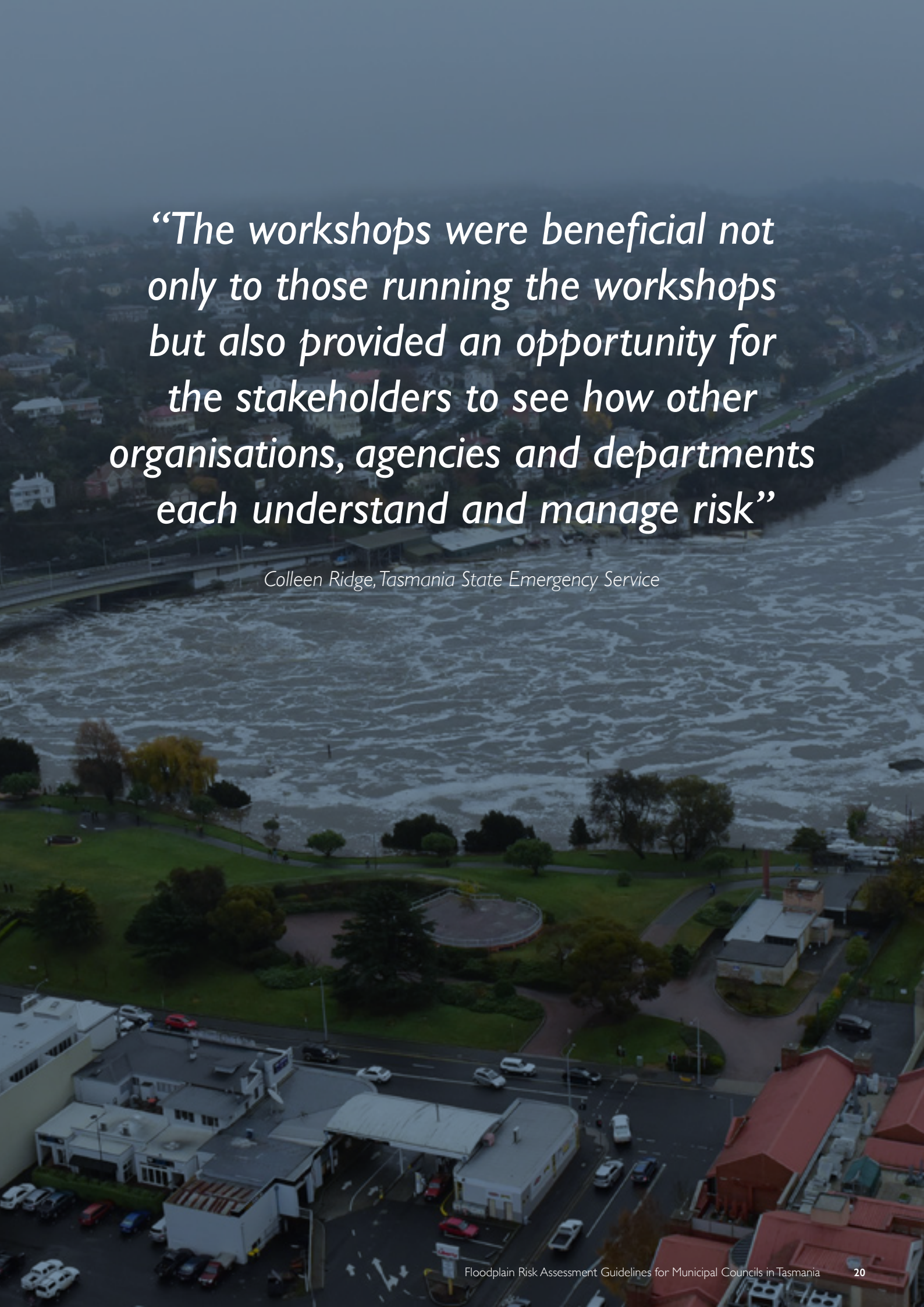
Section 6.7 of *NERAG (Handbook 10)* provides tables to assess the confidence level of the risk assessment

Capturing the workshop data

Outputs from each group in the risk assessment workshop should be captured by the facilitator or an assigned person. Outputs can be captured using spreadsheets, papers, or specialised online tools. Automating the process will help save time in the workshop and ensure the relevant information is captured. A synthesis of the workshop data is then prepared and distributed to participants prior to the next workshop (risk treatment workshop).

