Lower George River Floodplain Risk Management Plan

Prepared for:	**Break O'Day Council**
Date:	**May 2013** **Rev00**

transport infrastructure | community infrastructure | industrial infrastructure | climate change





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Report Revision History					
Rev No.	**Description**	**Prepared by**	**Reviewed by**	**Authorised by**	**Date**

Executive Summary

This report represents the outcomes from a risk assessment undertaken in accordance with National Emergency Risk Assessment Guidelines (NERAG) for the lower George River floodplain near the township of St Helens.

A broad range of hazards and consequences have been assessed with many actions or activities identified which if implemented would contribute to reduction in the magnitude of the consequence.

Risks have been identified through a stakeholder input process. Modelling using state of the art flood modelling software was applied to identified hazards relating to George River flooding to assist in identify the likelihood and potential consequence of the hazard to assist assignment of a risk rating.

The risk assessment process, consistent with NERAG specifications, documented many identified hazards, three of which are the specific focus of the floodplain risk assessment:-

- Flooding – Inundation
- Flooding – high velocity stream flows
- Storm tide

Developed from the identified specific hazards, this risk management plan documents numerous consequences of the hazard using Bow-Tie diagrams. Also documented are threats which contribute to the magnitude of the consequence of hazard occurring (The Event).

The specific risks identified for the floodplain are presented in the following table in a format consistent with the Break O'Day Council (Council) specified risk register.

A range of potential barriers or activities are documented which may mitigate or reduce the consequence of the hazard. Also listed for consideration are indications of adverse impacts or unintended consequences of some treatments and solutions.

The risk assessment and prioritisation of treatment and actions are left in a format enabling the intended completion by stakeholders involved in practical implementation decisions.

RISK IDENTIFICATION					RISK ANALYSIS		
Risk No.	Risk	What can happen?	Possible causes / contributing threats include:-	Existing controls	Likelihood	Consequences	Risk rating
1	**River Floods - Deep Water**		REFER Bow Tie Diagrams but these include:- Intense or persistent rainfall, Stream flow restrictions (instream obstructions), Overtopping or failure of levee /dam structures, River Bank erosion diverting river flows, Debris Accumulated on structures, Extreme Tides coincident with river flood, Climate Change alterations to rainfall (intensity/frequency/duration IFD), Dam burst upstream, Wind/Wave setup and runup increasing depths, River flooding contributing to elevated bay water surface levels	REFER Bow Tie Diagrams but these include:- BOM weather advice, Local upstream resident advice, Flow Gauges, Climate Change projections, Planning Controls, Recovery plan, Emergency management plan, Levee/Physical flow barriers, Armouring/Protection, Rip/Rap emplacement, Obstruction Removal/Cleaning, Dredging, Alternative Access arrangements, Tide simulation/forecasting, Long term adaptation planning, Dam Safety management			
	River Floods - Deep Water	**Death or Personal Injury**	Drowing (unaware of depth of water on current used land areas or creation of increased depths / holes)	Manual road closures	Possible	Catastrophic	**High**
	River Floods - Deep Water	**Infrastructure Damage**	water damage, consequential additional damage (electrical shortage etc)	temporary relocatio/protection.	Possible	Major	**High**

RISK IDENTIFICATION					RISK ANALYSIS		
Risk No.	Risk	What can happen?	Possible causes / contributing threats include:-	Existing controls	Likelihood	Consequences	Risk rating
	River Floods - Deep Water	Isolated Community	impassable roads, infrastructure damage	limited	Likely	Moderate	High
	River Floods - Deep Water	Community Livelihood Impacts	Roads impassable restricting transport. Services impacted	limited	Likely	Moderate	High
	River Floods - Deep Water	Business interuption	Inundation of workplaces (aquaculture processing). Environmental stoppage to business processing	limited, planning scheme limitations	Likely	Moderate	High
	River Floods - Deep Water	Tourism Impacts	loss of attractiveness of destimation, inaccessability of locations / services	limited,	Likely	Moderate	High
	River Floods - Deep Water	Debris along river bed	flooding events deposit debris within stream channels or on floodplain	limited clearing	Almost Certain	Minor	Medium
	River Floods - Deep Water	Erosion	Saturated banks may become unstable contributing to collapse	some erosion stabilisation inplace. Adhoc riprap and armouring	Likely	Moderate	Medium
	River Floods - Deep Water	Reduced Property Values	inaccessibility, change to regulations, loss of productivity	planning scheme controls on development. Floodplain extent is reasonably understood for owners	Likely	Minor	Medium

RISK IDENTIFICATION					RISK ANALYSIS		
Risk No.	Risk	What can happen?	Possible causes / contributing threats include:-	Existing controls	Likelihood	Consequences	Risk rating
	River Floods - Deep Water	Loss of productive land	inundation prevents effective utility or increases damage/losses if used.	limited current systems / ability in place to manage loss. Existing control includes the levee bank	Likely	Minor	Medium
	River Floods - Deep Water	Impact on Agriculture/Aquaculture	reduced ability to utilise prodiuctive assets, closures of productivity. Inundation leading to excess/accidental outflows/discharges'	limited. Planning/legislative controls to reduce larger impacts	Likely	Minor	Medium
	River Floods - Deep Water	Loss of habitat for flora and/or fauna	reduction in suitable habitat through water depths, changes to surface conditions	limited	Likely	Minor	Medium
	River Floods - Deep Water	Loss of flora and/or fauna	relocation or death of flora/faua species through altered habitat or direct impact	limited	Likely	Minor	Medium
	River Floods - Deep Water	Stormwater flooding	stormwater system impacted by increased floodwater/sea surface depths reduce capacit//capability of systems	Increased inundation depths contribute to reduced capacity/capability of stormwater management systems	Likely	Moderate	High

RISK IDENTIFICATION					RISK ANALYSIS		
Risk No.	Risk	What can happen?	Possible causes / contributing threats include:-	Existing controls	Likelihood	Consequences	Risk rating
2	**River Floods - High Stream velocities**		REFER Bow Tie Diagrams but these include:- Intense or persistent rainfall, Stream flow restrictions (instream obstructions) redirecting natural water course eg. River bank erosion diverting river flows, Climate Change alterations to rainfall (intensity/frequency/duration IFD), Dam burst upstream,	REFER Bow Tie Diagrams but these include:- BOM weather advice, Local upstream resident advice, Flow Gauges, Climate Change projections, Planning Controls, Recovery plan, Emergency management plan, Levee/Physical flow barriers, Armouring/Protection, Rip/Rap emplacement, Obstruction Removal/Cleaning, Dredging, Alternative Access arrangements, Tide simulation/forecasting, Long term adaptation planning, Dam Safety management			
	River Floods - High Stream velocities	**Death or Personal Injury**	Drowing (unaware of depth of water on current used land areas or creation of increased depths / holes)	Manual road closures	Possible	Catastrophic	**High**
	River Floods - High Stream velocities	**Loss of Infrastructure / services**	permanent damage	temporary relocatio/protection.	Possible	Major	**High**

RISK IDENTIFICATION					RISK ANALYSIS		
Risk No.	Risk	What can happen?	Possible causes / contributing threats include:-	Existing controls	Likelihood	Consequences	Risk rating
	River Floods - High Stream velocities	Infrastructure Damage	water damage, consequential additional damage (electrical shortage etc). Impact	temporary relocatio/protection.	Possible	Moderate	High
	River Floods - High Stream velocities	Erosion	Saturated banks maybecome unstable contributing to collapse	some erosion stabilisation inplace. Adhoc riprap and armouring	Likely	Moderate	High
	River Floods - High Stream velocities	Floodwater directed into township	new channel formation in soft floodplain sediments, significant event overtopping existing banks/controls	some erosion stabilisation inplace.	Unlikely	Catastrophic	Medium
	River Floods - High Stream velocities	Public health impacts	isolation of community, damage to services impacting on public health	limited	Possible	Moderate	Medium

RISK IDENTIFICATION					RISK ANALYSIS		
Risk No.	Risk	What can happen?	Possible causes / contributing threats include:-	Existing controls	Likelihood	Consequences	Risk rating
3	**Tidal Inundation - "Storm Tides"**		REFER Bow Tie Diagrams but these include:- Extreme Tides coincident with river flood, Climate Change alterations to rainfall (intensity/frequency/duration IFD), Wind/Wave setup and runup increasing depths, River flooding contributing to elevated bay water surface levels	REFER Bow Tie Diagrams but these include:- BOM weather advice, Climate Change projections, Planning Controls, Recovery plan, Emergency management plan, Levee/Physical flow barriers, Armouring/Protection, Rip/Rap emplacement, Alternative Access arrangements, Tide simulation/forecasting, Long term adaptation planning,			
	Tidal Inundation - "Storm Tides"	**Business interuption**	Inundation of workplaces (aquaculture processing). Environmental stoppage to business processing	limited, planning scheme limitations	Likely	Moderate	**High**
	Tidal Inundation - "Storm Tides"	**Stormwater flooding**	stormwater system impacted by increased floodwater/sea surface depths reduce capacit//capability of systems	Increased inundation depths contribute to reduced capacity/capability of stormwater management systems	Likely	Moderate	**High**
	Tidal Inundation - "Storm Tides"	**Infrastructure Damage**	water damage, consequential additional damage (electrical shortage etc)	temporary relocatio/protection.	Possible	Major	**High**
	Tidal Inundation - "Storm Tides"	**Tourism Impacts**	loss of attractiveness of destimation, inaccessability of locations / services	limited,	Likely	Moderate	**High**

RISK IDENTIFICATION					RISK ANALYSIS		
Risk No.	Risk	What can happen?	Possible causes / contributing threats include:-	Existing controls	Likelihood	Consequences	Risk rating
	Tidal Inundation - "Storm Tides"	Isolated Community	impassable roads, infrastructure damage	limited	Likely	Moderate	High
	Tidal Inundation - "Storm Tides"	Impact on Agriculture/Aquaculture	reduced abilityto utilise prodiuctive assets, closures of productivity. Inundation leading to excess/accidental outflows/discharges'	limited. Planning/legislative controls to reduce larger impacts	Possible	Moderate	Medium

1. Background

Break O'Day Council (Council) engaged **pitt&sherry** to prepare a risk management plan for the Lower George River Floodplain. The scope of the assessment is restricted to the lower George River floodplain to Georges Bay though the assessment undertaken and risks identified are common to many areas further upstream in the catchment.

The risk management plan has been prepared to identify hazards and present potential risk management mitigation solutions to risks resulting from those hazards. The plan has been prepared in accordance with guidelines specified in the National Emergency Risk Assessment Guidelines (NERAG, 2010).

For this report, national risk assessment definitions of terms are applied as follows:

Hazard is a dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.

Natural hazard: Natural process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage

Historically a number of technical assessments have been undertaken investigating a range of issues and hazards identified for the floodplain project area though no comprehensive risk management plan has been produced.

This report documents additional analysis of flooding events and derives flood hazard ratings for a range of different probability river floods, integrating indicative coastal effects from tidal and wind wave effects.

This risk management plan documents activities that may be undertaken to implement barriers and controls (both physical and procedural) reducing the consequence of risks from the hazards present in the floodplain project area.

1.1 Site Background

The report scope has been restricted to the area of the George River within the lower George floodplain to its discharge into Georges Bay (refer to Figure 1-1 following).

Figure 1-1. Project Area

The purpose of the report is to qualitatively assess the likelihood and consequence of potential emergency events occurring within the project area. The report represents an assessment of emergency risks within the floodplain area. The risk evaluation is based on qualitative data collated from an array of research reports and investigations into various risk aspects and potential hazards for the project area or more generally for the municipality. In many circumstances, the data is considered semi-quantitative in that it is based on investigation of measured datasets or recorded observed occurrences, such as river gauge flood flow data and surveyed inundation levels.

A number of previous investigations have been undertaken for the vicinity of the floodplain from which information was sourced for this report including:-

- Legge, R & Cameron, G, 2003. The Tasmanian Emergency Risk Management Project – Municpality of Break O'Day.
- Sprod, D. 2003. Rivercare Plan – Lower George River. Lower George Landcare Group, St Helens.
- SKM, 2005. Design Works for the Lower George River National Disaster Mitigation Program
- Mount, R., Crawford, C., Veal, C. and White C. 2005. Bringing Back the Bay – Marine Habitats and Water Quality in Georges Bay.
- Fox-Hughes, P. 2009. A Heavy Rainfall Event in Northern Tasmania during 27 to 30 January 2004, Australian Meteorological and Oceanographic Journal 58 (2009) 151-166. March 2009.
- Mole, M and Carley, J, 2010. Inundation levels for George River Floodplain, St Helens Tasmania. Report produced for Break O'Day council. WRL Technical Report 2010/04, February, 2010. technical report prepared for **pitt&sherry** 2010.
- Rand,S., Mitchell, W., Water Research Laboratory of UNSW and SGS Economics and Planning, 2010. Break O'Day Council, Coastal Risk Management Plan.
- Mitchell, W. 2010. Break O'Day council – Coastal Risk Management Plan. **pitt&sherry** technical report for Break O'Day council.
- Harkin, J and Attwater, C. 2011. The Tasmanian Coastal Adaptation Decision Pathways Project.
- Rand, S., 2011. Break O'Day Council – Georges Bay Coastal Inundation Vulnerability. Report prepared for Tasmanian Coastal Adaptation Pathways Project.
- **pitt&sherry**, 2012. Tasmanian Coastal Adaptation Decision Pathways Project: Inundation Control Works for the George River Floodplain – Binalong Bay Access. Report prepared for Local Government Association of Tasmania.
- LGAT, Tasmanian Planning Commission and SGS Economics and Planning, 2012. Tasmanian Coastal Adaptation Decision Pathways Project: Rising to the Challenge; Developing Flexible Coastal Adaptation Pathways for Local Communities.

As noted during stakeholder meetings, the restricted geographic scope excluded upstream property and assets for which many stakeholders had direct interests though the risks and controls were considered to be applicable in most circumstances to a broader area than the defined scope.

Field inspection of the project area was undertaken over a number of visits by **pitt&sherry** representatives in conjunction with representatives from the State Emergency Services, the Break O'Day Council and landowners and concerned stakeholders.

Technical information and analysis, including flood hazard modelling for the area, was integrated with information obtained and assessed in stakeholder workshops and subsequent discussions. Information provided by stakeholders or assessed for this project is described in **Appendix A**.

Stakeholder liaison included presentation and discussion with the Lower George River trust at its 2012 Annual General Meeting, a specially convened and facilitated stakeholder risk assessment workshop and additional stakeholder meetings and feedback hosted by Council or **pitt&sherry**.

1.2 Scope for Workshop / Inputs

A scoping form and preliminary assessment plan was distributed to stakeholders prior to the workshop to facilitate successful collection of important data and risk assessment information to successfully deliver the project.

The scoping form and preliminary assessment plan can be found in **Appendix B**. This document outlines various requirements of the workshop including the objectives, the risk assessment methodology and the expected outcomes of the workshop.

Other inputs obtained from council workshop participants included face to face and telephone communications.

1.3 References

The references used to ensure industry knowledge and extensive local experience was considered included the following:

- Mhairi Revie – State Emergency Services
- Sven Rand – **pitt&sherry**
- Yvette Edward – **pitt&sherry**
- Alison Hugo – Break O'Day Council
- Polly Buchorn - Break O'Day Council
- Leigh Stevens - Break O'Day Council
- Dr Hugh Pederson - Myriax
- Tina Hussey - Myriax
- R Nisbet - Priory resident
- Heather Knight - St Helens resident
- Allan Flintoff - St Helens resident
- Jan Derek Chapple - Priory resident
- Lindsay Harris - St Helens resident
- Kristina Freshney - Break O'Day Council
- David Llewellyn - St Helens region resident
- Bill Griffiths - St Helens resident
- Julie Llewellyn - St Helens region resident

The valuable contributions provided for consideration in this process from the above participants, other concerned stakeholders and council officers is gratefully acknowledged.

2. Objectives and Expected Outcomes

2.1 Objectives

The objective of the risk assessment was to review the hazards related to the floodplain project area and identify risks which are considered by stakeholders to cause significant disruption to services, livelihoods and contribute to detrimental economic, social and environmental impacts.

The risk assessment was also used to investigate mitigation strategies and identify potential activities or barriers (both physical and procedural) which could be implemented to reduce the potential consequences of a hazardous event occurring.

The risk assessment principally focused on the hazards that have the potential to cause injury or fatality or significant economic impacts.

The workshop objectives were as follows;

- Identify hazards within the project area of concern to stakeholders for which investigation was required
- Identify potential causes and consequences of an event resulting from the identified hazards
- Identify controls and safeguards to reduce the risk of the hazardous event occurring
- Investigate potential inherent risks and residual risks associated with each consequence
- Produce a prioritised action list for implementable activities which will contribute to minimising the risks as far as reasonably practicable

2.2 Expected Outcomes

The expected outcomes from the risk assessment process were as follows;

- To produce the information required to assist in the development of comprehensive hazard identification and ratings to enable a semi quantitative risk assessment drawing on appropriate technical expertise, scientific and empirical assessments and experience and anecdotal of the stakeholders
- A set of prioritised activities to be implemented in order to reduce the risks associated with hazards identified in the project area. It is considered that action prioritisation will be undertaken by stakeholder involved in practical implementation decisions.

3. Method

3.1 National Emergency Management Risk Assessment Guidelines (NERAG)

The risk assessment process undertaken is consistent with, and has been based on, the National Emergency Risk Assessment Guidelines and follows standard risk management framework processes.

- **Communicate and Consult** – this crucial initial component incorporated input from bottom-up sources (concerned and directly affected stakeholders), management and governance expertise (SES and Council) and technical experts (risk assessment facilitators, researchers and modellers including flood and coastal processes). The broad range of participants included;

  - Those who may be affected by detrimental impacts
  - Those who may contribute specialist knowledge
  - Those who have jurisdictional control
- **Context establishment** – Information gathering and analysis
- **Risk Identification** – broad input from diverse stakeholder groups to identify relevant risks
- **Analyse Risks** – Controls, consequences and likelihoods, risk ratings and confidence in assessments
- **Risk evaluation and recommended treatments**

3.2 Flood Hazard Identification

One of the most significant risks within the floodplain was identified by all stakeholders to involve George River flooding events. Hazards identified directly related to the flooding events are those of high stream flows and also excessive depth of water contributing to inundation hazards.

To enable appropriate assessment of likelihood and consequence of the flooding events, flood modelling was undertaken in the newly developed flood modelling package EonFusion flood by Myriax software. The modelling package enables both grid based and particle flow modelling to be undertaken with boundary conditions varied for a broad range of scenarios which included;

- River flood volumes with recurrence intervals from 2 year ARI (Annual Recurrence Interval) up to 100 year based on current (historic) flood events and stream flow records
- Variation of stream characteristics to simulate improved channel flows representing flows with obstructions removed (eg willows and debris) and similarly to represent increased blockages of drainage paths. Increasing levee bank structure sizes were also investigated
- Potential effects of climate change on rainfall intensity, runoff and consequently river flow and flood plain hazards
  - the George River catchment and St Helens area is projected to be one the most vulnerable and hardest hit areas of Tasmania based on recent climate change research
- Integrated with the river flood modelling were a number of scenarios investigating various tidal scenarios including extreme storm surge tides and the impact of projected sea level rise

The outputs were summarised in a series of flood hazard rating maps and model outputs broadly consistent with national floodplain risk management guidelines including those developed by the NSW Department of Environment, Climate Change - ***Flood Risk Management Guide incorporating sea level benchmarks in flood risk assessments. 2010***.

Flood hazard rating was derived as the multiple of the water depth (m) and the flow velocity (m/s) with hazard assessed broadly consistent with the categories in Figure 3-1 below.

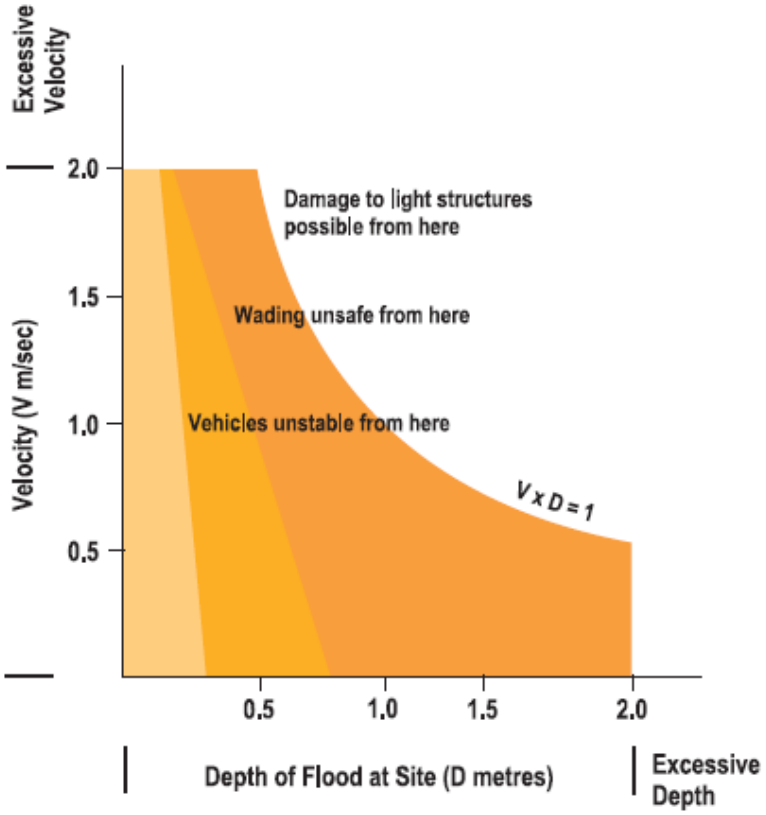

Figure 3-1. Flood Hazard Rating - Velocity and Depth Relationships (Floodplain Development Manual 2005)

3.3 Hazard Identification

Risk assessment knowledge and technical expertise described in previously referenced sources[1] was used to identify foreseeable significant risks associated with hazards within the project area.

The following hazards were identified from the previous municipal risk assessment and through contributions from the diverse stakeholder expertise are listed in Table 3-1 below. The first three of the identified Hazards are the specific focus of this risk management plan.

[1] Stated in sections 1.1 and 1.3

Table 3-1. Hazards Considered

Code	Hazard name	Top event
LGF1	**Flood Depth**	1 Inundation
LGF2	**Flood Flows**	2 High Power Stream Flow
LGF3	**Storm 'Surge' Tide**	3 Storm Tide inundation
LGF4	**Fire**	4 Wildfire
LGF5	**Storm**	5 Storm (land or sea Gale, Tornado)
LGF6	**Severe Weather**	6 Snow, Fog, Rain, Hail, Electrical storm, heatwave, drought
LGF7	**Earthquake/Landslip**	7 Seismic Event - Earthquake/Landslip/Tsunami
LGF8	**Exotic Animal Disease**	8 Epidemic
LGF9	**Infrastructure Failure**	9 Infrastructure Failure
LGF10	**Structural Fire**	10 Fire in residence, commercial or industrial complex
LGF11	**Hazardous Material**	11 Gas Leak/explosion
LGF12	**Pollution**	12 Spill or Discharge
LGF13	**Transport accident**	13 Transport Accident

3.4 Risk Assessment Method

Bow-Tie analysis was used to systematically review hazards associated with the Lower George River floodplain.

Bow-Tie analysis provides a visual representation of the relationships between the potential causes and consequences of hazards and control measures. Specialist software, BowTie*XP* was used to build the bowtie diagrams.

Figure 3-2 below is a representation of how the bowtie diagram is constructed in the BowTie*XP* software.

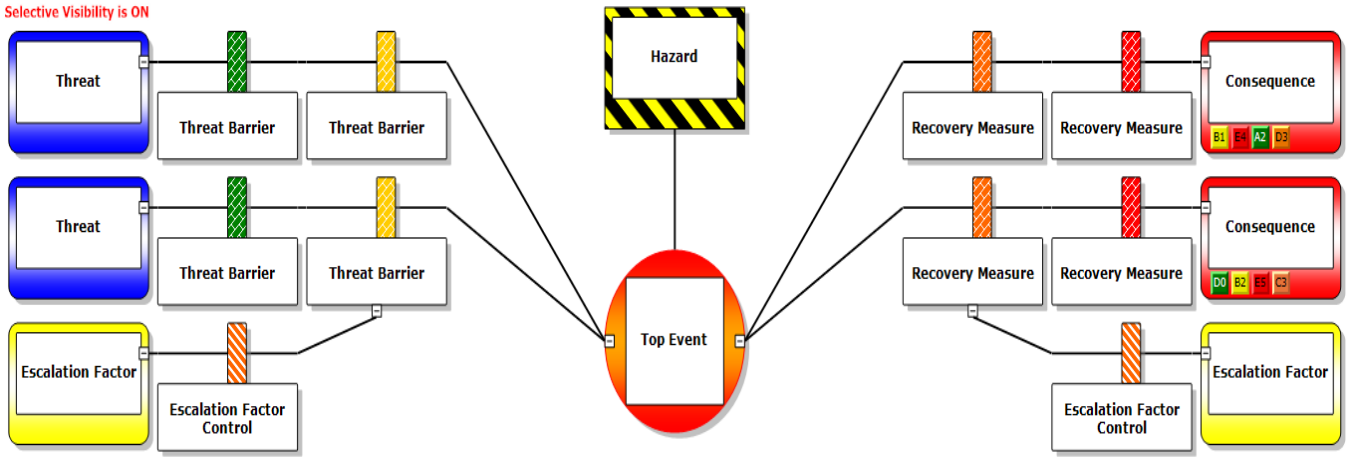

Figure 3-2. Example of how a Bow-Tie diagram is built using the specialist software

Relevant Bow-Tie diagrams were developed in the specialist software by **pitt&sherry** using the results of prior hazard identification processes and input through this assessments. Bowties were developed prior to the workshop, during the workshop with stakeholder input and subsequent to the workshop with ongoing feedback and analysis provided by stakeholders and in particular Council officers. The Bow-Ties form the basis for the risk assessment.

The Top Event (flood depth, flood flows or storm surge tide *LGF1-3*) is at the centre of the Bow-Tie diagram. To the left of the Top Event is a list of Threats and Threat Barriers (controls) and to the right of the Top Event is a list of Consequences and Recovery Measures. The barriers and recovery measures were colour coded according to the estimated effectiveness.