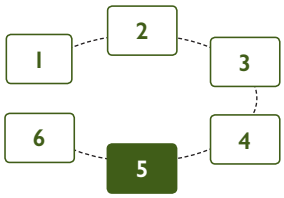
Outputs at Stage 4 completion:

- ✓ A risk description list
- ✓ A list of current flood risk controls and their assessed level of control
- ✓ A draft flood risk register identifying the risk description, consequences, likelihood and level of confidence (distributed to stakeholders)



"The workshops were beneficial not only to those running the workshops but also provided an opportunity for the stakeholders to see how other organisations, agencies and departments each understand and manage risk"

Colleen Ridge, Tasmania State Emergency Service



Stage 5: Risk treatment workshop

What are the priority risks are how can they be managed?

The risk treatment workshop aims to review the outcomes from the previous risk assessment workshop and address the following steps of the NERAG process:

- Risk evaluation
- Risk treatment

THE HUONVILLE EXPERIENCE

There were approximately 20 participants at each workshop.

Risk evaluation

The risk evaluation activities aim to assign a priority to each risk identified from 1 (highest priority) to 5 (lowest priority). At the beginning of the workshop as a single group, the priority level classification levels are discussed and agreed. Then in small breakout groups, each risk is assigned a priority level. The confidence level assign to each risk from the previous workshop is used with the likelihood and consequence levels to determine a priority rating.

Section 7.1-7.2 of *NERAG (Handbook 10)* provides tables to assess priority levels

Once a priority has been assigned each risk, they are categorised as either:

- Category 1 – Requiring treatment
- Category 2 – Requires further analysis and re-evaluation
- Category 3 – Requires ongoing monitoring and maintenance of existing control

Figure 10 from *NERAG (Handbook 10)* provides an outline of the decision tree process to help categorise risks

THE HUONVILLE EXPERIENCE

There were four category 1 risks identified in the 1% AEP scenario, requiring treatment.

Risk treatment

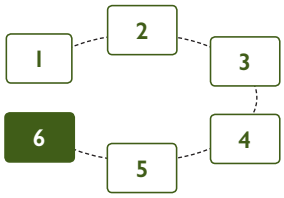
The risk treatment activity seeks to modify those risks that are not acceptable to participants based on the current controls in place (Category 1). Again in breakout groups, risk treatment options are identified for each risk requiring treatment. The groups then come together to discuss their treatments in an open discussion, to agree on a collective decision.

Following this, the option is evaluated for inclusion into a risk treatment plan. Each risk in the register should be assigned an organisation responsible for the management and/or treatment of the risk.

Figure 11 from *NERAG (Handbook 10)* provides an outline of the risk treatment planning process

Outputs at Stage 5 completion:

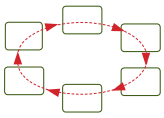
- ✓ Summary risk assessment for each flood hazard scenario
- ✓ Schedule of prioritised risk recommended for further action, management and including into Council's all-hazards register
- ✓ List of evaluated risk treatment options
- ✓ Updated flood risk register (distributed to stakeholders)
- ✓ A risk assessment and risk treatment report



Stage 6: Implementing flood risk management controls

The extent and involvement of stakeholders in the implementation of flood risk management controls will be driven by the risk treatment plan developed in the previous stage. Coordinating the implementation of a flood risk treatment is the responsibility of the organisation that was assigned to that risk.

Ongoing communication, consultation, monitoring and review of flood risk



Communication and consultation

Communication and consultation occurs in all stages of the floodplain risk assessment process.

After the workshops, reporting should include a risk assessment treatment report, provided by the project manager to the Council and other business owners and key stakeholders. The report should append the flood study undertaken by the flood modelling consultant and all other risk documentation generated as part of the process.

THE HUONVILLE EXPERIENCE

Huon Valley Council was the key support to the project team by facilitating effective stakeholder participation in the process.

Monitoring and review is an ongoing activity that involves periodically reviewing the floodplain risk management process, identifying new risks or re-assessing existing risks. This activity should be done as part of routine business, with risks being monitored by the organisation assigned responsibility for managing that risk.

Outputs at Stage 6 completion:

- ✓ Updated risk management documentation

Lessons from the Huonville floodplain risk assessment

Key lessons from the Huonville floodplain risk assessment include:

- The importance of appointing an experienced project manager to coordinate the floodplain risk management process and ensure stakeholders are effectively engaged
- The need to follow the NERAG risk assessment process, scaled to the local level, to achieve consistent outcomes
- The benefits of engaging with targeted stakeholders in a workshop setting who have a suitable level of skills and local experience in managing flood risk
- The importance of utilising local knowledge, networks and people throughout the process to allow location-specific insights into the function of the community before and after a flood
- The need to have data available (or obtain data) for use in the flood study to improve the reliability of the scenario hazard modelling and quantitative assessment of consequences

References

[1] White CJ, Remenyi T, McEvoy D, Trundle A and Corney SP (2016) ***2016 Tasmanian State Natural Disaster Risk Assessment***, University of Tasmania, Hobart, TAS.