The colour legend for the interpreted effectiveness of controls is provided in Figure 3-3 below. The assigned category is identified on the Bow-Tie by the colour of the control tab (the top peg).

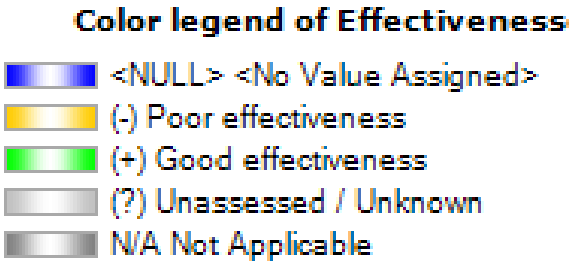

Figure 3-3. Interpreted effectiveness of action/barrier

Actions were also identified where further control measures were required to reduce the risk of the Top Event occurring as far as reasonably practicable. The actions were assigned a criticality of low, medium or high and colour coded according to criticality.

The Bow-Tie diagrams produced for this assessment can be found in **Appendix D.**

3.5 Risk Analysis Method

A semi quantitative risk analysis (SQRA) method was used to analyse the risk associated with each identified hazard.

The SQRA is typically based on NERAG risk matrices. For this assessment, however, a preferred risk matrix was supplied by Council to ensure consistency with councils risk register.

The risk matrices were incorporated in the Bow-Tie software and used to analyse the risk for the range of hazards identified within the project area. The consequences for each hazard were given a risk rating as an ***inherent***, or initial risk in the absence of any mitigation or adaptation barriers or controls and as a ***residual*** risk when the identified controls are in place.

3.5.1 Confidence Ratings

In accordance with NERAG, the risk assessment has assigned risk according to the confidence assigned to the assessment. NERAG specifies the below categorisation of confidence assignment (Figure 3-4).

Confidence Criteria	Low Confidence	Moderate Confidence	High Confidence
Data/Information	Neither community nor hazard specific; anecdotal only	Community or hazard specific; validated historical or scientific	Community and hazard specific; validated historical and scientific
Team knowledge	Neither hazard nor process (risk assessment) specific	Hazard or process specific	Hazard and process specific
Agreement	Neither on interpretations nor on ratings	On interpretations or ratings	On interpretations and ratings

Figure 3-4. Confidence Ratings

Consistent with NERAG, the risk assessments presented in this report are considered to have moderate to high confidence ratings for Data/Information. The process specific team knowledge is also considered to be moderate to high confidence.

However, until the risk analysis is fully assessed and the outcomes are further investigated by stakeholder contributors, the agreement category is defined as "Neither on agreement or rating". Consequently, all risk rating matrices in this assessment require application of a low confidence matrix resulting in a more conservative assignment of intolerable risk than may be achieved with more detailed analysis.

3.5.2 Risk Matrices

Risk ratings matrices as specified according to NERAG as per Figure 3-5 below.

High Confidence Level

Likelihood Level	Consequence Level: Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain					
Likely					
Possible					
Unlikely					
Rare					
Very Rare					
Almost Incredible					

Medium Confidence Level

Likelihood Level	Consequence Level: Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain					
Likely					
Possible					
Unlikely					
Rare					
Very Rare					
Almost Incredible					

Low Confidence Level

Likelihood Level	Consequence Level: Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain					
Likely					
Possible					
Unlikely					
Rare					
Very Rare					
Almost Incredible					

	Intolerable
	Tolerable subject to ALARP
	Broadly Acceptable

Figure 3-5. Risk Matrices (NERAG)

For this analysis however, the risk rating process involved application of a Council specified matrix of likelihoods and consequences (**Error! Reference source not found.**) specified by Council (with an example of application documented in Figure 3-7 following).

Likelihood	Consequence				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	Medium	Medium	High	Extreme	Extreme
Likely	Low	Medium	High	High	Extreme
Possible	Low	Medium	Medium	High	High
Unlikely	Low	Low	Medium	Medium	Medium
Rare	Low	Low	Low	Low	Medium

Figure 3-6. Council risk rating

For example, the risk analysis for the consequence of Death or Personal Injury resulting from high velocity water flow is indicated in Figure 3-7 below. In brackets is the interpreted rating prior to any controls or procedures put in place, while the un-bracketed value is the interpreted residual risk rating with controls in place.

For ease of interpretation of the rating code, the likelihood has been assigned alphabetically with A being most likely to E being most unlikely. The consequence of the hazard has been rated numerically with 1 being lowest impact to 5 being the greatest (catastrophic) impact.

Assignment of consequence ratings was consistent with consequence descriptions for a range of possible impacts (eg social, economic, project impacts etc) based on information supplied by Council.

Consequence Death or Personal Injury

		1	2	3	4	5
	Low Confidence	Insignificant (near misses or inconsequential short term failures)	Minor (Isolated, short to mid term repairable impacts)	Moderate (Isolated but significant mid term losses)	Major (Multiple severe mid to long term losses)	Catastrophic- Widespread unrecoverable or long term losses
A	Almost Certain >= annual					
B	Likely (approximately Annual)					
C	Possible May arise once in 10 yrs (~10% AEP)					[5C]
D	Unlikely may arise once in 10 to 25 yrs (~0.1 to 0.25% AEP)					5D
E	Rare unlikely to occur in next 25 years <(~0.025% AEP)					

Figure 3-7. Risk Rating for Death or Personal Injury

The risk analysis can be identified on the Bow-Tie diagrams in **Appendix D** by the colour coded boxes beneath each consequence. The risk analysis for the above example is illustrated in Figure 3-8.

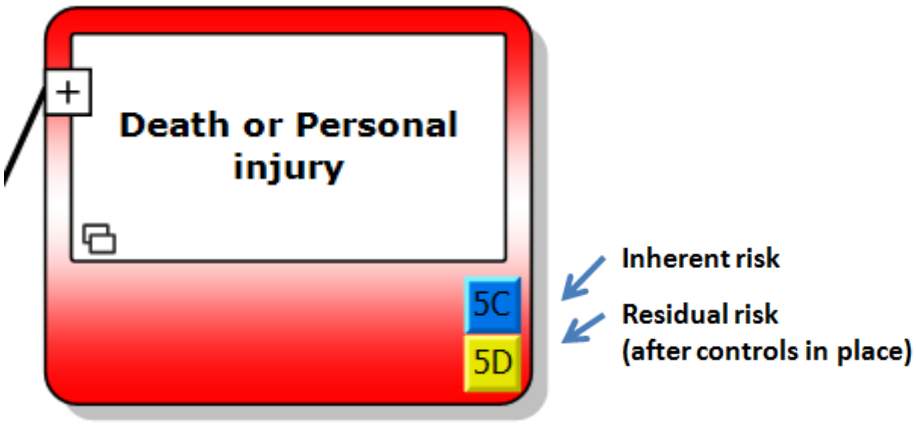

Figure 3-8. Bow-Tie Consequence indicating risk rating

4. Results

4.1 Flood Hazard Rating

Flood hazard ratings are presented coloured according to hazard index in the following images for a range of estimated flood volumes.

Hazard rating categories are broadly consistent with ratings prescribed in the floodplain risk management manual (NSW 2005)

The flood hazard ratings for 2 year flood flow scenarios for the current river channel and a and a potential 'cleaned' river channel are presented in
Figure 4-1 and
Figure 4-2 following.

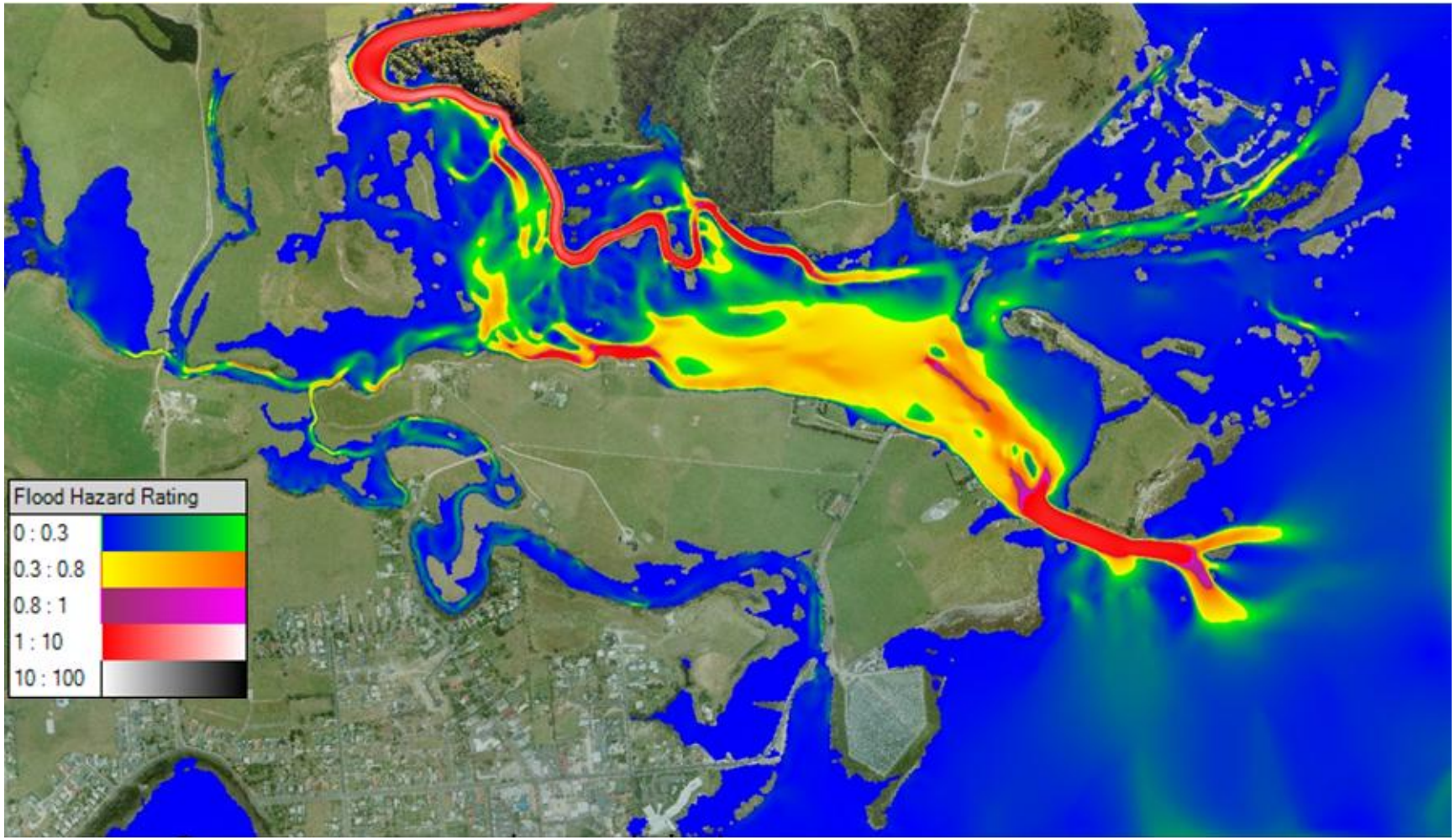

Figure 4-1. River Flood Hazard Rating - 2yr ARI - Current Topography/Channels

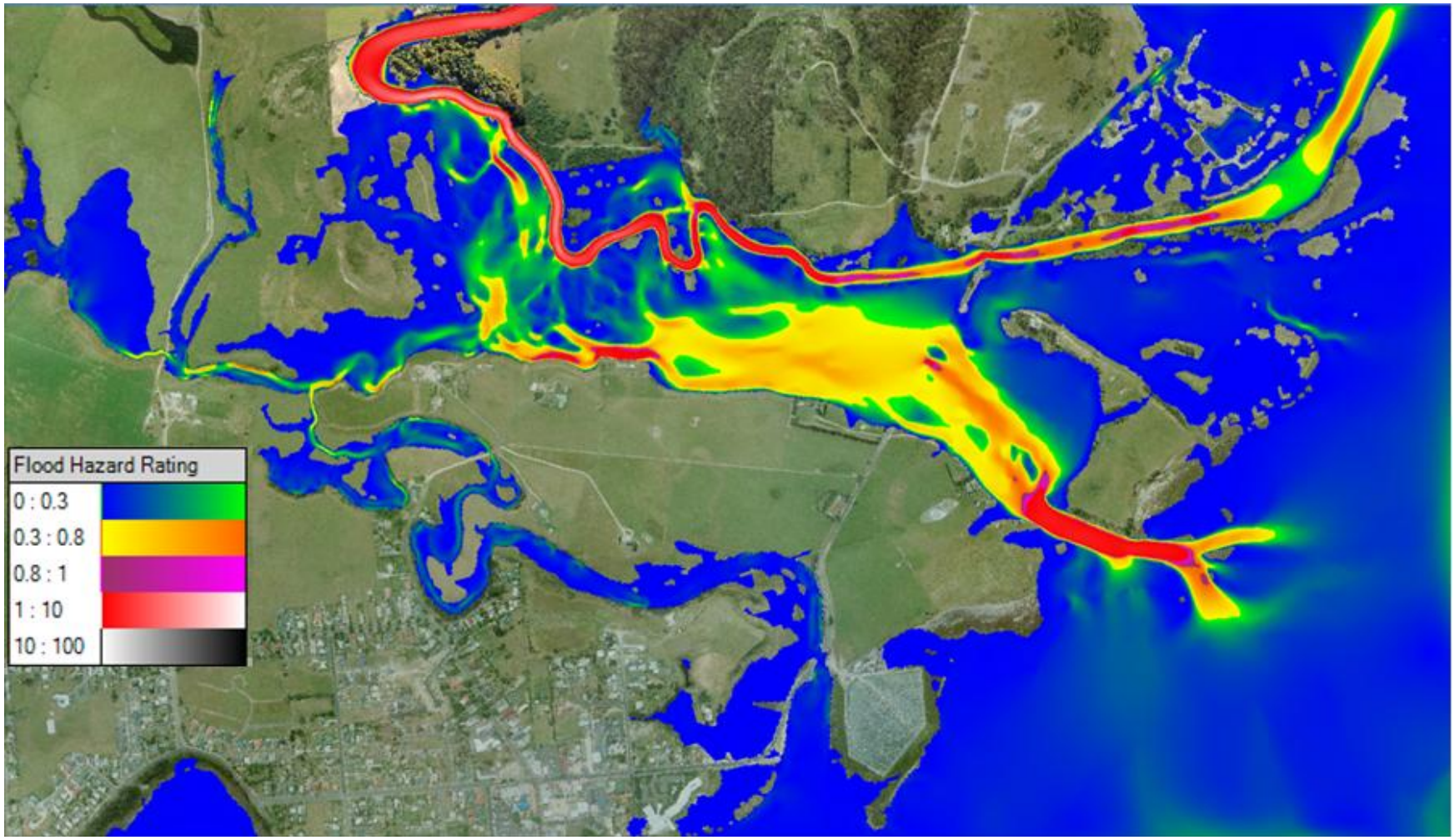

Figure 4-2. River Flood Hazard Rating - 2yr ARI - "Cleared" topography/channels

The difference between the two scenarios (cleared minus current) is presented in Figure 4-3 following.

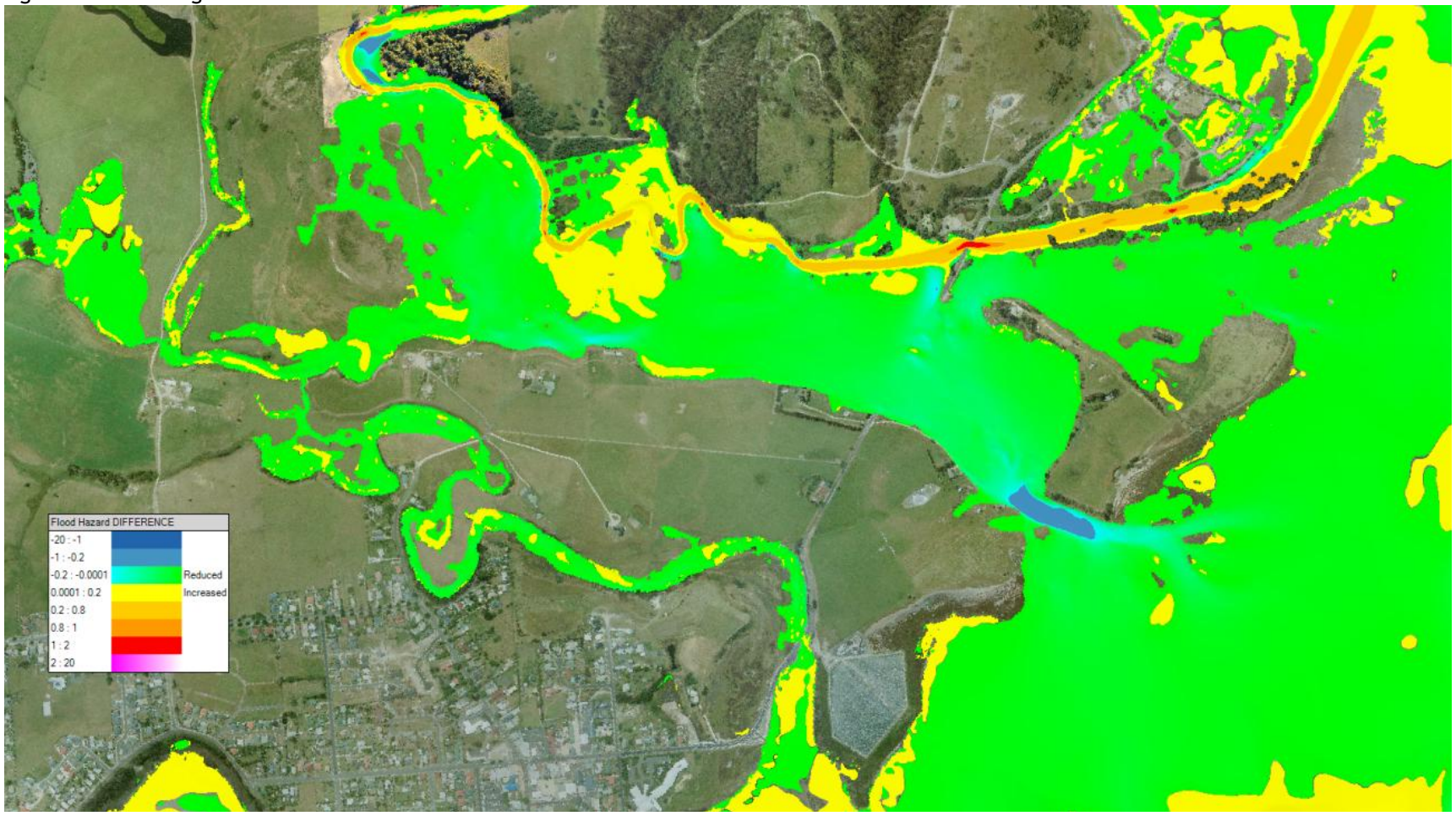

Figure 4-3. Difference in Hazard Rating 2yr ARI (Cleared minus Current)

The flood hazard rating for a 50 year ARI flood is presented in Figure 4-4 below.

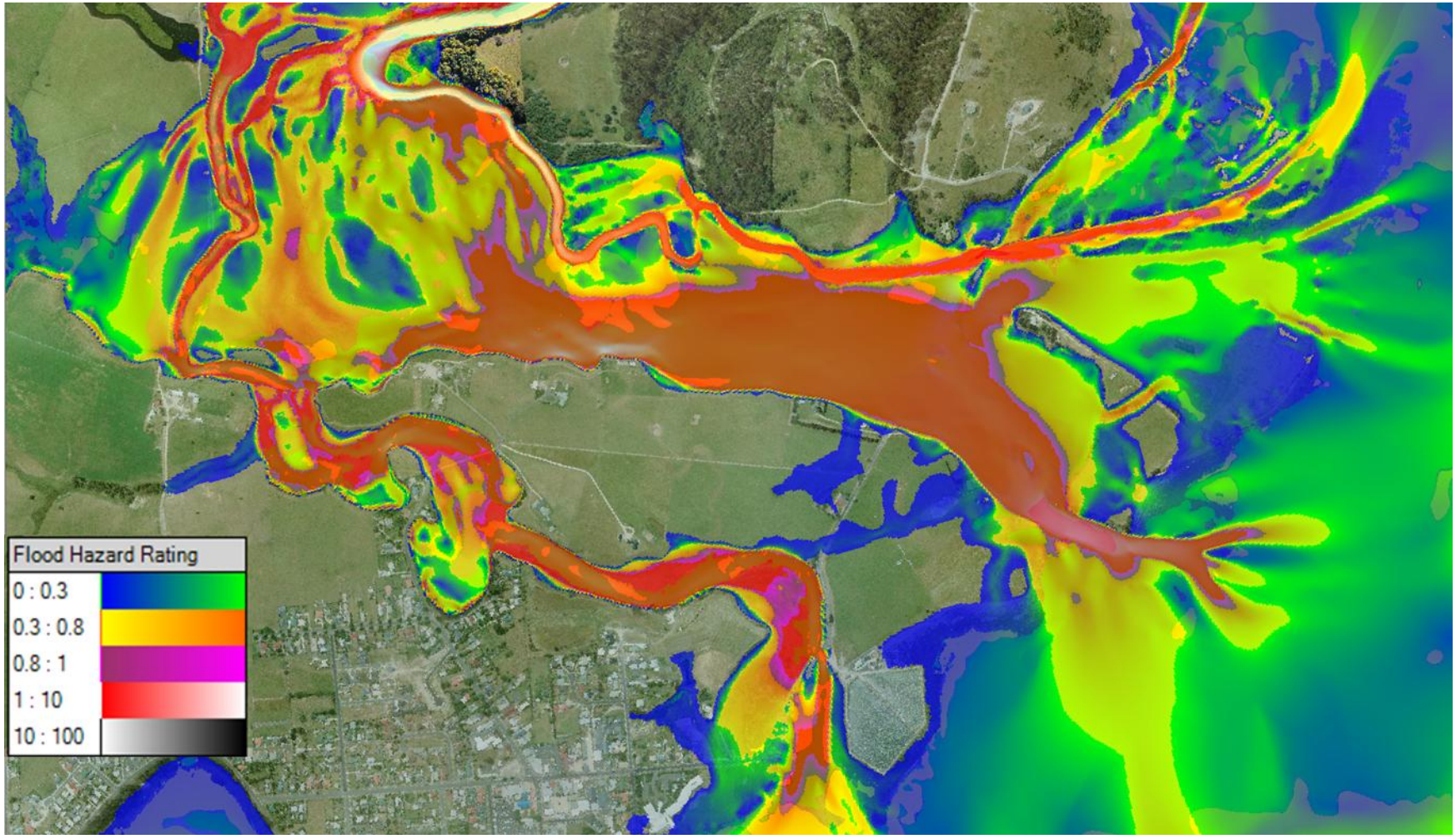

Figure 4-4. River Flood Hazard Rating - 50yr ARI

The flood hazard rating for a 100 year ARI flood is presented in Figure 4-5 following.

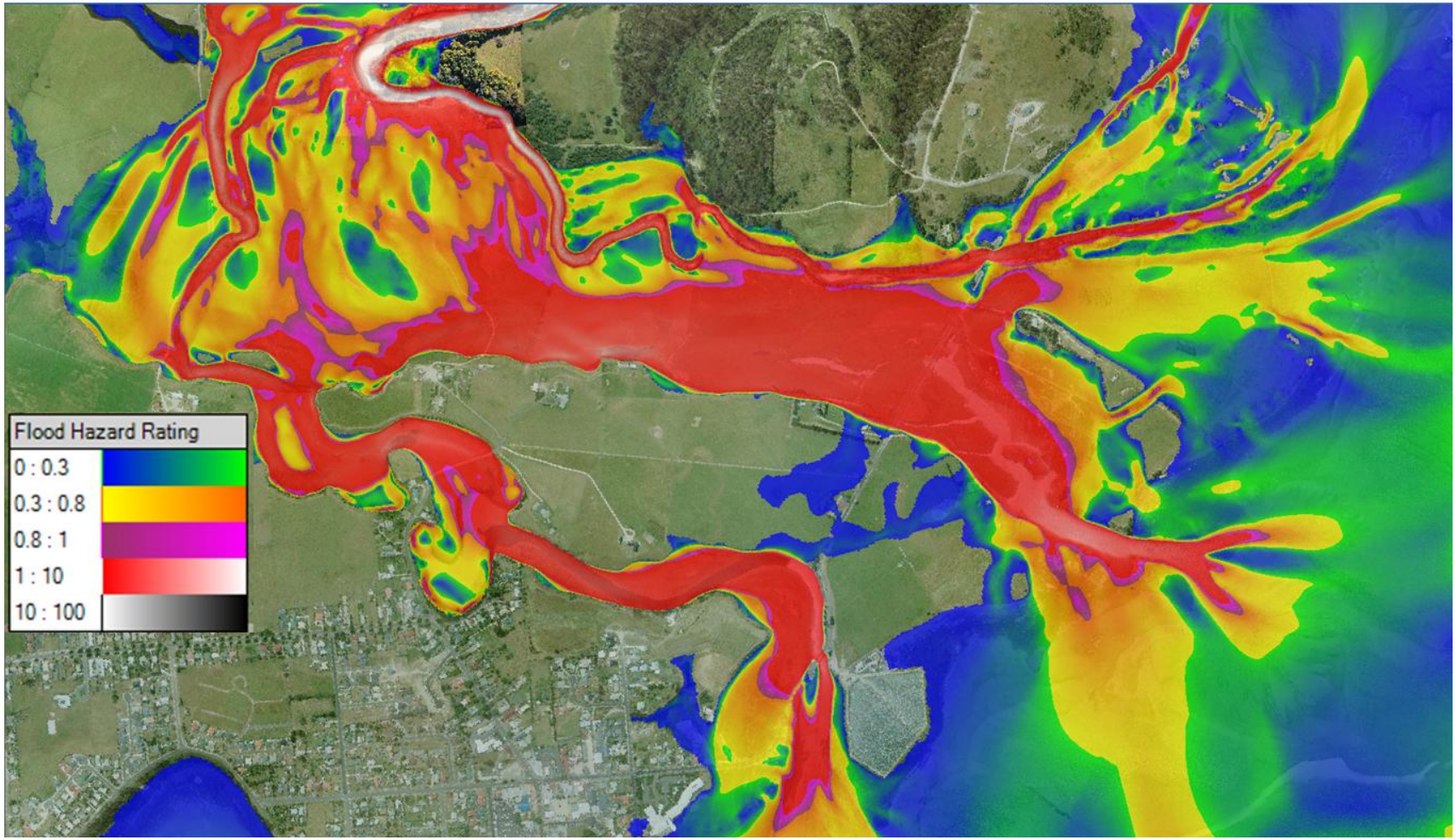

Figure 4-5. River Flood Hazard Rating - 100yr ARI

The flood hazard rating for a 100 year ARI flood as estimated for the end of the century is presented in Figure 4-6 below.

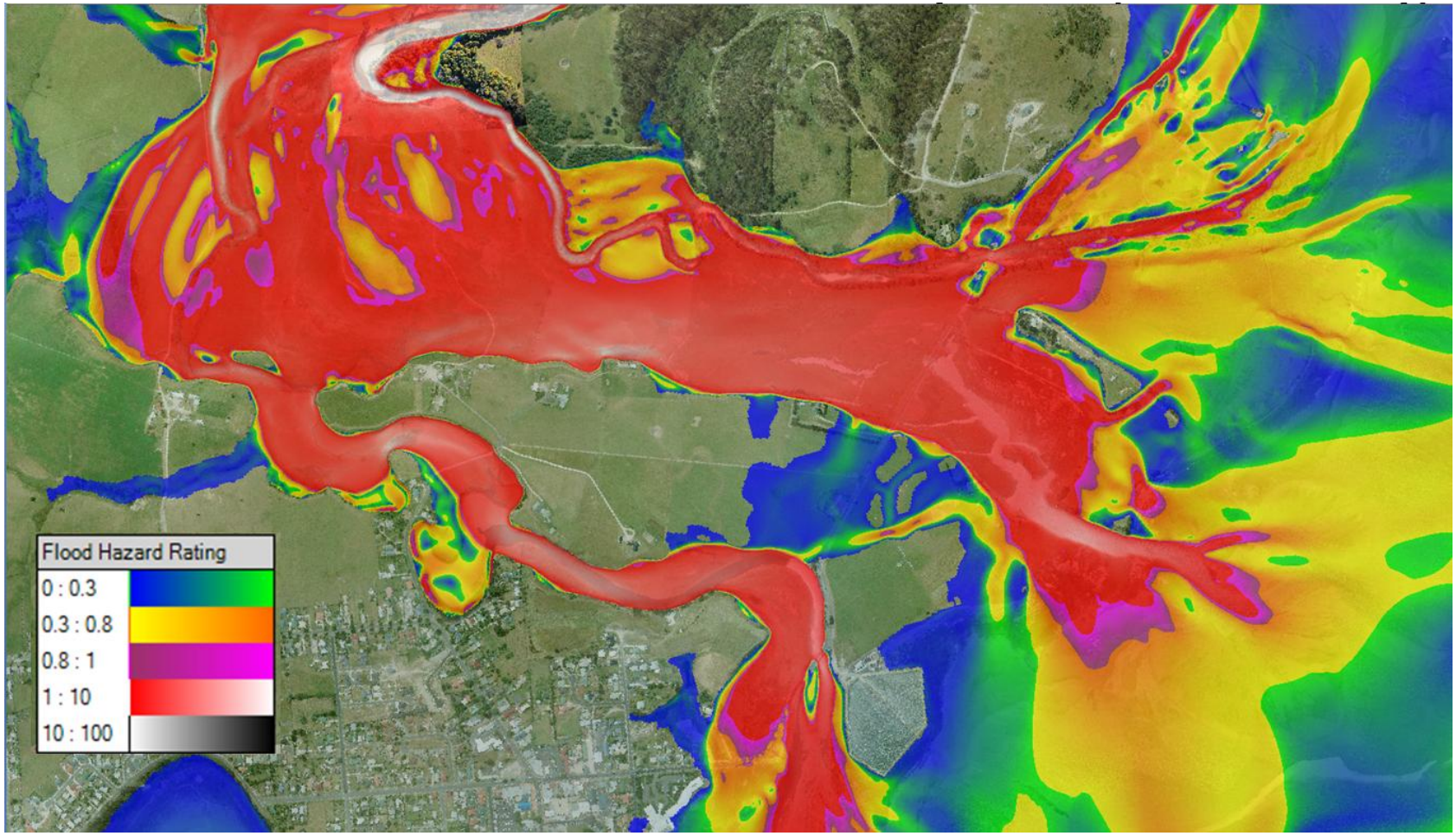

Figure 4-6. River Flood Hazard Rating - 100yr ARI end of century

4.2 Hazard Register

The Bow-Ties developed for the hazard assessment are included in **Appendix D.** The Bow-Ties indicated include a complete range of risk identified in this analysis of the floodplain and also includes broader 'municipal wide' risks previously identified in council risk assessment processes.
The Hazard register has been produced using the format of Council's risk register and is designed for stakeholders to identify the action plans for treating risks.

The three principle risks assessed for the floodplain, inundation, high velocity water flows and storm tide inundation have been incorporated into a Council consistent risk register included as **Appendix E.** It should be noted, however, that for consistency with NERAG a full suite of potential hazards have been considered for the project. Hazards previously identified in council documents (Legge and Cameron, 2003) have been incorporated for consideration in the Bow-Tie analysis process and are listed in **Appendix D.**

4.3 Risk Ratings

Risk ratings assessed for the range of hazards identified for the floodplain are listed in **Appendix F** and are presented on individual consequences within the Bow-Ties in **Appendix D**. The hazard rating applied to individual risks are indicated in **Appendix F.**

Consequence tables and Likelihood tables used to assess the risk hazard ratings were those provided by Council to enable consistency in risk assessment and are included in **Appendix H.**

The Council specified assignments are consistent with those specified in NERAG, though for comparison, the NERAG specified consequence and likelihood assessment tables are included as **Appendix I**.

To assist in determination of priority of actions the hazard ratings are indicated as an inherent value (assuming the event has occurred and where no controls have been put in place) compared to a residual value (assuming an event has occurred but where potential barriers or mitigating activities have been implemented).

4.4 Activities and Actions

Some actions and barriers have been identified as potentially applicable to reduce the consequence of events are indicated on the Bow-Tie diagrams and listed in full in **Appendix G**.

It is important to note that the list of activities is not considered to necessarily represent the only solutions available to different stakeholders.

The following table (Table 4-1) provides an overview of activities associated with the suggested activity and action listed in the appendix.

Table 4-1. Activities and Actions to reduce impact of hazards

Activity	Name	Frequency	Description	Responsibility
Av1. RipRap -	Design and emplace physical barriers to reduce flow velocity	As required	Design and emplace physical barriers to reduce flow velocity. Particularly important for areas identified as exposed to and vulnerable to high velocity flows.	Council/State Shared (or undetermined responsibility)

Activity	Name	Frequency	Description	Responsibility
Av2. Clean -	Obstruction removal	As required	Removal of in-stream physical obstructions. Requires careful analysis for potentially adverse impacts. Particularly important for maintaining flow paths in vulnerable structures to minimise potential increases in structural loading (eg the Bridge and causeway drains). Whole scale alteration and removal of stream flow blockages has been modelled to indicate a marginal reduction in flood hazard across the majority of the exposed floodplain and individual isolated sections of river bank for which erosion is likely to be reduced. However, the modelling also indicates a marginal increase in flood hazard rating and likely erosion in some river bank sections and a marked increase in flow velocities experienced at the causeway bridge.	Council/State Shared (or undetermined responsibility)
Av3 Armour / Review	Review functionality and requirements for armouring	Yearly	Review functionality and requirements for armouring to identify areas of deficiency and to prioritise requirements for additional protection. Sections with exposed infrastructure are likely to benefit from establishment of physical protection such as hardened 'armoured' walls and scour protection.	Council/State Shared (or undetermined responsibility)
Av4. Dams -	Review of design and safety of dams	As required	Regular review and maintenance of dams. Certification. While it is considered that limited significant storages exist in the catchment above the floodplain project area a sudden release may result in hazardous flows across the floodplain.	Water management section of DPIPWE
Av5. Levee bank -	Design and Build levee banks	As required	Build or enlarge levee banks to manage flows of flood waters. Aim to reduce velocity and power of stream at points where overtopping occurs (preventing overtopping) or redirecting water course to reduce flow power away from sensitive locations. This activity may be appropriate in conjunction with AV1 and Av3. As for Av2 however, potentially adverse affects may occur. Increased levee bank protection results in altered stream flow characteristics downstream and may displace the problem being 'solved'.	Council/State Shared (or undetermined responsibility)
Av6. Dredge -	Dredge stream channel deeper/wider	As required	physical removal of sediment deposition within channel to enhance flows. Removal of sediment from the downstream sections of the river will improve the ability to remove flood flows. However, the floodplain mouth is tidal and in situations of coincident high tide and river flooding the effectiveness of the action is reduced. Potentially detrimental consequences need to be considered in disturbance of sediment, particularly considering the significant upstream mining activities.	Marine and Safety Tasmania (Tidal regions)

Activity	Name	Frequency	Description	Responsibility
Av7. EWS -	Early Warning System	As required	Establish an early warning system to provide warning based on rainfall intensity gauges and/or gauged stream flows. An early warning system linked to identified upstream storm events or rapidly increasing low rates is considered a high priority which may contribute to a significant reduction in risk to people in the lower sections of the floodplain. Anecdotally, stakeholders are informed by residents in the upper catchment areas when potentially damaging events are in progress. The system requires formalisation and where possible automation to ensure maximum available time of warning and maximum dissemination of advice regarding the potential hazard.	Police and Emergency Management - Offsite Emergency Planning Unit
Av8. Alternate transport	Alternate transport arrangements	As required	In place procedure for securing and implementing alternate transport for critical requirements/supplies (Helicopter/boat et al). A significant problem was described in the isolation and potential exposure to further risk of the current communities due to flood waters (or storm surge tides) due to closure of the causeway and the alternative Reids road.	State Emergency Services
Av9. EMP	Emergency Management Plan	As required	EMP Break O'Day Municipal emergency management plan Preparation and appropriate implementation of municipal emergency management plan. Ensure up to date and regularly reviewed for currency and appropriateness. Implementation as soon as reasonably practical prior to/during and post event. Specific treatments required for the hazards identified in this risk assessment plan.	Council/State Shared (or undetermined responsibility)
AV10 Recovery Plan	Develop recovery plan		Development of a recovery plan for implementation in advance of a hazard event occurring. A recovery plan for dealing with the aftermath of a significant event should be prepared and regularly reviewed to ensure optimal efficiency in managing a recovery from the even and minimising the potential impact of delayed or inappropriate responses.	State Emergency Services?
Av11 Legislative /Planning Scheme restrictions	Legislative / Planning Scheme restrictions		Planning Scheme restrictions to manage overland flows from developments and restrict/limit adverse impacts	Break O'Day Council
Av12 Climate Change	Climate Change	As required	Ensure information relating to potential adverse impacts of projected climate change is adequately incorporated in planning and development	Council/State Shared (or undetermined responsibility)
Av 13 Fire Plans	Develop Implementable Fire Plans	As required	Develop municipal and individual fire management plans	Individuals and Council
Av 15 Stormwater	Stormwater Strategic Plan		Develop and implement stormwater management plan to review and strategically design appropriate mitigation features to accommodate the foreseeable impacts	Break O'Day Council
Av 16 Floodplain Categorisation	Categorise Floodplain areas by Hazard rating	As required	Mapping floodplain by hazard rating categories to assist with planning requirements	Break O'Day Council

In accordance with standard risk assessment processes the planning must be considered as an iterative and ongoing process with stakeholder review and input crucial to identify and prioritise actions.

5. Recommendations

The risk ratings presented in this report should be adopted by Stakeholders and used to develop strategic risk management plans on the Lower George River floodplain.

In accordance with Council instruction the priority assigned to implementation of actions and activities will be determined according to various stakeholder needs and interests and developed in response to risks pertinent to specific situations.

The risk register prepared will enable prioritisation of action required and the treatment plan to be selected in conjunction with further stakeholder input.

6. References

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Harkin, J and Attwater, C. 2011. ***The Tasmanian Coastal Adaptation Decision Pathways Project***.

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LGAT, Tasmanian Planning Commission and SGS Economics and Planning, 2012. ***Tasmanian Coastal Adaptation Decision Pathways Project: Rising to the Challenge; Developing Flexible Coastal Adaptation Pathways for Local Communities***.

Tasmanian State Emergency Management Committee, 2010. ***National Emergency Risk Assessment Guidelines***. Tasmanian State Emergency Service, Hobart, 2010.

Attachments

Appendix A	*Data Mining / Information Collation*
Appendix B	*Scoping Form for Stakeholder input*
Appendix C	*Scoping Plan for Stakeholder Consideration of Initial Concerns*
Appendix D	*Bow-Tie Diagrams*
Appendix E	*Hazard Register*
Appendix F	*Risk Hazard Ratings*
Appendix G	*Action Register*
Appendix H	*Council specified Consequence / Likelihood Tables and risk rating matrix*
Appendix I	*NERAG Consequence / Likelihood Tables and risk rating matrix*

Appendix A

Data Mining / Information Collation

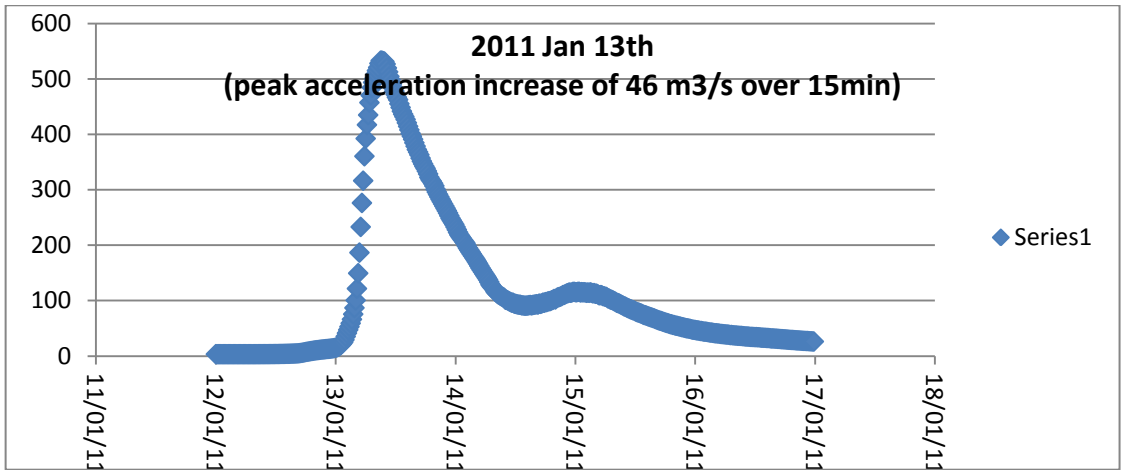
1. River flow information

Information obtained through analysis of the Water Information System for Tasmania (WIST) for station 2205 with data available from 10 April 1968 to 20 February 2013 though with various sections of missing information.

The below table provides flood flow information obtained from the George River stream gauge which was analysed for a range of specific information pertinent to the flood analysis.

GEORGE RIVER AT St.HELENS WATER SUPPLY INTAKE Station No 2205- Stream Flow Measured in: Cumecs (Cubic Metres Per Second)				
Length of record				
10_04_1968-to-20_02_2013	***44.9 Years***	***with 31.2 Years of data***		
record period	Max FLOW m3 per sec		Max Increase in flow (+ m3 per sec per minute)	
10_04_1968-to-31_12_1969	501.1	30/05/1969 23:00	1.1	30/05/1969 14:45
01_01_1970-to-31_12_1979	337.7	28/04/1974 9:00	0.9	22/03/1974 13:30
01_01_1980-to-31_12_1989	581.9	18/05/1986 12:15	4.1	18/05/1986 11:00
01_01_1990-to-02_10_1990	31.8	10/08/1990 17:15	0.1	5/08/1990 10:15
01_01_2002-to-31_12_2007	333.6	22/10/2005 3:00	0.8	21/10/2005 22:00
01_01_2008-to-05_12_2012	646.0	24/03/2011 8:15	3.1	13/01/2011 5:00
01_01_2012-to-20_02_2013	102.4	25/05/2012 23:15	0.3	25/05/2012 19:45
MAXIMUM FROM RECORD	**646.0**	**24/03/2011 8:15**	**4.1**	**18/05/1986 11:00**

As an example of flood flows, the below figure represents the peak flow recorded for the 13th January 2011 flood event (peak flow of 646m3/s and max rate of change of 3.1 m3 per second per minute).



2. Estimated Flow Volumes

The following flood flow volumes have been used in generation of the floodplain outputs (Rand, 2011).

Recurrence interval (Annual Exceedance Probability AEP)		Historically observed volumes	Projected Rainfall intensity changes		Potential volume impacts *(rainfall intensity)* Cumecs (m3/s)		Volume increases including effects of *(+11.7% runoff)* Cumecs (m3/s)	
ARI	AEP	Cumecs (m3/s)	by 2050	by 2091	by 2050	by 2091	by 2050	by 2091
			%age change					
1.01	*0.990099*	49.4						
1.11	*0.900009*	55.5						
1.25	*0.8*	66.9						
2	*0.5*	127.6	19%	29%	***152***	***165***	*170*	***184***
5	*0.2*	270.2	24%	36%	***335***	***369***	*374*	***412***
10	*0.1*	386.4	19%	29%	***460***	***499***	*514*	***558***
15	*0.0666666*	456.2						
20	*0.05*	506.4	29%	44%	***652***	***729***	*728*	***815***
25	*0.04*	545.5						
30	*0.03333*	577.8						
50	*0.02*	668.8	31%	47%	***876***	***986***	*979*	***1101***
75	*0.0133*	741.9						
100	*0.01*	794.2	32%	49%	***1051***	***1187***	*1174*	***1326***
200	*0.005*	921.5	33%	51%	***1229***	***1392***	*1373*	***1555***
500	*0.002*	1092.5	35%	53%	***1470***	***1670***	*1642*	***1865***
1000	*0.001*	1224.0	35%	54%	***1655***	***1883***	*1849*	***2104***

3. Georges bay storm surge tidal level information

High Water reference level for St Helens (DPAC Stage 2 mapping project) = 0.672m AHD

Canute Sea Level Calculator outputs for projected extreme tides

Potential storm surge inundation levels - Georges Bay (m AHD)						
ARI	**2**	**5**	**10**	**20**	**50**	**100**
~AEP	*0.394*	*0.182*	*0.1*	*0.05*	*0.02*	*0.01*
Present Day	1.05	1.08	1.12	1.14	1.16	1.18
2050 *(inc A1FI SLR)*	1.21	1.25	1.28	1.32	1.36	1.38
2100 *(inc A1FI SLR)*	1.55	1.70	1.75	1.82	1.93	1.96
Wind / Wave setup *(modified for directional strength)(m addition to surface level)*						
2000m Fetch	0.08	0.10	0.11	0.13	0.14	0.16
5000m Fetch	0.18	0.23	0.26	0.30	0.36	0.40

Extreme sea levels that may be experienced in Georges Bay including potential wind wave setup at the Georges River mouth for an estimated 1 in 100yr or 1% AEP event combining surge tide and wave setup are adopted as;

Currently (2012):- 1.58m AHD
At 2100 (including A1FI sea level rise):- 2.36m AHD

4. Anecdotal information / photography

Information pertinent to this risk assessment has been collated from a variety of sources. The information represents a compilation of valuable local knowledge, advice and historic observations considered relevant to the risk management and planning process.

In addition to local stakeholder supplied information, data was collected during a number of site visits (including a suite of photography representing different floods and perspectives on previous or current landuse).

5. Photographic data sets captured or provided for use in analysis

2012 Site inspection

Locations of "logs/vegetated island" blockages

Photo and GPS location for of back step of farmhouse anecdotally house representing local landowners advice of the highest point of flood waters during the very significant 1929 flood event.

2012 aerials of river path

Captured at low altitude for entire river path within project area. Reference to location of existing blockages and current status of river bank.

2011, 2009 and 2004 Flood events

Imagery from land owners provided for reference and use in calibration of surface flood flow modelling.

6. Stakeholder Advice on flood water rate of rise

Particularly pertinent to this risk assessment is advice from one of the floodplain land owners regarding the rate of rise of the flood water during what was recalled as a 1980 flood.

" The floodwater on a sunny day (in St Helens) rose so fast across the floodplain that the vehicle in which they were travelling from the levee bank corner back to higher ground was engulfed and washed a short distance down the floodplain, fortunately reaching a point at which they could drive up the hill slope and exit the water.".

Analysis of the rate of rise observed in the stream flow gauge has been undertaken to attempt to identify records and timeframes representing significant rapid rates of flood water depth increases and consequently a highly significant hazard.

From the available flow record, the greatest observed rate of flood water rise (previous section) indicates that on 18 May 1986 the flow gauge recorded a rise of 4m3/s per minute which was observed approximately 1 hr before the peak flow of the event.

If an event of that magnitude was sustained over a period of 2 hours the change in flow volume represents an increase in 480m3/s.

Depending on the initial flow volume at the time of the 'pulse' the increase potentially represents inundation and flooding across the floodplain changing from potentially nil flood flow to an estimated 20yr ARI event within two hours.

Appendix B

Scoping Form for Stakeholder Input

21 November 2012

Dear Stakeholder

Lower George River Floodplain Risk Management Plan

pitt&sherry have been engaged by Break O'Day Council to prepare a risk management plan for the Lower George River floodplain.

The plan will build on previous assessments and analysis to report on risks to specific assets and identify and document appropriate responses or solutions to mitigate the impact or consequences of the risks identified. The key outcome intended will be a plan documenting recommended actions and responsibilities.

Previous reports have identified a range of potentially vulnerable assets within the floodplain and a number of principally long term hazards to those assets. While considering the long term risks, this process will provide more focus on specific short term risks and mitigation options.

We are seeking your involvement in a workshop to be held on Wednesday 28th November at the Break O'Day Council Chambers from 1pm to contribute to the risk management planning process. Myriax Pty Ltd will be attending to demonstrate the state of the art flood modelling package EonFusion Flood. The Flood modelling software is being applied to identify a range of what-if scenarios to assist in the risk management process (for example, what is the impact of removing the willows or deepening the channel at the river mouth what is the consequence of a flood coinciding with an abnormal high tide).

pitt&sherry will facilitate the risk assessment using Bowtie analysis to systematically review indentified hazards associated with the Lower George River floodplain.

The Bowtie process provides a visual representation of the relationships between the potential causes and consequences of hazards and control measures. Specialist software, BowTieXP will be used to build the Bowtie diagrams.

The following steps will be carried out in building the Bowtie diagrams:

1. Identify the Hazards (entity with the potential to cause harm)
2. Identify Top Events or ways in which the hazard could get out of control
3. Identify Threats or causes of the Top Event
4. Identify Consequences or outcomes of the Top Event
5. Identify Threat Controls – ways of preventing the Threats from occurring
6. Identify Recovery Measures – ways of recovering from the Top Event should it occur

The left side of the Bowtie diagram shows the Threats and Threat Barriers (controls) and the right side of the Bowtie diagram shows the Consequences and the Recovery Measures. The barriers can be linked to the specific procedures with responsible people and can be colour coded for effectiveness. Actions will be identified and allocated against controls during the workshop to ensure that the risk of the Top Event occurring has been reduced as far as reasonably practicable.

Prior to attending the meeting we are hoping you would give some consideration to a number of specific concerns or issues that may impact on your assets, property or lifestyle and in particular if you could note them for discussion according to the following categories:

pitt&sherry
sustainablethinking
transport infrastructure
community infrastructure
industrial infrastructure
climate change

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Hazard (what exactly is the 'thing' or feature that requires to be controlled or managed) examples for the Lower George River Floodplain include

- "Fast Flowing River water"
- "Deep water"
- "Sea Water" or "Salt Water"
- Sediment, Logs or debris
- Fire?
- ....etc

Top Event (What might occur that causes the hazard to be a concern?). Most hazards may not actually be a problem until they are involved in an "event".
Examples include:-

- Fast flowing water outside the river banks
- Salt water inundation over productive land (abnormal high tide)
- River sediment deposited on productive land
- Coastal storm tide exceeding the level of retaining walls at the waste water treatment facility
- Deep water over the top of the roadway
- Inundation of the wastewater pump station
- Debris accumulating on bridge structure
- .....etc

Threat (what factors actually contribute to the event occurring?)
Examples include:

- East Coast low pressure system contributing to intense rainfall in the river catchment
- river bank erosion causing a diversion of the river system
- abnormal meteorologic conditions coinciding with 'king' or high astronomic tidal conditions contributing to storm surge
- Increased vegetation growth within the river channels restricting water flows
- construction of diversion features or systems which influence the river flow
- .....etc

Consequence (Ultimately the "so what" if the event occurs)

- Personal injury (people hurt by fast moving water or struck by debris or swept from the causeway)
- Death
- Infrastructure damage (debris impacts on bridge causing destruction or damage)
- Livelihood impacts (spills or inflows impacting on sea food quality)
- Erosion undermining road or other infrastructure leading to reduced amenity or utility or simply increased repair costs
- Reduced property values
- Loss of habitat for fauna or loss of flora
- Loss of flora or fauna
- ....etc

Threat Controls (Essentially what could be done to avoid or reduce the impacts)
Examples which may be investigated may include;

- removal of willows to alter flow velocities
- construction of increased drainage capacity to alter flow velocities or inundation depths
- barriers or armouring to protect specific assets or features
- sediment reduction to amend or alter flow velocities
- relocation of specific assets
- positioning of early warning system to identify and warn of potentially significant floodflows
- .....etc

Recovery Measures (what can be done to minimise the damage given the event occurs)
Examples may include;

- Emergency Services to mitigate inundation from flooding
- Sand Bagging
- Relocation Plans
- ...etc

Prior to the meeting, **pitt&sherry** representatives in conjunction with the State Emergency Service will be inspecting features and assets on the floodplain.