[2] Bureau of Infrastructure and Transport Economics (2008) ***About Australia's Regions - June 2008***, Department of Infrastructure, Transport, Regional Development and Local Government, Canberra, ACT.

[3] Entura (2016a) ***Floodplain Risk Assessment Process for Tasmania: Huonville Case Study – Floodplain Risk and Management Study***, Entura, Cambridge, TAS.

[4] Commonwealth of Australia (2015a) ***National Emergency Risk Assessment Guidelines – Handbook 10***, Commonwealth of Australia, Canberra, ACT.

[5] Commonwealth of Australia (2015b) ***National Emergency Risk Assessment Guidelines: Practice Guide – Handbook 11***, Commonwealth of Australia, Canberra, ACT.

[6] Australian Emergency Management Institute (2013) ***Handbook 7: Managing the floodplain. A guide to best practice in flood risk management in Australia,*** Australian Emergency Management Institute, Canberra, ACT.

[7] Entura (2016b) ***Floodplain Risk Assessment Process for Tasmania: Huonville Case Study***, Entura, Cambridge, TAS.

[8] Standards Australia & Standards New Zealand (2009) ***AS/NZS ISO 31000:2009 Risk Management - Principles and Guidelines***, Standards Australia and Standards New Zealand, Sydney, Australia and Wellington, New Zealand.

[9] White CJ, Grose MR, Corney SP, Bennett JC, Holz GK, Sanabria LA, McInnes KL, Cechet RP, Gaynor SM and Bindoff NL (2010) ***Climate Futures for Tasmania: extreme events technical report***, Antarctic Climate & Ecosystems Cooperative Research Centre, Hobart, TAS.

[10] McInnes KL, White CJ, Haigh ID, Hemer MA, Hoeke RK, Holbrook NJ, Kiem AS, Oliver ECJ, Ranasinghe R, Walsh KJE, Westra S and Cox R (2016) Natural hazards in Australia: sea level and coastal extremes, ***Climatic Change***, doi: 10.1007/s10584- 016-1647-8.

[11] McInnes KL, O'Grady JG, Hemer M, Macadam I, Abbs DJ, White CJ, Corney SP, Grose MR, Holz GK, Gaynor SM and Bindoff NL (2012) ***Climate Futures for Tasmania: extreme tide and sea-level events technical report***, Antarctic Climate & Ecosystems Cooperative Research Centre, Hobart, TAS.

[12] Johnson F, White CJ, van Dijk A, Ekström M, Evans JP, Jakob D, Kiem AS, Leonard M, Rouillard A and Westra S (2016) Natural hazards in Australia: floods, ***Climatic Change***, doi:10.1007/s10584-016-1689-y.

[13] Australian Emergency Management Institute (2013) ***Handbook 6: National Strategy for Disaster Resilience. Community Engagement Framework***, Australian Emergency Management Institute, Canberra, ACT.

[14] Emergency Management Australia (2002) ***Disaster Loss Assessment Guidelines – Manual 27***, Emergency Management Australia, Canberra, ACT.

[15] Standards Australia & Standards New Zealand (2013) ***SA/SNZ HB 89:2013 Risk Management - Guidelines on Risk Assessment Techniques***, Standards Australia & Standards New Zealand, Sydney, Australia and Wellington, New Zealand.

ISBN 978-1-86295-877-7 (print)
ISBN 978-1-86295-876-0 (web)

AUTHORS:
Christopher J White, Timothy D Ramm and Chris Irvine

CONTACT:
School of Engineering & ICT, Private Bag 65, Hobart, Tasmania, 7001
Tel: +61 3 6226 2135

RECOMMENDED CITATION:
White CJ, Ramm TD and Irvine C 2016, *Floodplain Risk Assessment Guidelines for Municipal Councils in Tasmania*, University of Tasmania, Hobart.

PHOTO CREDITS:
Front & back cover: Mhairi Revie, State Emergency Service
p2: Department of Police, Fire and Emergency Management
p4: Jim Reilly
p7 &10: Rebecca Bell, Huon Valley Council
p13: Entura, Huonville Floodplain Risk and Management Study
p17, 20 & 23: Mhairi Revie, State Emergency Service

PARTNERS

UNIVERSITY of TASMANIA

SES STATE EMERGENCY SERVICE

SUPPORT

Tasmania

Australian Government
Attorney-General's Department