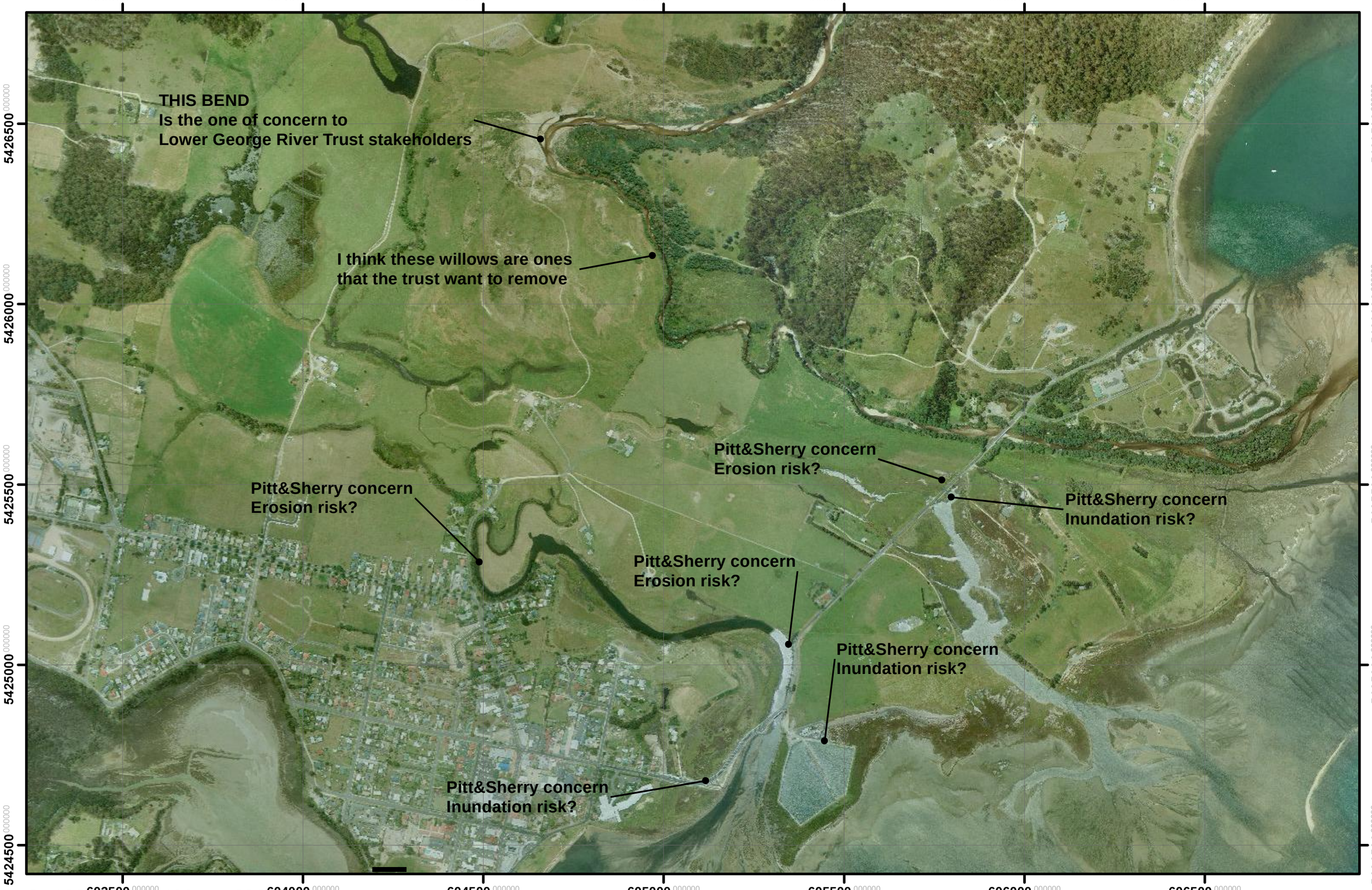
Please direct any queries to Mr Sven Rand by phone on 6323 1916 or mobile 0419 447 509 or email to srand@pittsh.com.au.

Yours sincerely

Sven Rand
Senior Consultant
Launceston Office

Appendix C

Scoping Plan for Stakeholder Consideration of Initial Concerns

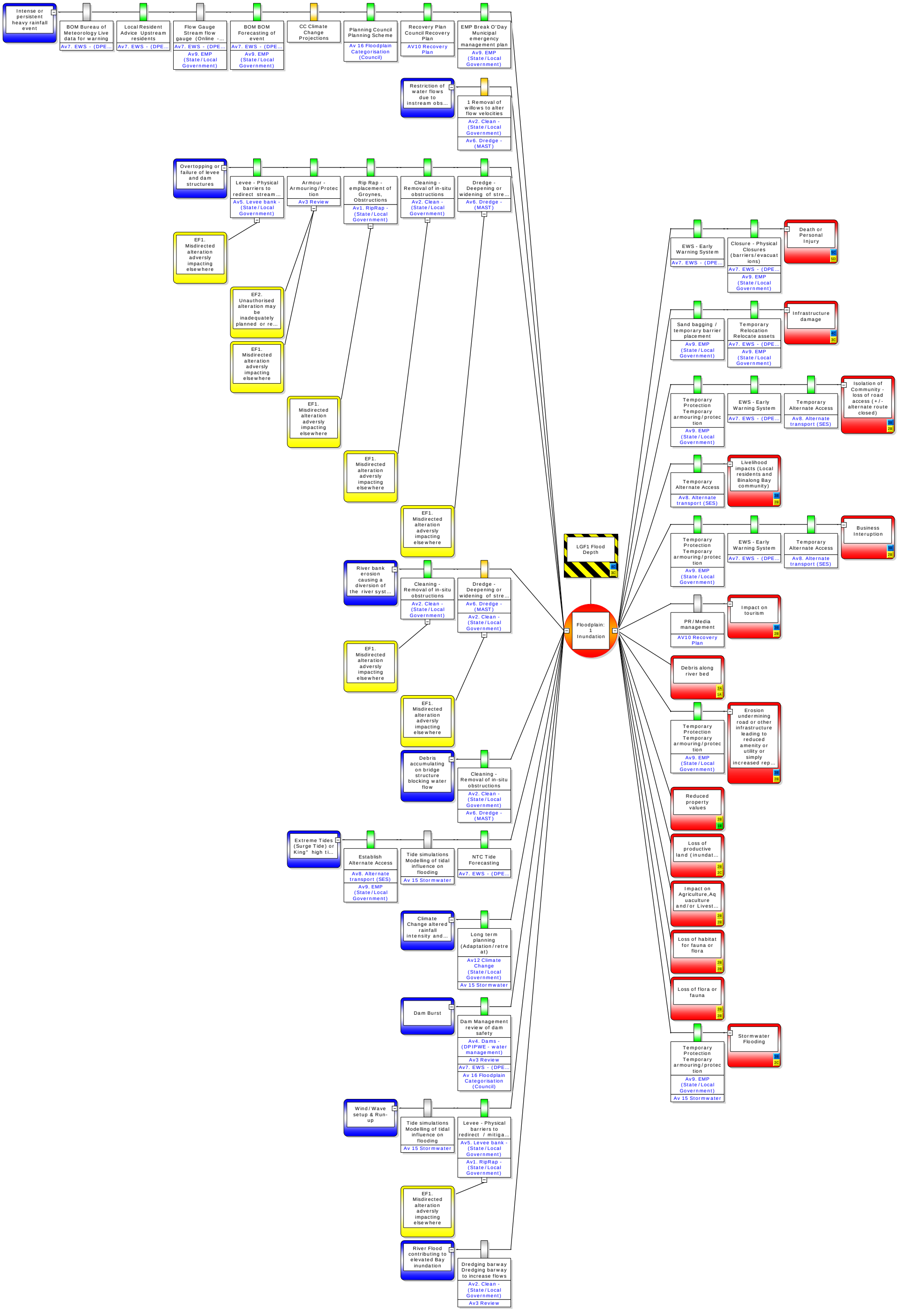


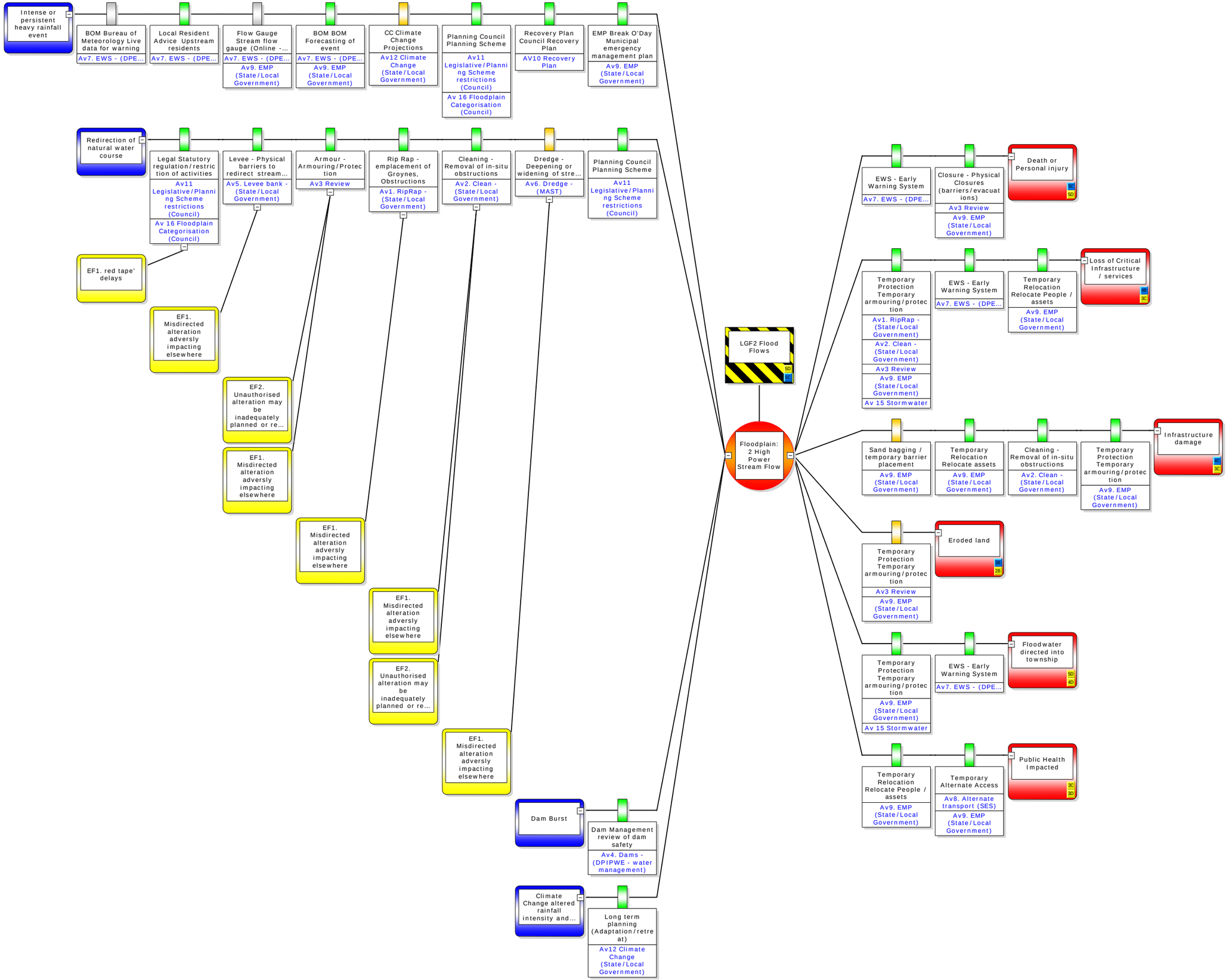
Ortho Imagery 31 December 2009
Base image by TASMAP (C) State of Tasmania
Base data by theLIST (C) State of Tasmania

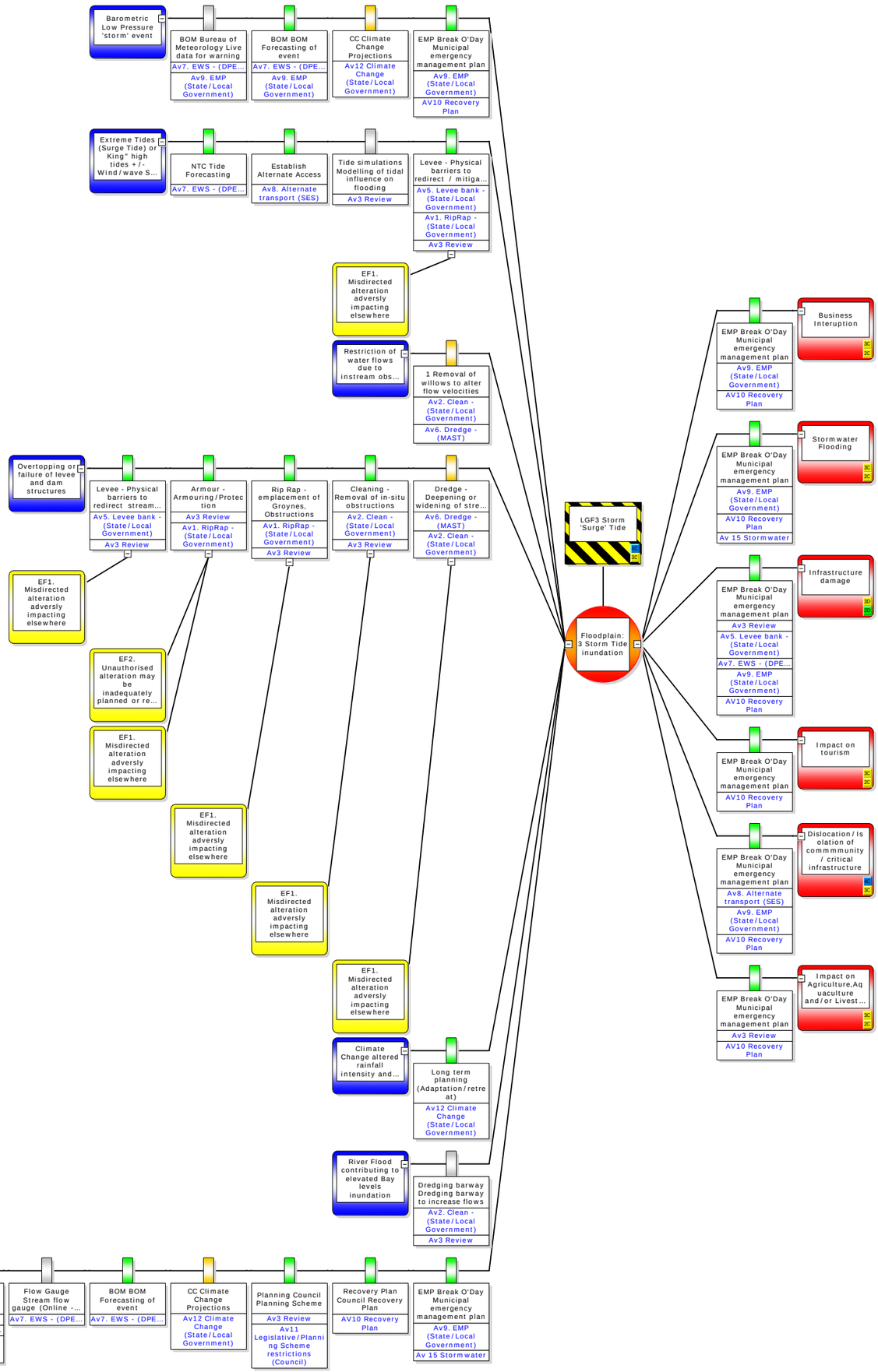
Lower George River - Flood Plain

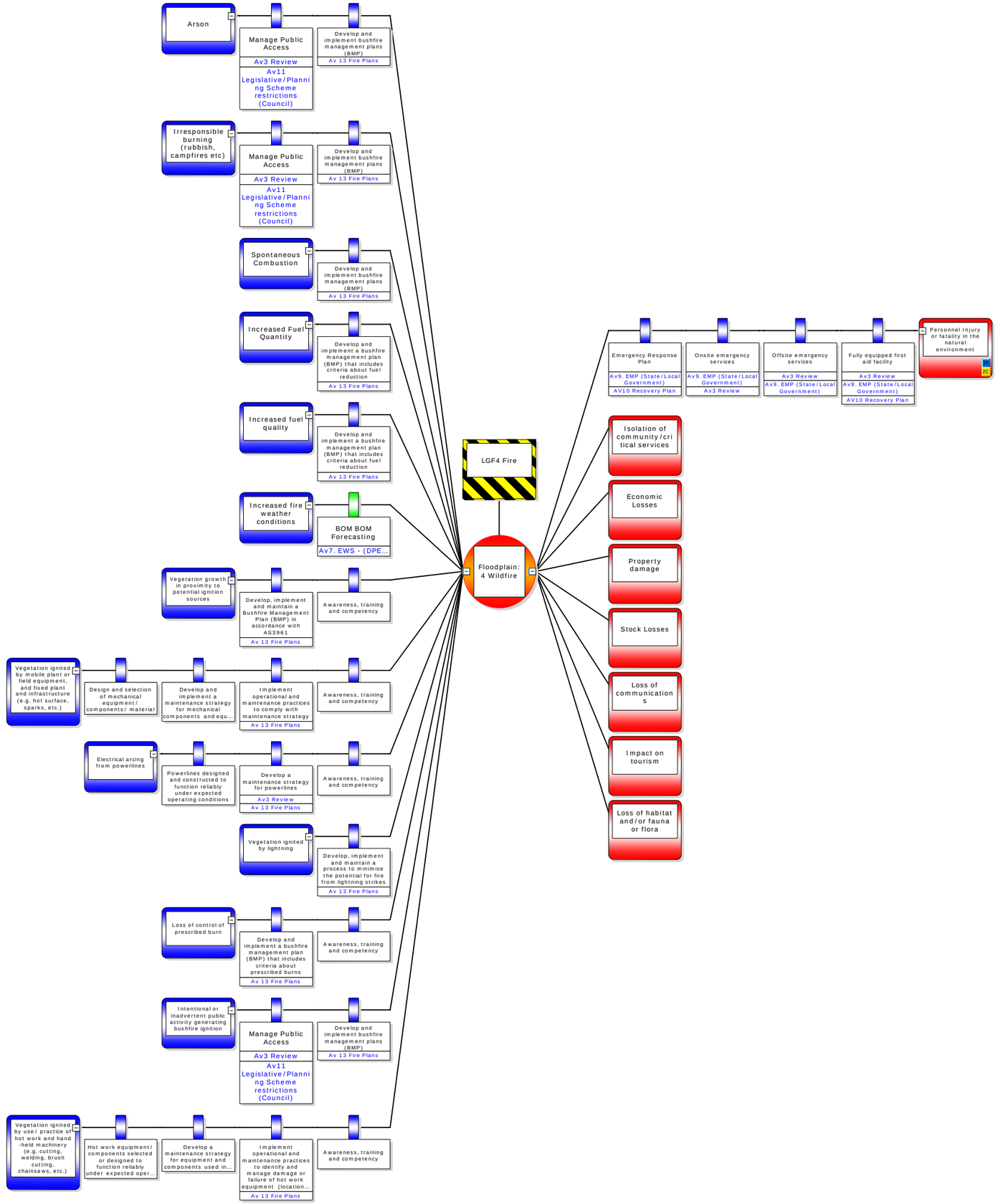
Appendix D

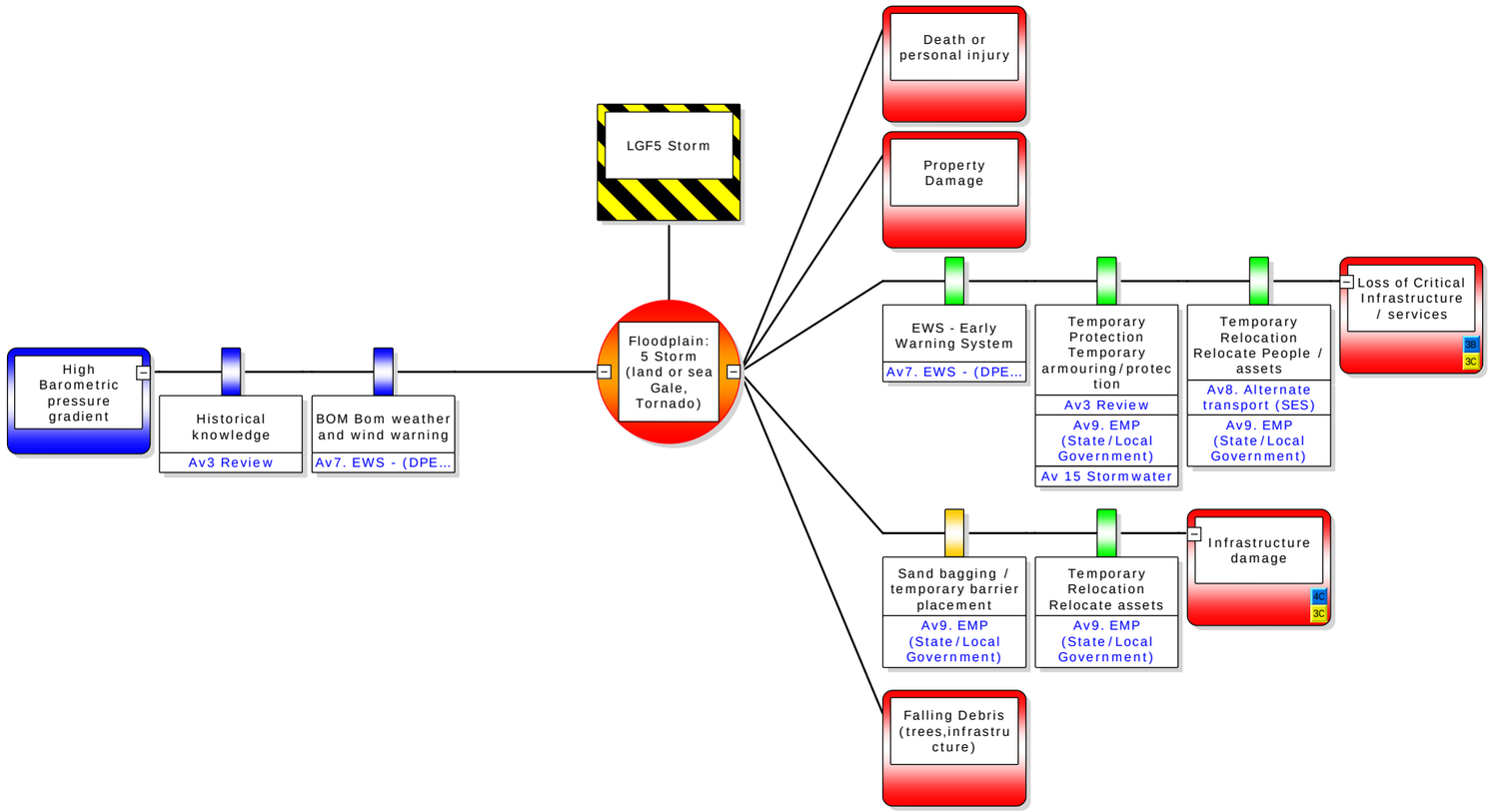
Bow-Tie Diagrams

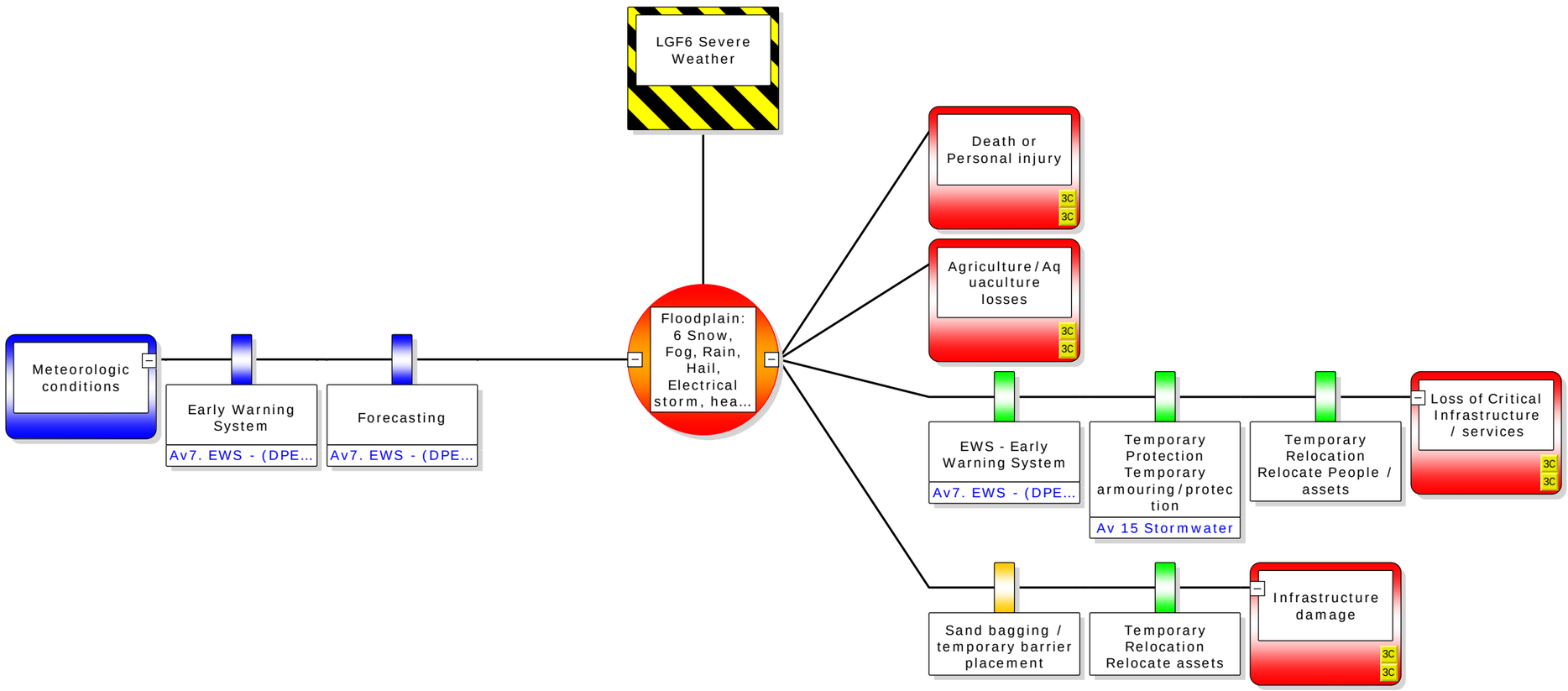

Intense or persistent heavy rainfall event
BOM Bureau of Meteorology Live data for warning
Av7. EWS - (DPE...
Local Resident Advice Upstream residents
Av7. EWS - (DPE...
Flow Gauge Stream flow gauge (Online -...
Av7. EWS - (DPE...
Av9. EMP (State/Local Government)
BOM BOM Forecasting of event
Av7. EWS - (DPE...
Av9. EMP (State/Local Government)
CC Climate Change Projections
Planning Council Planning Scheme
Av 16 Floodplain Categorisation (Council)
Recovery Plan Council Recovery Plan
AV10 Recovery Plan
EMP Break O'Day Municipal emergency management plan
Av9. EMP (State/Local Government)
Restriction of water flows due to instream obs...
1 Removal of willows to alter flow velocities
Av2. Clean - (State/Local Government)
Av6. Dredge - (MAST)
Overtopping or failure of levee and dam structures
Levee - Physical barriers to redirect stream...
Av5. Levee bank - (State/Local Government)
Armour - Armouring/Protection
Av3 Review
Rip Rap - emplacement of Groynes, Obstructions
Av1. RipRap - (State/Local Government)
Cleaning - Removal of in-situ obstructions
Av2. Clean - (State/Local Government)
Dredge - Deepening or widening of stre...
Av6. Dredge - (MAST)
EF1. Misdirected alteration adversly impacting elsewhere
EF2. Unauthorised alteration may be inadequately planned or re...
EF1. Misdirected alteration adversly impacting elsewhere
EF1. Misdirected alteration adversly impacting elsewhere
EF1. Misdirected alteration adversly impacting elsewhere
EF1. Misdirected alteration adversly impacting elsewhere
River bank erosion causing a diversion of the river syst...
Cleaning - Removal of in-situ obstructions
Av2. Clean - (State/Local Government)
Dredge - Deepening or widening of stre...
Av6. Dredge - (MAST)
Av2. Clean - (State/Local Government)
EF1. Misdirected alteration adversly impacting elsewhere
EF1. Misdirected alteration adversly impacting elsewhere
Debris accumulating on bridge structure blocking water flow
Cleaning - Removal of in-situ obstructions
Av2. Clean - (State/Local Government)
Av6. Dredge - (MAST)
Extreme Tides (Surge Tide) or King" high tI...
Establish Alternate Access
Av8. Alternate transport (SES)
Av9. EMP (State/Local Government)
Tide simulations Modelling of tidal influence on flooding
Av 15 Stormwater
NTC Tide Forecasting
Av7. EWS - (DPE...
Climate Change altered rainfall intensity and...
Long term planning (Adaptation/retreat)
Av12 Climate Change (State/Local Government)
Av 15 Stormwater
Dam Burst
Dam Management review of dam safety
Av4. Dams - (DPIPWE - water management)
Av3 Review
Av7. EWS - (DPE...
Av 16 Floodplain Categorisation (Council)
Wind/Wave setup & Run-up
Tide simulations Modelling of tidal influence on flooding
Av 15 Stormwater
Levee - Physical barriers to redirect / mitiga...
Av5. Levee bank - (State/Local Government)
Av1. RipRap - (State/Local Government)
EF1. Misdirected alteration adversly impacting elsewhere
River Flood contributing to elevated Bay inundation
Dredging barway Dredging barway to increase flows
Av2. Clean - (State/Local Government)
Av3 Review
LGF1 Flood Depth
Floodplain: 1 Inundation
EWS - Early Warning System
Av7. EWS - (DPE...
Closure - Physical Closures (barriers/evacuations)
Av7. EWS - (DPE...
Av9. EMP (State/Local Government)
Death or Personal Injury
Sand bagging / temporary barrier placement
Av9. EMP (State/Local Government)
Temporary Relocation Relocate assets
Av7. EWS - (DPE...
Av9. EMP (State/Local Government)
Infrastructure damage
Temporary Protection Temporary armouring/protection
Av9. EMP (State/Local Government)
EWS - Early Warning System
Av7. EWS - (DPE...
Temporary Alternate Access
Av8. Alternate transport (SES)
Isolation of Community - loss of road access (+/- alternate route closed)
Temporary Alternate Access
Av8. Alternate transport (SES)
Livelihood impacts (Local residents and Binalong Bay community)
Temporary Protection Temporary armouring/protection
Av9. EMP (State/Local Government)
EWS - Early Warning System
Av7. EWS - (DPE...
Temporary Alternate Access
Av8. Alternate transport (SES)
Business Interuption
PR/Media management
AV10 Recovery Plan
Impact on tourism
Debris along river bed
Temporary Protection Temporary armouring/protection
Av9. EMP (State/Local Government)
Erosion undermining road or other infrastructure leading to reduced amenity or utility or simply increased rep...
Reduced property values
Loss of productive land (inundat...
Impact on Agriculture,Aquaculture and/or Livest...
Loss of habitat for fauna or flora
Loss of flora or fauna
Temporary Protection Temporary armouring/protection
Av9. EMP (State/Local Government)
Av 15 Stormwater
Stormwater Flooding

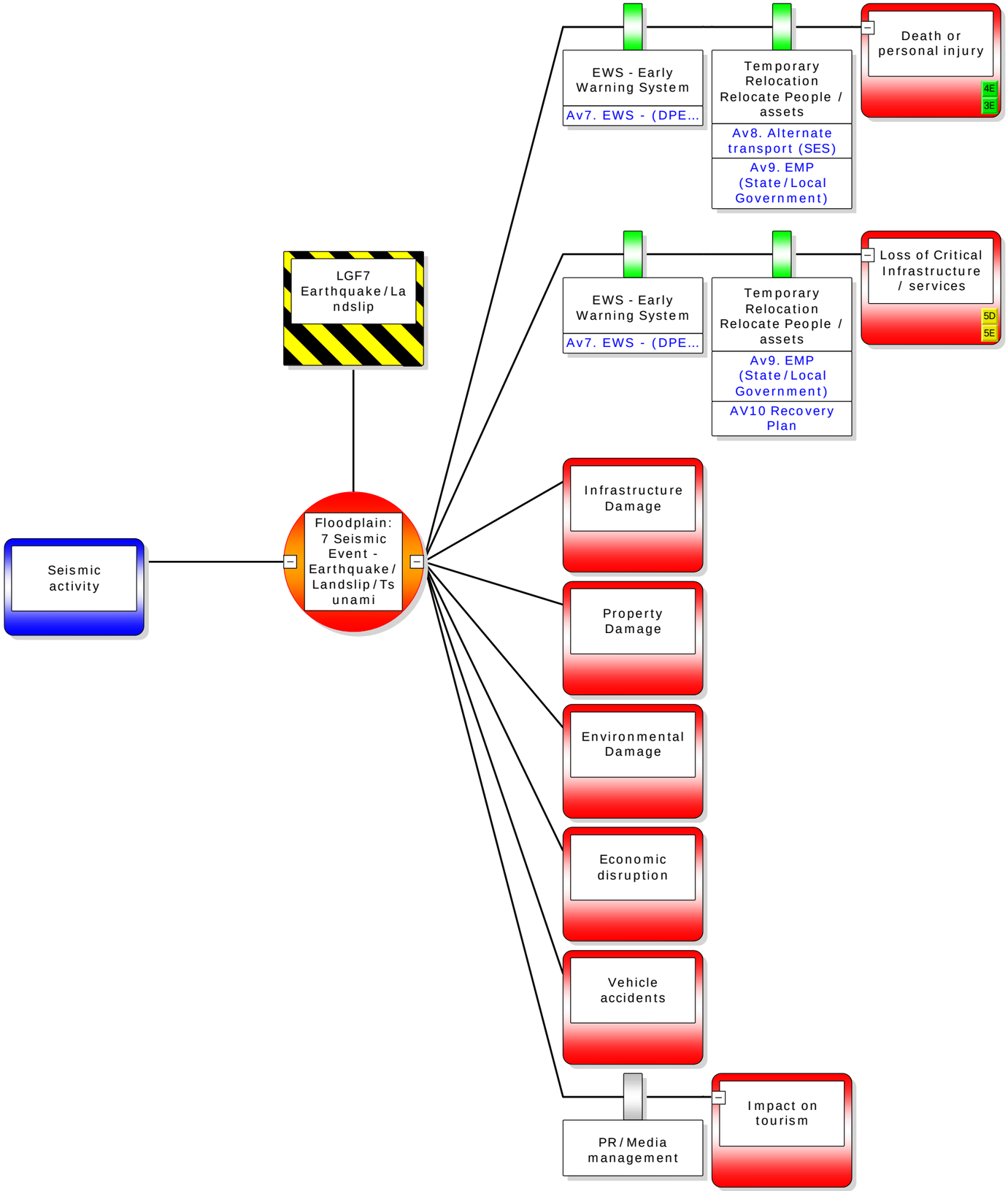

Intense or persistent heavy rainfall event
BOM Bureau of Meteorology Live data for warning
Av7. EWS - (DPE...
Local Resident Advice Upstream residents
Av7. EWS - (DPE...
Flow Gauge Stream flow gauge (Online -...
Av7. EWS - (DPE...
Av9. EMP (State/Local Government)
BOM BOM Forecasting of event
Av7. EWS - (DPE...
Av9. EMP (State/Local Government)
CC Climate Change Projections
Av12 Climate Change (State/Local Government)
Planning Council Planning Scheme
Av11 Legislative/Planning Scheme restrictions (Council)
Av 16 Floodplain Categorisation (Council)
Recovery Plan Council Recovery Plan
AV10 Recovery Plan
EMP Break O'Day Municipal emergency management plan
Av9. EMP (State/Local Government)
Redirection of natural water course
Legal Statutory regulation/restriction of activities
Av11 Legislative/Planning Scheme restrictions (Council)
Av 16 Floodplain Categorisation (Council)
EF1. red tape' delays
Levee - Physical barriers to redirect stream...
Av5. Levee bank - (State/Local Government)
EF1. Misdirected alteration adversly impacting elsewhere
Armour - Armouring/Protection
Av3 Review
EF2. Unauthorised alteration may be inadequately planned or re...
EF1. Misdirected alteration adversly impacting elsewhere
Rip Rap - emplacement of Groynes, Obstructions
Av1. RipRap - (State/Local Government)
EF1. Misdirected alteration adversly impacting elsewhere
EF2. Unauthorised alteration may be inadequately planned or re...
Cleaning - Removal of in-situ obstructions
Av2. Clean - (State/Local Government)
EF1. Misdirected alteration adversly impacting elsewhere
Dredge - Deepening or widening of stre...
Av6. Dredge - (MAST)
Planning Council Planning Scheme
Av11 Legislative/Planning Scheme restrictions (Council)
Dam Burst
Dam Management review of dam safety
Av4. Dams - (DPIPWE - water management)
Climate Change altered rainfall intensity and...
Long term planning (Adaptation/retreat)
Av12 Climate Change (State/Local Government)
LGF2 Flood Flows
5D
2C
Floodplain: 2 High Power Stream Flow
EWS - Early Warning System
Av7. EWS - (DPE...
Closure - Physical Closures (barriers/evacuations)
Av3 Review
Av9. EMP (State/Local Government)
Death or Personal injury
5C
5D
Temporary Protection Temporary armouring/protection
Av1. RipRap - (State/Local Government)
Av2. Clean - (State/Local Government)
Av3 Review
Av9. EMP (State/Local Government)
Av 15 Stormwater
EWS - Early Warning System
Av7. EWS - (DPE...
Temporary Relocation Relocate People / assets
Av9. EMP (State/Local Government)
Loss of Critical Infrastructure / services
3C
3C
Sand bagging / temporary barrier placement
Av9. EMP (State/Local Government)
Temporary Relocation Relocate assets
Av9. EMP (State/Local Government)
Cleaning - Removal of in-situ obstructions
Av2. Clean - (State/Local Government)
Temporary Protection Temporary armouring/protection
Av9. EMP (State/Local Government)
Infrastructure damage
4C
3C
Temporary Protection Temporary armouring/protection
Av3 Review
Av9. EMP (State/Local Government)
Eroded land
3B
2B
Temporary Protection Temporary armouring/protection
Av9. EMP (State/Local Government)
Av 15 Stormwater
EWS - Early Warning System
Av7. EWS - (DPE...
Floodwater directed into township
5D
4D
Temporary Relocation Relocate People / assets
Av9. EMP (State/Local Government)
Temporary Alternate Access
Av8. Alternate transport (SES)
Av9. EMP (State/Local Government)
Public Health Impacted
3C
3D

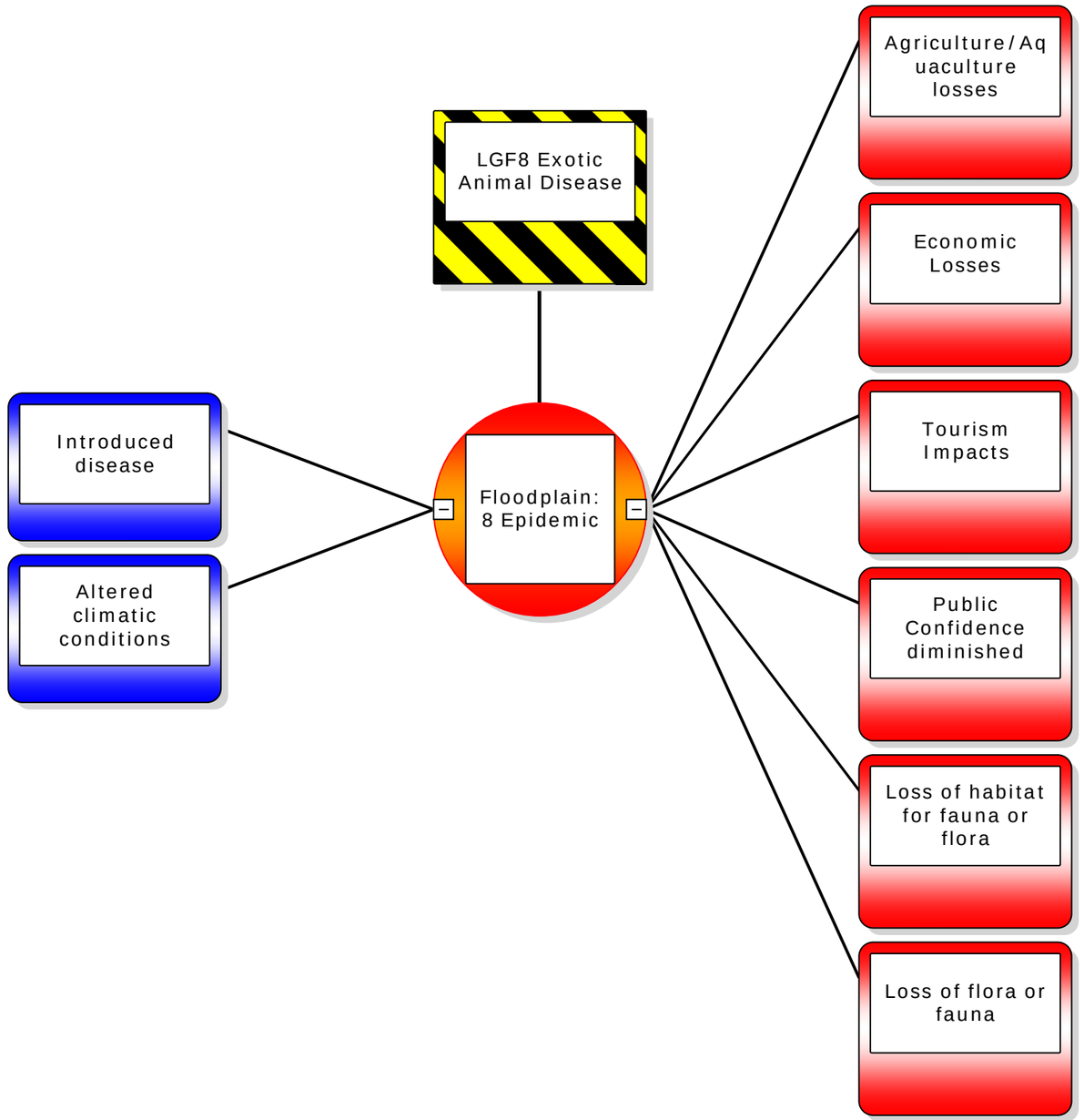

Barometric Low Pressure 'storm' event
BOM Bureau of Meteorology Live data for warning
Av7. EWS - (DPE...
Av9. EMP (State/Local Government)
BOM BOM Forecasting of event
Av7. EWS - (DPE...
Av9. EMP (State/Local Government)
CC Climate Change Projections
Av12 Climate Change (State/Local Government)
EMP Break O'Day Municipal emergency management plan
Av9. EMP (State/Local Government)
AV10 Recovery Plan
Extreme Tides (Surge Tide) or King" high tides +/- Wind/wave S...
NTC Tide Forecasting
Av7. EWS - (DPE...
Establish Alternate Access
Av8. Alternate transport (SES)
Tide simulations Modelling of tidal influence on flooding
Av3 Review
Levee - Physical barriers to redirect / mitiga...
Av5. Levee bank - (State/Local Government)
Av1. RipRap - (State/Local Government)
Av3 Review
EF1. Misdirected alteration adversly impacting elsewhere
Restriction of water flows due to instream obs...
1 Removal of willows to alter flow velocities
Av2. Clean - (State/Local Government)
Av6. Dredge - (MAST)
Overtopping or failure of levee and dam structures
Levee - Physical barriers to redirect stream...
Av5. Levee bank - (State/Local Government)
Av3 Review
Armour - Armouring/Protection
Av3 Review
Av1. RipRap - (State/Local Government)
Rip Rap - emplacement of Groynes, Obstructions
Av1. RipRap - (State/Local Government)
Av3 Review
Cleaning - Removal of in-situ obstructions
Av2. Clean - (State/Local Government)
Av3 Review
Dredge - Deepening or widening of stre...
Av6. Dredge - (MAST)
Av2. Clean - (State/Local Government)
EF1. Misdirected alteration adversly impacting elsewhere
EF2. Unauthorised alteration may be inadequately planned or re...
EF1. Misdirected alteration adversly impacting elsewhere
EF1. Misdirected alteration adversly impacting elsewhere
EF1. Misdirected alteration adversly impacting elsewhere
EF1. Misdirected alteration adversly impacting elsewhere
LGF3 Storm 'Surge' Tide
3C
2C
Floodplain: 3 Storm Tide inundation
EMP Break O'Day Municipal emergency management plan
Av9. EMP (State/Local Government)
AV10 Recovery Plan
Business Interuption
3C
2C
EMP Break O'Day Municipal emergency management plan
Av9. EMP (State/Local Government)
AV10 Recovery Plan
Av 15 Stormwater
Stormwater Flooding
3C
2C
EMP Break O'Day Municipal emergency management plan
Av3 Review
Av5. Levee bank - (State/Local Government)
Av7. EWS - (DPE...
Av9. EMP (State/Local Government)
AV10 Recovery Plan
Infrastructure damage
3D
2C
EMP Break O'Day Municipal emergency management plan
Av3 Review
AV10 Recovery Plan
Impact on tourism
3C
2C
EMP Break O'Day Municipal emergency management plan
Av8. Alternate transport (SES)
Av9. EMP (State/Local Government)
AV10 Recovery Plan
Dislocation / Isolation of commmmunity / critical infrastructure
3C
2C
EMP Break O'Day Municipal emergency management plan
Av3 Review
AV10 Recovery Plan
Impact on Agriculture,Aquaculture and/or Livest...
3C
2C
Climate Change altered rainfall intensity and...
Long term planning (Adaptation/retreat)
Av12 Climate Change (State/Local Government)
River Flood contributing to elevated Bay levels inundation
Dredging barway Dredging barway to increase flows
Av2. Clean - (State/Local Government)
Av3 Review
River flooding / overland flows contributing to elevated tidal...
BOM Bureau of Meteorology Live data for warning
Av3 Review
Local Resident Advice Upstream residents
Av3 Review
Av7. EWS - (DPE...
Av9. EMP (State/Local Government)
Flow Gauge Stream flow gauge (Online -...
Av7. EWS - (DPE...
BOM BOM Forecasting of event
Av7. EWS - (DPE...
CC Climate Change Projections
Av12 Climate Change (State/Local Government)
Planning Council Planning Scheme
Av3 Review
Av11 Legislative/Planning Scheme restrictions (Council)
Recovery Plan Council Recovery Plan
AV10 Recovery Plan
EMP Break O'Day Municipal emergency management plan
Av9. EMP (State/Local Government)
Av 15 Stormwater

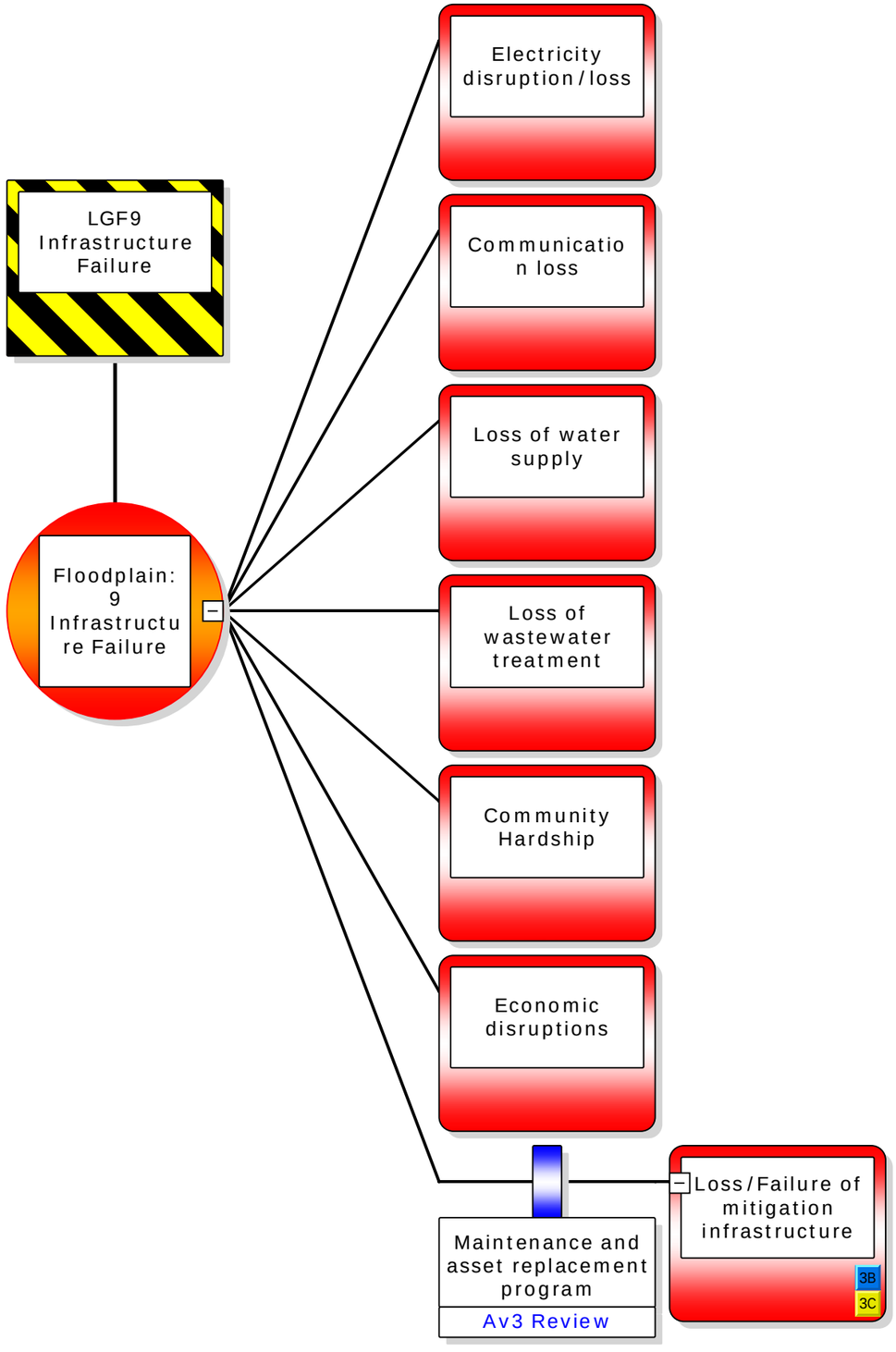

Arson
Manage Public Access
Av3 Review
Av11 Legislative/Planning Scheme restrictions (Council)
Develop and implement bushfire management plans (BMP)
Av 13 Fire Plans
Irresponsible burning (rubbish, campfires etc)
Manage Public Access
Av3 Review
Av11 Legislative/Planning Scheme restrictions (Council)
Develop and implement bushfire management plans (BMP)
Av 13 Fire Plans
Spontaneous Combustion
Develop and implement bushfire management plans (BMP)
Av 13 Fire Plans
Increased Fuel Quantity
Develop and implement a bushfire management plan (BMP) that includes criteria about fuel reduction
Av 13 Fire Plans
Increased fuel quality
Develop and implement a bushfire management plan (BMP) that includes criteria about fuel reduction
Av 13 Fire Plans
Increased fire weather conditions
BOM BOM Forecasting
Av7. EWS - (DPE...
Vegetation growth in proximity to potential ignition sources
Develop, implement and maintain a Bushfire Management Plan (BMP) in accordance with AS3961
Av 13 Fire Plans
Awareness, training and competency
Vegetation ignited by mobile plant or field equipment, and fixed plant and infrastructure (e.g. hot surface, sparks, etc.)
Design and selection of mechanical equipment/ components/ material
Develop and implement a maintenance strategy for mechanical components and equ...
Implement operational and maintenance practices to comply with maintenance strategy
Av 13 Fire Plans
Awareness, training and competency
Electrical arcing from powerlines
Powerlines designed and constructed to function reliably under expected operating conditions
Develop a maintenance strategy for powerlines
Av3 Review
Av 13 Fire Plans
Awareness, training and competency
Vegetation ignited by lightning
Develop, implement and maintain a process to minimise the potential for fire from lightning strikes
Av 13 Fire Plans
Loss of control of prescribed burn
Develop and implement a bushfire management plan (BMP) that includes criteria about prescribed burns
Av 13 Fire Plans
Awareness, training and competency
Intentional or inadvertent public activity generating bushfire ignition
Manage Public Access
Av3 Review
Av11 Legislative/Planning Scheme restrictions (Council)
Develop and implement bushfire management plans (BMP)
Av 13 Fire Plans
Vegetation ignited by use/ practice of hot work and hand -held machinery (e.g. cutting, welding, brush cutting, chainsaws, etc.)
Hot work equipment/ components selected or designed to function reliably under expected oper...
Develop a maintenance strategy for equipment and components used in...
Implement operational and maintenance practices to identify and manage damage or failure of hot work equipment (location...
Av 13 Fire Plans
Awareness, training and competency
LGF4 Fire
Floodplain: 4 Wildfire
Emergency Response Plan
Av9. EMP (State/Local Government)
AV10 Recovery Plan
Onsite emergency services
Av9. EMP (State/Local Government)
Av3 Review
Offsite emergency services
Av3 Review
Av9. EMP (State/Local Government)
Fully equipped first aid facility
Av3 Review
Av9. EMP (State/Local Government)
AV10 Recovery Plan
Personnel injury or fatality in the natural environment
Isolation of community/critical services
Economic Losses
Property damage
Stock Losses
Loss of communications
Impact on tourism
Loss of habitat and/or fauna or flora

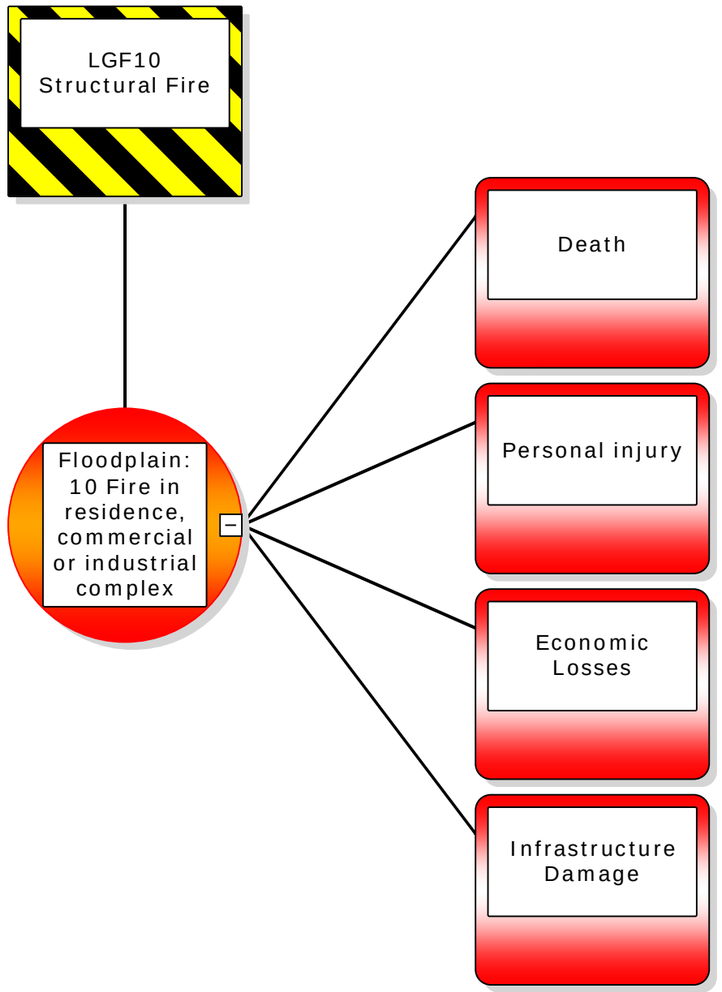

High Barometric pressure gradient
Historical knowledge
Av3 Review
BOM Bom weather and wind warning
Av7. EWS - (DPE...
LGF5 Storm
Floodplain: 5 Storm (land or sea Gale, Tornado)
Death or personal injury
Property Damage
EWS - Early Warning System
Av7. EWS - (DPE...
Temporary Protection Temporary armouring/protection
Av3 Review
Av9. EMP (State/Local Government)
Av 15 Stormwater
Temporary Relocation Relocate People / assets
Av8. Alternate transport (SES)
Av9. EMP (State/Local Government)
Loss of Critical Infrastructure / services
3B
3C
Sand bagging / temporary barrier placement
Av9. EMP (State/Local Government)
Temporary Relocation Relocate assets
Av9. EMP (State/Local Government)
Infrastructure damage
2C
3C
Falling Debris (trees,infrastructure)

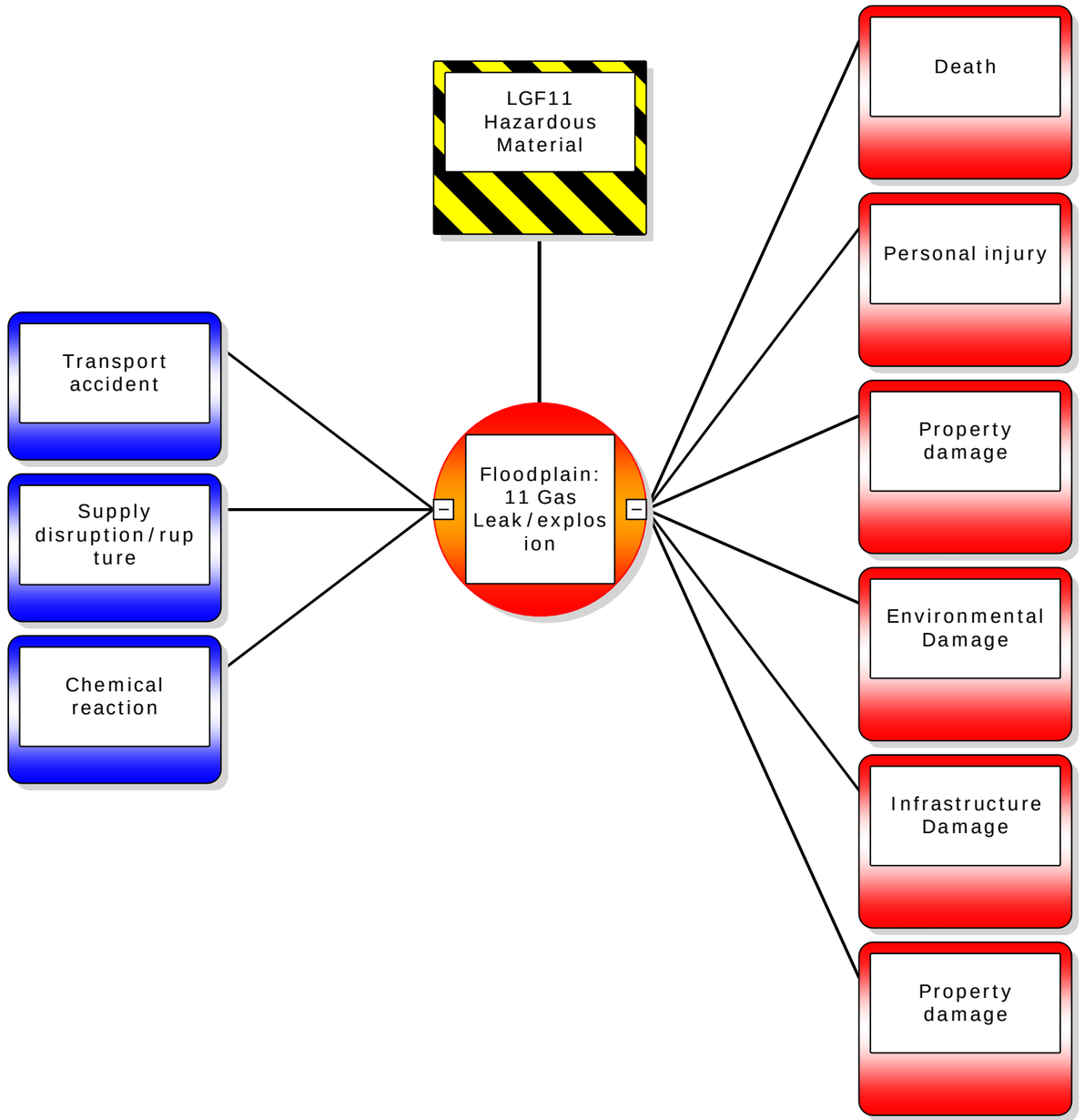

LGF6 Severe Weather
Floodplain: 6 Snow, Fog, Rain, Hail, Electrical storm, hea...
Meteorologic conditions
Early Warning System
Av7. EWS - (DPE...
Forecasting
Av7. EWS - (DPE...
Death or Personal injury
3C
3C
Agriculture / Aquaculture losses
3C
3C
EWS - Early Warning System
Av7. EWS - (DPE...
Temporary Protection Temporary armouring / protection
Av 15 Stormwater
Temporary Relocation Relocate People / assets
Loss of Critical Infrastructure / services
3C
3C
Sand bagging / temporary barrier placement
Temporary Relocation Relocate assets
Infrastructure damage
3C
3C

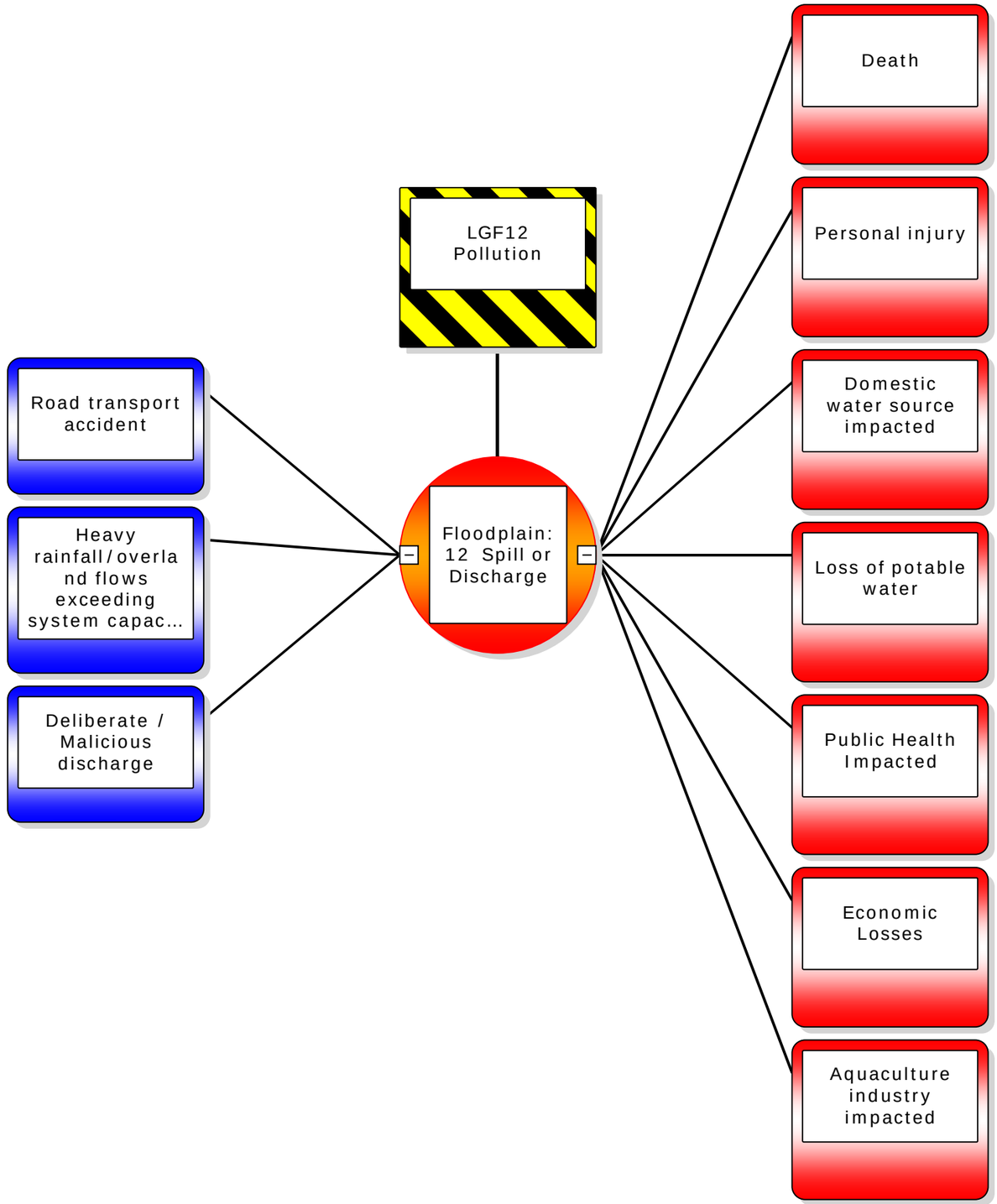

Death or personal injury
4E
3E
EWS - Early Warning System
Av7. EWS - (DPE...
Temporary Relocation Relocate People / assets
Av8. Alternate transport (SES)
Av9. EMP (State/Local Government)
Loss of Critical Infrastructure / services
5D
5E
EWS - Early Warning System
Av7. EWS - (DPE...
Temporary Relocation Relocate People / assets
Av9. EMP (State/Local Government)
AV10 Recovery Plan
LGF7 Earthquake/Landslip
Floodplain: 7 Seismic Event - Earthquake/Landslip/Tsunami
Seismic activity
Infrastructure Damage
Property Damage
Environmental Damage
Economic disruption
Vehicle accidents
PR/Media management
Impact on tourism

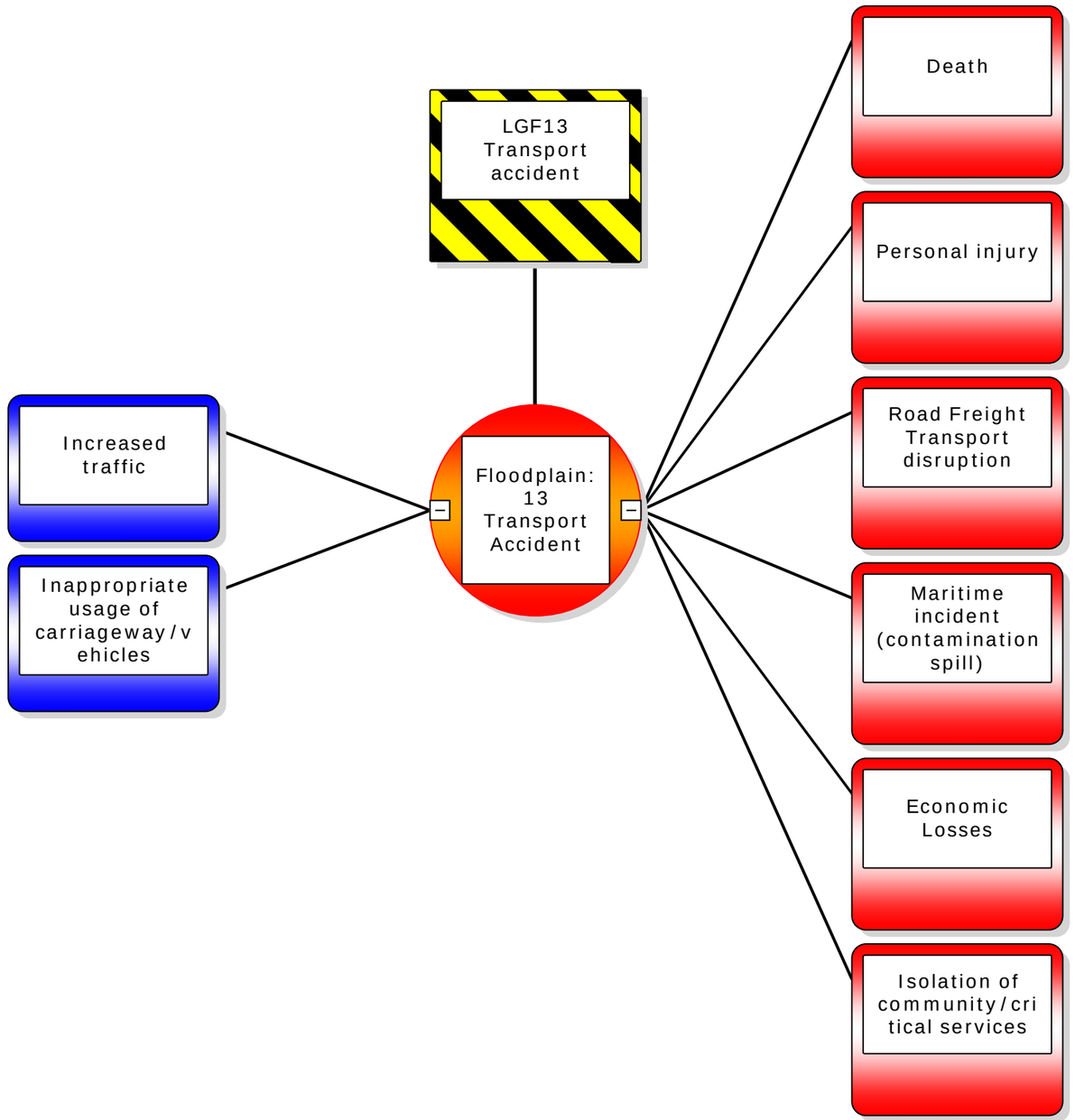

LGF8 Exotic Animal Disease
Introduced disease
Altered climatic conditions
Floodplain: 8 Epidemic
Agriculture/Aquaculture losses
Economic Losses
Tourism Impacts
Public Confidence diminished
Loss of habitat for fauna or flora
Loss of flora or fauna


LGF9 Infrastructure Failure
Floodplain: 9 Infrastructure Failure
Electricity disruption / loss
Communication loss
Loss of water supply
Loss of wastewater treatment
Community Hardship
Economic disruptions
Maintenance and asset replacement program
Av3 Review
Loss/Failure of mitigation infrastructure
3B
3C


LGF10
Structural Fire
Floodplain: 10 Fire in residence, commercial or industrial complex
Death
Personal injury
Economic Losses
Infrastructure Damage


LGF11
Hazardous
Material
Transport
accident
Supply
disruption/rup
ture
Chemical
reaction
Floodplain:
11 Gas
Leak/explos
ion
Death
Personal injury
Property
damage
Environmental
Damage
Infrastructure
Damage
Property
damage


LGF12
Pollution
Road transport accident
Heavy rainfall/overland flows exceeding system capac...
Deliberate / Malicious discharge
Floodplain: 12 Spill or Discharge
Death
Personal injury
Domestic water source impacted
Loss of potable water
Public Health Impacted
Economic Losses
Aquaculture industry impacted


LGF13 Transport accident
Increased traffic
Inappropriate usage of carriageway/vehicles
Floodplain: 13 Transport Accident
Death
Personal injury
Road Freight Transport disruption
Maritime incident (contamination spill)
Economic Losses
Isolation of community/critical services

Appendix E

Hazard Register

RISK REGISTER

RISK IDENTIFICATION							RISK ANALYSIS					RISK TREATMENT		
Risk No.	Risk	What can happen?	Possible causes / contributing threats include:-	Existing controls	Is risk credible?	Is risk insurable?	Likelihood	Consequences	Risk rating	Action required	Is risk acceptable?	Treatment option(s)	Residual risk	Risk treatment plan
1	River Floods - Deep Water		REFER Bow Tie Diagrams but these include:- Intense or persistent rainfall, Stream flow restrictions (instream obstructions), Overtopping or failure of levee /dam structures, River Bank erosion diverting river flows, Debris Accumulated on structures, Extreme Tides coincident with river flood, Cimate Change alterations to rainfall (intensity/frequency/duration IFD), Dam burst upstream, Wind/Wave setup and runup increasing depths, River flooding contributing to elevated bay water surface levels	REFER Bow Tie Diagrams but these include:- BOM weather advice, Local upstream resident advice, Flow Gauges, Climate Change projections, Planning Controls, Recovery plan, Emergency management plan, Levee/Physical flow barriers, Armouring/Protection, Rip/Rap emplacement, Obstruction Removal/Cleaning, Dredging, Alternative Access arrangements, Tide simulation/forecasting, Long term adaptation planning, Dam Safety management										
	River Floods - Deep Water	Death or Personal Injury	Drowing (unaware of depth of water on current used land areas or creation of increased depths / holes)	Manual road closures			Possible	Catastrophic	High			Refer report: Treatment options include installation of early warning system and emergency road closures	Medium	
	River Floods - Deep Water	Infrastructure Damage	water damage, consequential additional damage (electrical shortage etc)	temporary relocatio/protection.			Possible	Major	High			Refer report: includes permanent relocation, permanent protection	Medium	
	River Floods - Deep Water	Isolated Community	impassable roads, infrastructure damage	limited			Likely	Moderate	High			Refer report: includes temporary protection, alternative access, early warning	Medium	
	River Floods - Deep Water	Community Livelihood Impacts	Roads impassable restricting transport. Services impacted	limited			Likely	Moderate	High			Refer report: includes temporary protection, alternative access, early warning	Medium	
	River Floods - Deep Water	Business interuption	Inundation of workplaces (aquaculture processing). Environmental stoppage to business processing	limited, planning scheme limitations			Likely	Moderate	High			Refer report: includes temporary protection, alternative access, early warning	Medium	
	River Floods - Deep Water	Tourism Impacts	loss of attractiveness of destimation, inaccessability of locations / services	limited,			Likely	Moderate	High			refer report: includes PR / Media management	Medium	

RISK REGISTER

RISK IDENTIFICATION							RISK ANALYSIS					RISK TREATMENT		
Risk No.	Risk	What can happen?	Possible causes / contributing threats include:-	Existing controls	Is risk credible?	Is risk insurable?	Likelihood	Consequences	Risk rating	Action required	Is risk acceptable?	Treatment option(s)	Residual risk	Risk treatment plan
	River Floods - Deep Water	Debris along river bed	flooding events deposit debris within stream channels or on floodplain	limited clearing			Almost Certain	Minor	Medium			clearing/removal, channel enhancement (but with potential negative consequences)	Medium	
	River Floods - Deep Water	Erosion	Saturated banks may become unstable contributing to collapse	some erosion stabilisation inplace. Adhoc riprap and armouring			Likely	Moderate	Medium			a range available including armouring, stream channel clearing (with potential negative impacts)	Medium	
	River Floods - Deep Water	Reduced Property Values	inaccessibility, change to regulations, loss of productivity	planning scheme controls on development. Floodplain extent is reasonably understood for owners			Likely	Minor	Medium			include Planning controls	Low	
	River Floods - Deep Water	Loss of productive land	inundation prevents effective utility or increases damage/losses if used.	limited current systems / ability in place to manage loss. Existing control includes the levee bank			Likely	Minor	Medium			include armouring, clearing etc	Medium	
	River Floods - Deep Water	Impact on Agriculture/Aquaculture	reduced ability to utilise prodiuctive assets, closures of productivity. Inundation leading to excess/accidental outflows/discharges'	limited. Planning/legislative controls to reduce larger impacts			Likely	Minor	Medium			limited options include armouring, to reduce agriculture productivity losses, EWS to enable stock relocations	Medium	
	River Floods - Deep Water	Loss of habitat for flora and/or fauna	reduction in suitable habitat through water depths, changes to surface conditions	limited			Likely	Minor	Medium			limited options, with solutions for one scenario potentially impacting others	Medium	
	River Floods - Deep Water	Loss of flora and/or fauna	relocation or death of flora/faua species through altered habitat or direct impact	limited			Likely	Minor	Medium			limited options, with solutions for one scenario potentially impacting others	Medium	
	River Floods - Deep Water	Stormwater flooding	stormwater system impacted by increased floodwater/sea surface depths reduce capacit//capability of systems	Increased inundation depths contribute to reduced capacity/capability of stormwater management systems			Likely	Moderate	High			options include system review and redesign / replacement where apprpriate/ temporary installations et al.	Medium	

RISK REGISTER

RISK IDENTIFICATION							RISK ANALYSIS					RISK TREATMENT		
Risk No.	Risk	What can happen?	Possible causes / contributing threats include:-	Existing controls	Is risk credible?	Is risk insurable?	Likelihood	Consequences	Risk rating	Action required	Is risk acceptable?	Treatment option(s)	Residual risk	Risk treatment plan
2	River Floods - High Stream velocities		REFER Bow Tie Diagrams but these include:- Intense or persistent rainfall, Stream flow restrictions (instream obstructions) redirecting natural water course eg. River bank erosion diverting river flows, Cimate Change alterations to rainfall (intensity/frequency/duration IFD), Dam burst upstream,	REFER Bow Tie Diagrams but these include:- BOM weather advice, Local upstream resident advice, Flow Gauges, Climate Change projections, Planning Controls, Recovery plan, Emergency management plan, Levee/Physical flow barriers, Armouring/Protection, Rip/Rap emplacement, Obstruction Removal/Cleaning, Dredging, Alternative Access arrangements, Tide simulation/forecasting, Long term adaptation planning, Dam Safety management									
	River Floods - High Stream velocities	Death or Personal Injury	Drowing (unaware of depth of water on current used land areas or creation of increased depths / holes)	Manual road closures			Possible	Catastrophic	High			Refer report: Treatment options include installation of early warning system and emergency road closures	Medium	
	River Floods - High Stream velocities	Loss of Infrastructure / services	permanent damage	temporary relocatio/protection.			Possible	Major	High			Refer report: includes permanent relocation, permanent protection	Medium	
	River Floods - High Stream velocities	Infrastructure Damage	water damage, consequential additional damage (electrical shortage etc). Impact	temporary relocatio/protection.			Possible	Moderate	High			Refer report: includes permanent relocation, permanent protection	Medium	
	River Floods - High Stream velocities	Erosion	Saturated banks may become unstable contributing to collapse	some erosion stabilisation inplace. Adhoc riprap and armouring			Likely	Moderate	High			a range available including armouring, stream channel clearing (with potential negative impacts)	Medium	
	River Floods - High Stream velocities	Floodwater directed into township	new channel formation in soft floodplain sediments, significant event overtopping existing banks/controls	some erosion stabilisation inplace.			Unlikely	Catastrophic	Medium			a range available including armouring, stream channel clearing (with potential negative impacts)	Medium	

RISK REGISTER

RISK IDENTIFICATION							RISK ANALYSIS					RISK TREATMENT		
Risk No.	Risk	What can happen?	Possible causes / contributing threats include:-	Existing controls	Is risk credible?	Is risk insurable?	Likelihood	Consequences	Risk rating	Action required	Is risk acceptable?	Treatment option(s)	Residual risk	Risk treatment plan
	River Floods - High Stream velocities	Public health impacts	isolation of community, damage to services impacting on public health	limited			Possible	Moderate	Medium			a range available including armouring, stream channel clearing (with potential negative impacts)	Medium	
3	Tidal Inundation - "Storm Tides"		REFER Bow Tie Diagrams but these include:- Extreme Tides coincident with river flood, Cimate Change alterations to rainfall (intensity/frequency/duration IFD), Wind/Wave setup and runup increasing depths, River flooding contributing to elevated bay water surface levels	REFER Bow Tie Diagrams but these include:- BOM weather advice, Climate Change projections, Planning Controls, Recovery plan, Emergency management plan, Levee/Physical flow barriers, Armouring/Protection, Rip/Rap emplacement, Alternative Access arrangements, Tide simulation/forecasting, Long term adaptation planning,									
	Tidal Inundation - "Storm Tides"	Business interuption	Inundation of workplaces (aquaculture processing). Environmental stoppage to business processing	limited, planning scheme limitations			Likely	Moderate	High			Refer report: includes temporary protection, alternative access, early warning	Medium	
	Tidal Inundation - "Storm Tides"	Stormwater flooding	stormwater system impacted by increased floodwater/sea surface depths reduce capacit//capability of systems	Increased inundation depths contribute to reduced capacity/capability of stormwater management systems			Likely	Moderate	High			options include system review and redesign / replacement where apprpriate/ temporary installations et al.	Medium	
	Tidal Inundation - "Storm Tides"	Infrastructure Damage	water damage, consequential additional damage (electrical shortage etc)	temporary relocatio/protection.			Possible	Major	High			Refer report: includes permanent relocation, permanent protection	Medium	
	Tidal Inundation - "Storm Tides"	Tourism Impacts	loss of attractiveness of destimation, inaccessability of locations / services	limited,			Likely	Moderate	High			refer report: includes PR / Media management	Medium	
	Tidal Inundation - "Storm Tides"	Isolated Community	impassable roads, infrastructure damage	limited			Likely	Moderate	High			Refer report: includes temporary protection, alternative access	Medium	
	Tidal Inundation - "Storm Tides"	Impact on Agriculture/Aquaculture	reduced ability to utilise prodiuctive assets, closures of productivity. Inundation leading to excess/accidental outflows/discharges'	limited. Planning/legislative controls to reduce larger impacts			Possible	Moderate	Medium			limited options include armouring, to reduce agriculture productivity losses, EWS to enable stock relocations	Medium	

Appendix F

Risk Hazard Ratings

Location: Floodplain

Hazard: LGF1 Flood Depth / 1 Inundation

Consequence	Assessment	Inherent	Residual
Death or Personal Injury	Low Confidence	5C: HIGH - Intolerable	5D: MEDIUM - Tolerable subject to ALARP
Infrastructure damage	Low Confidence	4C: HIGH - Intolerable	3C: MEDIUM - Tolerable subject to ALARP
Isolation of Community - loss of road access (+/- alternate route closed)	Low Confidence	3B: HIGH - Intolerable	2B: MEDIUM - Tolerable subject to ALARP
Livelihood impacts (Local residents and Binalong Bay community)	Low Confidence	3B: HIGH - Intolerable	2B: MEDIUM - Tolerable subject to ALARP
Business Interuption	Low Confidence	3B: HIGH - Intolerable	2B: MEDIUM - Tolerable subject to ALARP
Impact on tourism	Low Confidence	3B: HIGH - Intolerable	2B: MEDIUM - Tolerable subject to ALARP
Debris along river bed	Low Confidence	2A: MEDIUM - Tolerable subject to ALARP	1A: MEDIUM - Tolerable subject to ALARP
Erosion undermining road or other infrastructure leading to reduced amenity or utility or simply increased repair cost	Low Confidence	3B: HIGH - Intolerable	2B: MEDIUM - Tolerable subject to ALARP
Reduced property values	Low Confidence	2B: MEDIUM - Tolerable subject to ALARP	1B: LOW - Broadly Acceptable
Loss of productive land (inundation)	Low Confidence	2B: MEDIUM - Tolerable subject to ALARP	2C: MEDIUM - Tolerable subject to ALARP
Impact on Agriculture,Aquaculture and/or Livestock	Low Confidence	2B: MEDIUM - Tolerable subject to ALARP	2B: MEDIUM - Tolerable subject to ALARP
Loss of habitat for fauna or flora	Low Confidence	2B: MEDIUM - Tolerable subject to ALARP	2B: MEDIUM - Tolerable subject to ALARP
Loss of flora or fauna	Low Confidence	2B: MEDIUM - Tolerable subject to ALARP	2B: MEDIUM - Tolerable subject to ALARP
Stormwater Flooding	Low Confidence	3B: HIGH - Intolerable	2C: MEDIUM - Tolerable subject to ALARP

Consequence Death or Personal Injury

Low Confidence		1 Insignificant (near misses or inconsequential short term failures)	2 Minor (Isolated, short to mid term repairable impacts)	3 Moderate (Isolated but significant mid term losses)	4 Major (Multiple severe mid to long term losses)	5 Catastrophic- Widespread unrecoverable or long term losses
A	Almost Certain >= annual					
B	Likely (approximately Annual)					
C	Possible May arise once in 10 yrs (~10% AEP)					[5C]
D	Unlikely may arise once in 10 to 25 yrs (~0.1 to 0.25% AEP)					5D
E	Rare unlikely to occur in next 25 years <(~0.025% AEP)					

Consequence Infrastructure damage

Low Confidence		1 Insignificant (near misses or inconsequential short term failures)	2 Minor (Isolated, short to mid term repairable impacts)	3 Moderate (Isolated but significant mid term losses)	4 Major (Multiple severe mid to long term losses)	5 Catastrophic- Widespread unrecoverable or long term losses
A	Almost Certain >= annual					
B	Likely (approximately Annual)					
C	Possible May arise once in 10 yrs (~10% AEP)			3C	[4C]	
D	Unlikely may arise once in 10 to 25 yrs (~0.1 to 0.25% AEP)					
E	Rare unlikely to occur in next 25 years <(~0.025% AEP)					

Consequence Isolation of Community - loss of road access (+/- alternate route closed)

Low Confidence	1 Insignificant (near misses or inconsequential short term failures)	2 Minor (Isolated, short to mid term repairable impacts)	3 Moderate (Isolated but significant mid term losses)	4 Major (Multiple severe mid to long term losses)	5 Catastrophic- Widespread unrecoverable or long term losses

A	Almost Certain >= annual		2B	[3B]		
B	Likely (approximately Annual)					
C	Possible May arise once in 10 yrs (~10% AEP)					
D	Unlikely may arise once in 10 to 25 yrs (~0.1 to 0.25% AEP)					
E	Rare unlikely to occur in next 25 years <(~0.025% AEP)					

Consequence Livelihood impacts (Local residents and Binalong Bay community)

Low Confidence		1 Insignificant (near misses or inconsequential short term failures)	2 Minor (Isolated, short to mid term repairable impacts)	3 Moderate (Isolated but significant mid term losses)	4 Major (Multiple severe mid to long term losses)	5 Catastrophic- Widespread unrecoverable or long term losses
A	Almost Certain >= annual					
B	Likely (approximately Annual)		2B	[3B]		
C	Possible May arise once in 10 yrs (~10% AEP)					
D	Unlikely may arise once in 10 to 25 yrs (~0.1 to 0.25% AEP)					
E	Rare unlikely to occur in next 25 years <(~0.025% AEP)					

Consequence Business Interuption

Low Confidence		1 Insignificant (near misses or inconsequential short term failures)	2 Minor (Isolated, short to mid term repairable impacts)	3 Moderate (Isolated but significant mid term losses)	4 Major (Multiple severe mid to long term losses)	5 Catastrophic- Widespread unrecoverable or long term losses
A	Almost Certain >= annual		2B	[3B]		
B	Likely (approximately Annual)					
C	Possible May arise once in 10 yrs (~10% AEP)					
D	Unlikely may arise once in 10 to 25 yrs (~0.1 to 0.25% AEP)					
E	Rare unlikely to occur in next 25 years <(~0.025% AEP)					

Consequence Impact on tourism

Low Confidence		1 Insignificant (near misses or inconsequential short term failures)	2 Minor (Isolated, short to mid term repairable impacts)	3 Moderate (Isolated but significant mid term losses)	4 Major (Multiple severe mid to long term losses)	5 Catastrophic- Widespread unrecoverable or long term losses
A	Almost Certain >= annual					
B	Likely (approximately Annual)		2B	[3B]		
C	Possible May arise once in 10 yrs (~10% AEP)					
D	Unlikely may arise once in 10 to 25 yrs (~0.1 to 0.25% AEP)					
E	Rare unlikely to occur in next 25 years <(~0.025% AEP)					

Consequence Debris along river bed

Low Confidence		1 Insignificant (near misses or inconsequential short term failures)	2 Minor (Isolated, short to mid term repairable impacts)	3 Moderate (Isolated but significant mid term losses)	4 Major (Multiple severe mid to long term losses)	5 Catastrophic- Widespread unrecoverable or long term losses
A	Almost Certain >= annual	1A	[2A]			
B	Likely (approximately Annual)					

C	Possible May arise once in 10 yrs (~10% AEP)					
D	Unlikely may arise once in 10 to 25 yrs (~0.1 to 0.25% AEP)					
E	Rare unlikely to occur in next 25 years <(~0.025% AEP)					

Consequence Erosion undermining road or other infrastructure leading to reduced amenity or utility or simply increased repair cost

Low Confidence		1 Insignificant (near misses or inconsequential short term failures)	2 Minor (Isolated, short to mid term repairable impacts)	3 Moderate (Isolated but significant mid term losses)	4 Major (Multiple severe mid to long term losses)	5 Catastrophic- Widespread unrecoverable or long term losses
A	Almost Certain >= annual		2B	[3B]		
B	Likely (approximately Annual)					
C	Possible May arise once in 10 yrs (~10% AEP)					
D	Unlikely may arise once in 10 to 25 yrs (~0.1 to 0.25% AEP)					
E	Rare unlikely to occur in next 25 years <(~0.025% AEP)					

Consequence Reduced property values

Low Confidence		1 Insignificant (near misses or inconsequential short term failures)	2 Minor (Isolated, short to mid term repairable impacts)	3 Moderate (Isolated but significant mid term losses)	4 Major (Multiple severe mid to long term losses)	5 Catastrophic- Widespread unrecoverable or long term losses
A	Almost Certain >= annual					
B	Likely (approximately Annual)	1B	[2B]			
C	Possible May arise once in 10 yrs (~10% AEP)					
D	Unlikely may arise once in 10 to 25 yrs (~0.1 to 0.25% AEP)					
E	Rare unlikely to occur in next 25 years <(~0.025% AEP)					

Consequence Loss of productive land (inundation)

Low Confidence		1 Insignificant (near misses or inconsequential short term failures)	2 Minor (Isolated, short to mid term repairable impacts)	3 Moderate (Isolated but significant mid term losses)	4 Major (Multiple severe mid to long term losses)	5 Catastrophic- Widespread unrecoverable or long term losses
A	Almost Certain >= annual					
B	Likely (approximately Annual)		[2B]			
C	Possible May arise once in 10 yrs (~10% AEP)		2C			
D	Unlikely may arise once in 10 to 25 yrs (~0.1 to 0.25% AEP)					
E	Rare unlikely to occur in next 25 years <(~0.025% AEP)					

Consequence Impact on Agriculture,Aquaculture and/or Livestock

Low Confidence		1 Insignificant (near misses or inconsequential short term failures)	2 Minor (Isolated, short to mid term repairable impacts)	3 Moderate (Isolated but significant mid term losses)	4 Major (Multiple severe mid to long term losses)	5 Catastrophic- Widespread unrecoverable or long term losses
A	Almost Certain >= annual					
B	Likely (approximately Annual)		[2B]			
C	Possible May arise once in 10 yrs (~10% AEP)					
D	Unlikely may arise					

	once in 10 to 25 yrs (~0.1 to 0.25% AEP)					
E	Rare unlikely to occur in next 25 years <(~0.025% AEP)					

Consequence Loss of habitat for fauna or flora

Low Confidence		1 Insignificant (near misses or inconsequential short term failures)	2 Minor (Isolated, short to mid term repairable impacts)	3 Moderate (Isolated but significant mid term losses)	4 Major (Multiple severe mid to long term losses)	5 Catastrophic- Widespread unrecoverable or long term losses
A	Almost Certain >= annual		[2B]			
B	Likely (approximately Annual)					
C	Possible May arise once in 10 yrs (~10% AEP)					
D	Unlikely may arise once in 10 to 25 yrs (~0.1 to 0.25% AEP)					
E	Rare unlikely to occur in next 25 years <(~0.025% AEP)					

Consequence Loss of flora or fauna

Low Confidence		1 Insignificant (near misses or inconsequential short term failures)	2 Minor (Isolated, short to mid term repairable impacts)	3 Moderate (Isolated but significant mid term losses)	4 Major (Multiple severe mid to long term losses)	5 Catastrophic- Widespread unrecoverable or long term losses
A	Almost Certain >= annual					
B	Likely (approximately Annual)		[2B]			
C	Possible May arise once in 10 yrs (~10% AEP)					
D	Unlikely may arise once in 10 to 25 yrs (~0.1 to 0.25% AEP)					
E	Rare unlikely to occur in next 25 years <(~0.025% AEP)					

Consequence Stormwater Flooding

Low Confidence		1 Insignificant (near misses or inconsequential short term failures)	2 Minor (Isolated, short to mid term repairable impacts)	3 Moderate (Isolated but significant mid term losses)	4 Major (Multiple severe mid to long term losses)	5 Catastrophic- Widespread unrecoverable or long term losses
A	Almost Certain >= annual		2C	[3B]		
B	Likely (approximately Annual)					
C	Possible May arise once in 10 yrs (~10% AEP)					
D	Unlikely may arise once in 10 to 25 yrs (~0.1 to 0.25% AEP)					
E	Rare unlikely to occur in next 25 years <(~0.025% AEP)					

Hazard: LGF2 Flood Flows / 2 High Power Stream Flow

Consequence	Assessment	Inherent	Residual
Death or Personal injury	Low Confidence	5C: HIGH - Intolerable	5D: MEDIUM - Tolerable subject to ALARP
Loss of Critical Infrastructure / services	Low Confidence	4B: HIGH - Intolerable	3C: MEDIUM - Tolerable subject to ALARP
Infrastructure damage	Low Confidence	4C: HIGH - Intolerable	3C: MEDIUM - Tolerable subject to ALARP
Eroded land	Low Confidence	3B: HIGH - Intolerable	2B: MEDIUM - Tolerable subject to ALARP
Floodwater directed into township	Low Confidence	5D: MEDIUM - Tolerable subject to ALARP	4D: MEDIUM - Tolerable subject to ALARP
Public Health Impacted	Low Confidence	3C: MEDIUM - Tolerable subject to ALARP	3D: MEDIUM - Tolerable subject to ALARP

Consequence Death or Personal injury

Low Confidence		1 Insignificant (near misses or inconsequential short term failures)	2 Minor (Isolated, short to mid term repairable impacts)	3 Moderate (Isolated but significant mid term losses)	4 Major (Multiple severe mid to long term losses)	5 Catastrophic- Widespread unrecoverable or long term losses
A	Almost Certain >= annual					
B	Likely (approximately Annual)					
C	Possible May arise once in 10 yrs (~10% AEP)					[5C]
D	Unlikely may arise once in 10 to 25 yrs (~0.1 to 0.25% AEP)					5D
E	Rare unlikely to occur in next 25 years <(~0.025% AEP)					

Consequence Loss of Critical Infrastructure / services

Low Confidence		1 Insignificant (near misses or inconsequential short term failures)	2 Minor (Isolated, short to mid term repairable impacts)	3 Moderate (Isolated but significant mid term losses)	4 Major (Multiple severe mid to long term losses)	5 Catastrophic- Widespread unrecoverable or long term losses
A	Almost Certain >= annual					
B	Likely (approximately Annual)				[4B]	
C	Possible May arise once in 10 yrs (~10% AEP)			3C		
D	Unlikely may arise once in 10 to 25 yrs (~0.1 to 0.25% AEP)					
E	Rare unlikely to occur in next 25 years <(~0.025% AEP)					

Consequence Infrastructure damage

Low Confidence		1 Insignificant (near misses or inconsequential short term failures)	2 Minor (Isolated, short to mid term repairable impacts)	3 Moderate (Isolated but significant mid term losses)	4 Major (Multiple severe mid to long term losses)	5 Catastrophic- Widespread unrecoverable or long term losses
A	Almost Certain >= annual					
B	Likely (approximately Annual)					
C	Possible May arise once in 10 yrs (~10% AEP)			3C	[4C]	
D	Unlikely may arise once in 10 to 25 yrs (~0.1 to 0.25% AEP)					
E	Rare unlikely to occur in next 25 years <(~0.025% AEP)					

Consequence Eroded land

Low Confidence		1 Insignificant (near misses or inconsequential short term failures)	2 Minor (Isolated, short to mid term repairable impacts)	3 Moderate (Isolated but significant mid term losses)	4 Major (Multiple severe mid to long term losses)	5 Catastrophic- Widespread unrecoverable or long term losses
A	Almost Certain					

	>= annual		2B	[3B]		
B	Likely (approximately Annual)					
C	Possible May arise once in 10 yrs (~10% AEP)					
D	Unlikely may arise once in 10 to 25 yrs (~0.1 to 0.25% AEP)					
E	Rare unlikely to occur in next 25 years <(~0.025% AEP)					

Consequence Floodwater directed into township

	Low Confidence	1 Insignificant (near misses or inconsequential short term failures)	2 Minor (Isolated, short to mid term repairable impacts)	3 Moderate (Isolated but significant mid term losses)	4 Major (Multiple severe mid to long term losses)	5 Catastrophic- Widespread unrecoverable or long term losses
A	Almost Certain >= annual					
B	Likely (approximately Annual)					
C	Possible May arise once in 10 yrs (~10% AEP)					
D	Unlikely may arise once in 10 to 25 yrs (~0.1 to 0.25% AEP)				4D	[5D]
E	Rare unlikely to occur in next 25 years <(~0.025% AEP)					

Consequence Public Health Impacted

	Low Confidence	1 Insignificant (near misses or inconsequential short term failures)	2 Minor (Isolated, short to mid term repairable impacts)	3 Moderate (Isolated but significant mid term losses)	4 Major (Multiple severe mid to long term losses)	5 Catastrophic- Widespread unrecoverable or long term losses
A	Almost Certain >= annual					
B	Likely (approximately Annual)					
C	Possible May arise once in 10 yrs (~10% AEP)			[3C]		
D	Unlikely may arise once in 10 to 25 yrs (~0.1 to 0.25% AEP)			3D		
E	Rare unlikely to occur in next 25 years <(~0.025% AEP)					

Hazard: LGF3 Storm 'Surge' Tide / 3 Storm Tide inundation

Consequence	Assessment	Inherent	Residual
Business Interuption	Low Confidence	3C: MEDIUM - Tolerable subject to ALARP	2C: MEDIUM - Tolerable subject to ALARP
Stormwater Flooding	Low Confidence	3C: MEDIUM - Tolerable subject to ALARP	2C: MEDIUM - Tolerable subject to ALARP
Infrastructure damage	Low Confidence	3D: MEDIUM - Tolerable subject to ALARP	2D: LOW - Broadly Acceptable
Impact on tourism	Low Confidence	3C: MEDIUM - Tolerable subject to ALARP	2C: MEDIUM - Tolerable subject to ALARP
Dislocation/Isolation of commmmunity / critical infrastructure	Low Confidence	4C: HIGH - Intolerable	3C: MEDIUM - Tolerable subject to ALARP
Impact on Agriculture,Aquaculture and/or Livestock	Low Confidence	3C: MEDIUM - Tolerable subject to ALARP	2C: MEDIUM - Tolerable subject to ALARP

Consequence Business Interuption

Low Confidence		1 Insignificant (near misses or inconsequential short term failures)	2 Minor (Isolated, short to mid term repairable impacts)	3 Moderate (Isolated but significant mid term losses)	4 Major (Multiple severe mid to long term losses)	5 Catastrophic- Widespread unrecoverable or long term losses
A	Almost Certain >= annual					
B	Likely (approximately Annual)					
C	Possible May arise once in 10 yrs (~10% AEP)		2C	[3C]		
D	Unlikely may arise once in 10 to 25 yrs (~0.1 to 0.25% AEP)					
E	Rare unlikely to occur in next 25 years <(~0.025% AEP)					

Consequence Stormwater Flooding

Low Confidence		1 Insignificant (near misses or inconsequential short term failures)	2 Minor (Isolated, short to mid term repairable impacts)	3 Moderate (Isolated but significant mid term losses)	4 Major (Multiple severe mid to long term losses)	5 Catastrophic- Widespread unrecoverable or long term losses
A	Almost Certain >= annual					
B	Likely (approximately Annual)					
C	Possible May arise once in 10 yrs (~10% AEP)		2C	[3C]		
D	Unlikely may arise once in 10 to 25 yrs (~0.1 to 0.25% AEP)					
E	Rare unlikely to occur in next 25 years <(~0.025% AEP)					

Consequence Infrastructure damage

Low Confidence		1 Insignificant (near misses or inconsequential short term failures)	2 Minor (Isolated, short to mid term repairable impacts)	3 Moderate (Isolated but significant mid term losses)	4 Major (Multiple severe mid to long term losses)	5 Catastrophic- Widespread unrecoverable or long term losses
A	Almost Certain >= annual					
B	Likely (approximately Annual)					
C	Possible May arise once in 10 yrs (~10% AEP)					
D	Unlikely may arise once in 10 to 25 yrs (~0.1 to 0.25% AEP)		2D	[3D]		
E	Rare unlikely to occur in next 25 years <(~0.025% AEP)					

Consequence Impact on tourism

Low Confidence		1 Insignificant (near misses or inconsequential short term failures)	2 Minor (Isolated, short to mid term repairable impacts)	3 Moderate (Isolated but significant mid term losses)	4 Major (Multiple severe mid to long term losses)	5 Catastrophic- Widespread unrecoverable or long term losses
A	Almost Certain					

	>= annual					
B	Likely (approximately Annual)					
C	Possible May arise once in 10 yrs (~10% AEP)		2C	[3C]		
D	Unlikely may arise once in 10 to 25 yrs (~0.1 to 0.25% AEP)					
E	Rare unlikely to occur in next 25 years <(~0.025% AEP)					

Consequence Dislocation / Isolation of commmmunity / critical infrastructure

	Low Confidence	1	2	3	4	5
		Insignificant (near misses or inconsequential short term failures)	Minor (Isolated, short to mid term repairable impacts)	Moderate (Isolated but significant mid term losses)	Major (Multiple severe mid to long term losses)	Catastrophic- Widespread unrecoverable or long term losses
A	Almost Certain >= annual					
B	Likely (approximately Annual)					
C	Possible May arise once in 10 yrs (~10% AEP)			3C	[4C]	
D	Unlikely may arise once in 10 to 25 yrs (~0.1 to 0.25% AEP)					
E	Rare unlikely to occur in next 25 years <(~0.025% AEP)					

Consequence Impact on Agriculture,Aquaculture and/or Livestock

	Low Confidence	1	2	3	4	5
		Insignificant (near misses or inconsequential short term failures)	Minor (Isolated, short to mid term repairable impacts)	Moderate (Isolated but significant mid term losses)	Major (Multiple severe mid to long term losses)	Catastrophic- Widespread unrecoverable or long term losses
A	Almost Certain >= annual					
B	Likely (approximately Annual)					
C	Possible May arise once in 10 yrs (~10% AEP)		2C	[3C]		
D	Unlikely may arise once in 10 to 25 yrs (~0.1 to 0.25% AEP)					
E	Rare unlikely to occur in next 25 years <(~0.025% AEP)					

Appendix G

Action Register

Barrier	*Hazard*	*Code*	*Name*	*Description*	*Barrier type*	*Effectiveness*	*Accountable*
(Haz.) LGF1 Flood Depth / 1	LGF1 Flood Depth / 1 Inundation	BOM	Bureau of Meteorology Live data for warning	Available from live monitors in catchmentcan provide early warning of 'dangerous' rainfall volumes.	Administrative	Unassessed / Unknown	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF1 Flood Depth / 1 Inundation //	LGF1 Flood Depth / 1 Inundation	Local Resident Advice	Upstream residents	Residents in upstream catchments currently liaise ad provide advice to those in lower regions. This can provide early warning of 'dangerous' rainfall volumes. Only effective where residents onsite at onset of event and when suitable communication process and information distribution system available (eg advice to BOM). Need clear communication protocol and confidence of process	Administrative	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF1 Flood Depth / 1 Inundation //	LGF1 Flood Depth / 1 Inundation	Flow Gauge	Stream flow gauge (Online - Data)	Analysis of flow gauge records to identify 'trigger' thresholds for warning advice. Only effective when operating correctly (maintenance required) and when information presented rapidly. Potentialy significant lag time in interpretation of information to provision of advice. Gauge positions may not provide optimum advice and insufficient coverage of catchment area	Administrative	Unassessed / Unknown	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF1 Flood Depth / 1	LGF1 Flood Depth / 1 Inundation	BOM	BOM Forecasting of event	Forecasting of meteorological systems to provide early warning of potential 'dangerous' rainfall volumes. IN PLACE and functioning	Administrative	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF1 Flood Depth / 1	LGF1 Flood Depth / 1 Inundation	CC	Climate Change Projections	Prjection of long term changes in climateForecasting of meteorological systems to provide early warning of potential 'dangerous' rainfall volumes. ClimateFutures and existing analyses. Long Term interpretation only may assist in long term planning Nil influence over short term/immediate issues.	Administrative	Poor effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF1 Flood	LGF1 Flood Depth / 1 Inundation	Planning	Council Planning Scheme	Limitation and/or enforcement of building/operations to limit potential impacts (building siting / land use etc).	Administrative	Good effectiveness	Council Break O'Day Council
(Haz.) LGF1 Flood	LGF1 Flood Depth / 1 Inundation	Recovery Plan	Council Recovery Plan	Documented procedures and processes ensuring optimised treatments and recovery in place prior to event to ensure impact of an event is minimised.	Procedural	Good effectiveness	Council Break O'Day Council
(Haz.) LGF1 Flood Depth / 1	LGF1 Flood Depth / 1 Inundation	EMP	Break O'Day Municipal emergency management plan	Preparation and appropriate implementation of municipal emergency management plan. Ensure up to date and regularly reviewed for currency and appriateness. Implementation as soon as reasonably practical prior to/during and post event.	Procedural	Good effectiveness	DPEM Police and Emergency Management - Offsite Emergency Planning Unit
(Haz.) LGF1 Flood Depth / 1	LGF1 Flood Depth / 1 Inundation	Levee -	Physical barriers to redirect stream flows	Design and placement of levy banks to redirect stream flows	Design - Protection System	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF1 Flood Depth / 1	LGF1 Flood Depth / 1 Inundation	Armour -	Armouring/Protection	Design and emplacement of physical armouring on stream banks	Guarding or Shielding	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF1 Flood Depth / 1	LGF1 Flood Depth / 1 Inundation	Rip Rap	- emplacement of Groynes, Obstructions	Design and emplacement of physical barriers to reduce stream velocities	Design - Protection System	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF1 Flood Depth / 1	LGF1 Flood Depth / 1 Inundation	Cleaning -	Removal of in-situ obstructions	Physical removal of obstructions, regularly undertaken	Inspection and Maintenance	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF1 Flood	LGF1 Flood Depth / 1 Inundation	Dredge -	Deepening or widening of stream	Removal of sediment from stream channel to enhance stream flow	Control of Energy Release	Good effectiveness	MAST Marine and Safety Tasmania (Tidal regions)
(Haz.) LGF1 Flood Depth / 1	LGF1 Flood Depth / 1 Inundation	Cleaning -	Removal of in-situ obstructions	Physical removal of obstructions, regularly undertaken	Inspection and Maintenance	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF1 Flood	LGF1 Flood Depth / 1 Inundation	Dredge -	Deepening or widening of stream	Removal of sediment from stream channel to enhance stream flow	Control of Energy Release	Poor effectiveness	MAST Marine and Safety Tasmania (Tidal regions)
(Haz.) LGF1 Flood Depth / 1	LGF1 Flood Depth / 1 Inundation	Cleaning -	Removal of in-situ obstructions	Physical removal of obstructions, regularly undertaken	Inspection and Maintenance	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF1 Flood	LGF1 Flood Depth / 1 Inundation		Establish Alternate Access			Good effectiveness	
(Haz.) LGF1 Flood Depth / 1	LGF1 Flood Depth / 1 Inundation	Tide simulations	Modelling of tidal influence on flooding	Computer simulation of tidal influences on flood flows and inundation depths. Tidal heights and records available for inputs for integration with flood information. Useful in providing early warning and for influencing in planing ddecisions.	Administrative	Unassessed / Unknown	
(Haz.) LGF1 Flood Depth / 1	LGF1 Flood Depth / 1 Inundation	NTC	Tide Forecasting	Forecasting of astronomical tidal influence is well established and can provide early warning of potential 'dangerous' tidal contributions. IN PLACE and functioning	Administrative	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF1 Flood	LGF1 Flood Depth / 1 Inundation		Long term planning (Adaptation/retreat)			Good effectiveness	
(Haz.) LGF1 Flood	LGF1 Flood Depth / 1 Inundation	Dam Management	review of dam safety	Regular review and maintenance of dam structures	Inspection and Maintenance	Good effectiveness	DPIPWE - water management Water management section of DPIPWE
(Haz.) LGF1 Flood Depth / 1	LGF1 Flood Depth / 1 Inundation	Tide simulations	Modelling of tidal influence on flooding	Computer simulation of tidal influences on flood flows and inundation depths. Tidal heights and records available for inputs for integration with flood information. Useful in providing early warning and for influencing in planing ddecisions.	Administrative	Unassessed / Unknown	
(Haz.) LGF1 Flood Depth / 1	LGF1 Flood Depth / 1 Inundation	Levee -	Physical barriers to redirect / mitigate	Design and placement of levy banks to redirect stream flows	Design - Protection System	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF1 Flood	LGF1 Flood Depth / 1 Inundation	Dredging barway	Dredging barway to increase flows	Increasing the vlocity of outflow may contribute to reduced inundation levels within the bay.		Unassessed / Unknown	
(Haz.) LGF1 Flood Depth / 1	LGF1 Flood Depth / 1 Inundation	EWS -	Early Warning System		Safety	Good effectiveness	DPEM Police and Emergency Management - Offsite Emergency Planning Unit
(Haz.) LGF1 Flood	LGF1 Flood Depth / 1 Inundation	Closure -	Physical Closures (barriers/evacuations)	Place physical barriers/warning signage to prevent access	Guarding or Shielding	Good effectiveness	TasPol Tasmania Police
(Haz.) LGF1 Flood	LGF1 Flood Depth / 1 Inundation		Sand bagging / temporary barrier placement			Good effectiveness	
(Haz.)	LGF1 Flood Depth / 1 Inundation	Temporary Relocation	Relocate assets	physical removal of assets from hazard	Separation (Time or Space)	Good effectiveness	
(Haz.) LGF1 Flood Depth / 1	LGF1 Flood Depth / 1 Inundation	Temporary Protection	Temporary armouring/protection	Design and emplacement of physical armouring/protection (eg sandbags)	Control of Energy Release	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF1 Flood Depth / 1	LGF1 Flood Depth / 1 Inundation	EWS -	Early Warning System		Safety	Good effectiveness	DPEM Police and Emergency Management - Offsite Emergency Planning Unit
(Haz.) LGF1 Flood Depth / 1	LGF1 Flood Depth / 1 Inundation		Temporary Alternate Access	Alternate transportation (helicopter/boat et al)		Good effectiveness	
(Haz.) LGF1 Flood Depth / 1	LGF1 Flood Depth / 1 Inundation	Temporary Protection	Temporary armouring/protection	Design and emplacement of physical armouring/protection (eg sandbags)	Control of Energy Release	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF1 Flood Depth / 1	LGF1 Flood Depth / 1 Inundation	EWS -	Early Warning System		Safety	Good effectiveness	DPEM Police and Emergency Management - Offsite Emergency Planning Unit
(Haz.)	LGF1 Flood Depth / 1 Inundation		Temporary Alternate Access	Alternate transportation (helicopter/boat et al)		Good effectiveness	

Barrier	*Hazard*	*Code*	*Name*	*Description*	*Barrier type*	*Effectiveness*	*Accountable*
(Haz.)	LGF1 Flood Depth / 1 Inundation		PR/Media management			Unassessed / Unknown	
(Haz.) LGF1 Flood Depth / 1 Inundation //	LGF1 Flood Depth / 1 Inundation	Temporary Protection	Temporary armouring/protection	Design and emplacement of physical armouring/protection (eg sandbags)	Control of Energy Release	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF1 Flood Depth / 1	LGF1 Flood Depth / 1 Inundation	Temporary Protection	Temporary armouring/protection	Design and emplacement of physical armouring/protection (eg sandbags)	Control of Energy Release	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF2 Flood Flows / 2 High	LGF2 Flood Flows / 2 High Power Stream Flow	BOM	Bureau of Meteorology Live data for warning	Available from live monitors in catchmentcan provide early warning of 'dangerous' rainfall volumes.	Administrative	Unassessed / Unknown	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF2 Flood Flows / 2 High Power Stream	LGF2 Flood Flows / 2 High Power Stream Flow	Local Resident Advice	Upstream residents	Residents in upstream catchments currently liaise ad provide advice to those in lower regions. This can provide early warning of 'dangerous' rainfall volumes. Only effective where residents onsite at onset of event and when suitable communication process and information distribution system available (eg advice to BOM). Need clear communication protocol and confidence of process	Administrative	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF2 Flood Flows / 2 High Power Stream	LGF2 Flood Flows / 2 High Power Stream Flow	Flow Gauge	Stream flow gauge (Online - Data)	Analysis of flow gauge records to identify 'trigger' thresholds for warning advice. Only effective when operating correctly (maintenance required) and when information presented rapidly. Potentialy significant lag time in interpretation of information to provision of advice. Gauge positions may not provide optimum advice and insufficient coverage of catchment area	Administrative	Unassessed / Unknown	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF2 Flood Flows / 2 High	LGF2 Flood Flows / 2 High Power Stream Flow	BOM	BOM Forecasting of event	Forecasting of meteorological systems to provide early warning of potential 'dangerous' rainfall volumes. IN PLACE and functioning	Administrative	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF2 Flood Flows / 2 High	LGF2 Flood Flows / 2 High Power Stream Flow	CC	Climate Change Projections	Prjection of long term changes in climateForecasting of meteorological systems to provide early warning of potential 'dangerous' rainfall volumes. ClimateFutures and existing analyses. Long Term interpretation only may assist in long term planning Nil influence over short term/immediate issues.	Administrative	Poor effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF2 Flood	LGF2 Flood Flows / 2 High Power Stream Flow	Planning	Council Planning Scheme	Limitation and/or enforcement of building/operations to limit potential impacts (building siting / land use etc).	Administrative	Good effectiveness	Council Break O'Day Council
(Haz.) LGF2 Flood	LGF2 Flood Flows / 2 High Power Stream Flow	Recovery Plan	Council Recovery Plan	Documented procedures and processes ensuring optimised treatments and recovery in place prior to event to ensure impact of an event is minimised.	Procedural	Good effectiveness	Council Break O'Day Council
(Haz.) LGF2 Flood Flows / 2 High	LGF2 Flood Flows / 2 High Power Stream Flow	EMP	Break O'Day Municipal emergency management plan	Preparation and appropriate implementation of municipal emergency management plan. Ensure up to date and regularly reviewed for currency and appriateness. Implementation as soon as reasonably practical prior to/during and post event.	Procedural	Good effectiveness	DPEM Police and Emergency Management - Offsite Emergency Planning Unit
(Haz.) LGF2 Flood Flows / 2 High	LGF2 Flood Flows / 2 High Power Stream Flow	Legal	Statutory regulation/restriction of activities	Regulations regarding physical activity and approval processes for assessing and then undertaken legitimate actions	Administrative	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF2 Flood Flows / 2 High	LGF2 Flood Flows / 2 High Power Stream Flow	Levee -	Physical barriers to redirect stream flows	Design and placement of levy banks to redirect stream flows	Design - Protection System	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF2 Flood Flows / 2 High	LGF2 Flood Flows / 2 High Power Stream Flow	Armour -	Armouring/Protection	Design and emplacement of physical armouring on stream banks	Guarding or Shielding	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF2 Flood Flows / 2 High	LGF2 Flood Flows / 2 High Power Stream Flow	Rip Rap	- emplacement of Groynes, Obstructions	Design and emplacement of physical barriers to reduce stream velocities	Design - Protection System	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF2 Flood Flows / 2 High	LGF2 Flood Flows / 2 High Power Stream Flow	Cleaning -	Removal of in-situ obstructions	Physical removal of obstructions, regularly undertaken	Inspection and Maintenance	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF2 Flood Flows / 2 High	LGF2 Flood Flows / 2 High Power Stream Flow	Cleaning -	Removal of in-situ obstructions	Physical removal of obstructions, regularly undertaken	Inspection and Maintenance	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF2 Flood	LGF2 Flood Flows / 2 High Power Stream Flow	Dredge -	Deepening or widening of stream	Removal of sediment from stream channel to enhance stream flow	Control of Energy Release	Poor effectiveness	MAST Marine and Safety Tasmania (Tidal regions)
(Haz.) LGF2 Flood	LGF2 Flood Flows / 2 High Power Stream Flow	Planning	Council Planning Scheme	Limitation and/or enforcement of building/operations to limit potential impacts (building siting / land use etc).	Administrative	Good effectiveness	Council Break O'Day Council
(Haz.) LGF2 Flood	LGF2 Flood Flows / 2 High Power Stream Flow	Dam Management	review of dam safety	Regular review and maintenance of dam structures	Inspection and Maintenance	Good effectiveness	DPIPWE - water management Water management section of DPIPWE
(Haz.) LGF2 Flood	LGF2 Flood Flows / 2 High Power Stream Flow		Long term planning (Adaptation/retreat)			Good effectiveness	
(Haz.) LGF2 Flood Flows / 2 High	LGF2 Flood Flows / 2 High Power Stream Flow	EWS -	Early Warning System		Safety	Good effectiveness	DPEM Police and Emergency Management - Offsite Emergency Planning Unit
(Haz.) LGF2 Flood	LGF2 Flood Flows / 2 High Power Stream Flow	Closure -	Physical Closures (barriers/evacuations)	Place physical barriers/warning signage to prevent access	Guarding or Shielding	Good effectiveness	TasPol Tasmania Police
(Haz.) LGF2 Flood Flows / 2 High	LGF2 Flood Flows / 2 High Power Stream Flow	Temporary Protection	Temporary armouring/protection	Design and emplacement of physical armouring/protection (eg sandbags)	Control of Energy Release	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF2 Flood Flows / 2 High	LGF2 Flood Flows / 2 High Power Stream Flow	EWS -	Early Warning System		Safety	Good effectiveness	DPEM Police and Emergency Management - Offsite Emergency Planning Unit
(Haz.) LGF2 Flood	LGF2 Flood Flows / 2 High Power Stream Flow	Temporary Relocation	Relocate People / assets	Physical removal of people and assets from hazard	Separation (Time or Space)	Good effectiveness	
(Haz.) LGF2 Flood	LGF2 Flood Flows / 2 High Power Stream Flow		Sand bagging / temporary barrier placement			Poor effectiveness	
(Haz.) LGF2 Flood	LGF2 Flood Flows / 2 High Power Stream Flow	Temporary Relocation	Relocate assets	physical removal of assets from hazard	Separation (Time or Space)	Good effectiveness	
(Haz.) LGF2 Flood	LGF2 Flood Flows / 2 High Power Stream Flow	Cleaning	- Removal of in-situ obstructions	Physical removal of obstructions, regularly undertaken	Inspection and Maintenance	Good effectiveness	
(Haz.) LGF2 Flood Flows / 2 High	LGF2 Flood Flows / 2 High Power Stream Flow	Temporary Protection	Temporary armouring/protection	Design and emplacement of physical armouring/protection (eg sandbags)	Control of Energy Release	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF2 Flood Flows / 2 High	LGF2 Flood Flows / 2 High Power Stream Flow	Temporary Protection	Temporary armouring/protection	Design and emplacement of physical armouring/protection (eg sandbags)	Control of Energy Release	Poor effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF2 Flood Flows / 2 High	LGF2 Flood Flows / 2 High Power Stream Flow	Temporary Protection	Temporary armouring/protection	Design and emplacement of physical armouring/protection (eg sandbags)	Control of Energy Release	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF2 Flood Flows / 2 High	LGF2 Flood Flows / 2 High Power Stream Flow	EWS -	Early Warning System		Safety	Good effectiveness	DPEM Police and Emergency Management - Offsite Emergency Planning Unit
(Haz.) LGF2 Flood	LGF2 Flood Flows / 2 High Power Stream Flow	Temporary Relocation	Relocate People / assets	Physical removal of people and assets from hazard	Separation (Time or Space)	Good effectiveness	
(Haz.) LGF2 Flood	LGF2 Flood Flows / 2 High Power Stream Flow		Temporary Alternate Access	Alternate transportation (helicopter/boat et al)		Good effectiveness	

Barrier	*Hazard*	*Code*	*Name*	*Description*	*Barrier type*	*Effectiveness*	*Accountable*
(Haz.) LGF3 Storm 'Surge' Tide /	LGF3 Storm 'Surge' Tide / 3 Storm Tide inundation	BOM	Bureau of Meteorology Live data for warning	Available from live monitors in catchmentcan provide early warning of 'dangerous' rainfall volumes.	Administrative	Unassessed / Unknown	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF3 Storm 'Surge' Tide /	LGF3 Storm 'Surge' Tide / 3 Storm Tide inundation	BOM	BOM Forecasting of event	Forecasting of meteorological systems to provide early warning of potential 'dangerous' rainfall volumes. IN PLACE and functioning	Administrative	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF3 Storm 'Surge' Tide /	LGF3 Storm 'Surge' Tide / 3 Storm Tide inundation	CC	Climate Change Projections	Prjection of long term changes in climateForecasting of meteorological systems to provide early warning of potential 'dangerous' rainfall volumes. ClimateFutures and existing analyses. Long Term interpretation only may assist in long term planning Nil influence over short term/immediate issues.	Administrative	Poor effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF3 Storm 'Surge' Tide /	LGF3 Storm 'Surge' Tide / 3 Storm Tide inundation	EMP	Break O'Day Municipal emergency management plan	Preparation and appropriate implementation of municipal emergency management plan. Ensure up to date and regularly reviewed for currency and appriateness. Implementation as soon as reasonably practical prior to/during and post event.	Procedural	Good effectiveness	DPEM Police and Emergency Management - Offsite Emergency Planning Unit
(Haz.) LGF3 Storm 'Surge' Tide /	LGF3 Storm 'Surge' Tide / 3 Storm Tide inundation	NTC	Tide Forecasting	Forecasting of astronomical tidal influence is well established and can provide early warning of potential 'dangerous' tidal contributions. IN PLACE and functioning	Administrative	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF3 Storm 'Surge' Tide /	LGF3 Storm 'Surge' Tide / 3 Storm Tide inundation		Establish Alternate Access			Good effectiveness	
(Haz.) LGF3 Storm 'Surge' Tide /	LGF3 Storm 'Surge' Tide / 3 Storm Tide inundation	Tide simulations	Modelling of tidal influence on flooding	Computer simulation of tidal influences on flood flows and inundation depths. Tidal heights and records available for inputs for integration with flood information. Useful in providing early warning and for influencing in planing ddecisions.	Administrative	Unassessed / Unknown	
(Haz.) LGF3 Storm 'Surge' Tide /	LGF3 Storm 'Surge' Tide / 3 Storm Tide inundation	Levee -	Physical barriers to redirect / mitigate	Design and placement of levy banks to redirect stream flows	Design - Protection System	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF3 Storm 'Surge' Tide /	LGF3 Storm 'Surge' Tide / 3 Storm Tide inundation	Levee -	Physical barriers to redirect stream flows	Design and placement of levy banks to redirect stream flows	Design - Protection System	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF3 Storm 'Surge' Tide /	LGF3 Storm 'Surge' Tide / 3 Storm Tide inundation	Armour -	Armouring/Protection	Design and emplacement of physical armouring on stream banks	Guarding or Shielding	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF3 Storm 'Surge' Tide /	LGF3 Storm 'Surge' Tide / 3 Storm Tide inundation	Rip Rap	- emplacement of Groynes, Obstructions	Design and emplacement of physical barriers to reduce stream velocities	Design - Protection System	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF3 Storm 'Surge' Tide /	LGF3 Storm 'Surge' Tide / 3 Storm Tide inundation	Cleaning -	Removal of in-situ obstructions	Physical removal of obstructions, regularly undertaken	Inspection and Maintenance	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF3 Storm	LGF3 Storm 'Surge' Tide / 3 Storm Tide inundation	Dredge -	Deepening or widening of stream	Removal of sediment from stream channel to enhance stream flow	Control of Energy Release	Poor effectiveness	MAST Marine and Safety Tasmania (Tidal regions)
(Haz.) LGF3 Storm	LGF3 Storm 'Surge' Tide / 3 Storm Tide inundation		Long term planning (Adaptation/retreat)			Good effectiveness	
(Haz.) LGF3 Storm	LGF3 Storm 'Surge' Tide / 3 Storm Tide inundation	Dredging barway	Dredging barway to increase flows	Increasing the vlocity of outflow may contribute to reduced inundation levels within the bay.		Unassessed / Unknown	
(Haz.) LGF3 Storm 'Surge' Tide /	LGF3 Storm 'Surge' Tide / 3 Storm Tide inundation	BOM	Bureau of Meteorology Live data for warning	Available from live monitors in catchmentcan provide early warning of 'dangerous' rainfall volumes.	Administrative	Unassessed / Unknown	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF3 Storm 'Surge' Tide / 3 Storm Tide	LGF3 Storm 'Surge' Tide / 3 Storm Tide inundation	Local Resident Advice	Upstream residents	Residents in upstream catchments currently liaise ad provide advice to those in lower regions. This can provide early warning of 'dangerous' rainfall volumes. Only effective where residents onsite at onset of event and when suitable communication process and information distribution system available (eg advice to BOM). Need clear communication protocol and confidence of process	Administrative	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF3 Storm 'Surge' Tide / 3 Storm Tide	LGF3 Storm 'Surge' Tide / 3 Storm Tide inundation	Flow Gauge	Stream flow gauge (Online - Data)	Analysis of flow gauge records to identify 'trigger' thresholds for warning advice. Only effective when operating correctly (maintenance required) and when information presented rapidly. Potentialy significant lag time in interpretation of information to provision of advice. Gauge positions may not provide optimum advice and insufficient coverage of catchment area	Administrative	Unassessed / Unknown	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF3 Storm 'Surge' Tide /	LGF3 Storm 'Surge' Tide / 3 Storm Tide inundation	BOM	BOM Forecasting of event	Forecasting of meteorological systems to provide early warning of potential 'dangerous' rainfall volumes. IN PLACE and functioning	Administrative	Good effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF3 Storm 'Surge' Tide /	LGF3 Storm 'Surge' Tide / 3 Storm Tide inundation	CC	Climate Change Projections	Prjection of long term changes in climateForecasting of meteorological systems to provide early warning of potential 'dangerous' rainfall volumes. ClimateFutures and existing analyses. Long Term interpretation only may assist in long term planning Nil influence over short term/immediate issues.	Administrative	Poor effectiveness	State/Local Government Council/State Shared (or indetermined responsibility)
(Haz.) LGF3 Storm 'Surge' Tide /	LGF3 Storm 'Surge' Tide / 3 Storm Tide inundation	Planning	Council Planning Scheme	Limitation and/or enforcement of building/operations to limit potential impacts (building siting / land use etc).	Administrative	Good effectiveness	Council Break O'Day Council
(Haz.) LGF3 Storm 'Surge' Tide /	LGF3 Storm 'Surge' Tide / 3 Storm Tide inundation	Recovery Plan	Council Recovery Plan	Documented procedures and processes ensuring optimised treatments and recovery in place prior to event to ensure impact of an event is minimised.	Procedural	Good effectiveness	Council Break O'Day Council
(Haz.) LGF3 Storm 'Surge' Tide /	LGF3 Storm 'Surge' Tide / 3 Storm Tide inundation	EMP	Break O'Day Municipal emergency management plan	Preparation and appropriate implementation of municipal emergency management plan. Ensure up to date and regularly reviewed for currency and appriateness. Implementation as soon as reasonably practical prior to/during and post event.	Procedural	Good effectiveness	DPEM Police and Emergency Management - Offsite Emergency Planning Unit
(Haz.) LGF3 Storm 'Surge' Tide /	LGF3 Storm 'Surge' Tide / 3 Storm Tide inundation	EMP	Break O'Day Municipal emergency management plan	Preparation and appropriate implementation of municipal emergency management plan. Ensure up to date and regularly reviewed for currency and appriateness. Implementation as soon as reasonably practical prior to/during and post event.	Procedural	Good effectiveness	DPEM Police and Emergency Management - Offsite Emergency Planning Unit
(Haz.) LGF3 Storm 'Surge' Tide /	LGF3 Storm 'Surge' Tide / 3 Storm Tide inundation	EMP	Break O'Day Municipal emergency management plan	Preparation and appropriate implementation of municipal emergency management plan. Ensure up to date and regularly reviewed for currency and appriateness. Implementation as soon as reasonably practical prior to/during and post event.	Procedural	Good effectiveness	DPEM Police and Emergency Management - Offsite Emergency Planning Unit
(Haz.) LGF3 Storm 'Surge' Tide /	LGF3 Storm 'Surge' Tide / 3 Storm Tide inundation	EMP	Break O'Day Municipal emergency management plan	Preparation and appropriate implementation of municipal emergency management plan. Ensure up to date and regularly reviewed for currency and appriateness. Implementation as soon as reasonably practical prior to/during and post event.	Procedural	Good effectiveness	DPEM Police and Emergency Management - Offsite Emergency Planning Unit
(Haz.) LGF3 Storm 'Surge' Tide /	LGF3 Storm 'Surge' Tide / 3 Storm Tide inundation	EMP	Break O'Day Municipal emergency management plan	Preparation and appropriate implementation of municipal emergency management plan. Ensure up to date and regularly reviewed for currency and appriateness. Implementation as soon as reasonably practical prior to/during and post event.	Procedural	Good effectiveness	DPEM Police and Emergency Management - Offsite Emergency Planning Unit
(Haz.) LGF3 Storm 'Surge' Tide /	LGF3 Storm 'Surge' Tide / 3 Storm Tide inundation	EMP	Break O'Day Municipal emergency management plan	Preparation and appropriate implementation of municipal emergency management plan. Ensure up to date and regularly reviewed for currency and appriateness. Implementation as soon as reasonably practical prior to/during and post event.	Procedural	Good effectiveness	DPEM Police and Emergency Management - Offsite Emergency Planning Unit
(Haz.) LGF3 Storm 'Surge' Tide /	LGF3 Storm 'Surge' Tide / 3 Storm Tide inundation	EMP	Break O'Day Municipal emergency management plan	Preparation and appropriate implementation of municipal emergency management plan. Ensure up to date and regularly reviewed for currency and appriateness. Implementation as soon as reasonably practical prior to/during and post event.	Procedural	Good effectiveness	DPEM Police and Emergency Management - Offsite Emergency Planning Unit

Appendix H

Council Specified Consequence / Likelihood Tables and Risk Rating Matrix

Council specified risk likelihood criteria

Likelihood Scales

Rating	Recurrent Risks	Single Events
Almost Certain	Could occur several times per year	More likely than not 90-99%
Likely	May arise about once per year	As likely as not 70-89%
Possible	May arise once in 10 years	Less likely than not but still possible 30-69%
Unlikely	May arise once in 10 years to 25 years	Unlikely but not impossible 10-29%
Rare	Unlikely to occur during the next 25 years	Negligible 1-9%

Council specified consequence Scales

	OH & S	Public Safety	Financial	Local Economy & Growth	Community & Lifestyle	Environment & Sustainability	Public Administration
Catastrophic	Death	Large numbers of serious injuries or loss of lives	Huge financial loss > or equal to $4m (~10% rate revenue)	Regional decline leading to widespread business failure, loss of employment and hardship	The municipality would be seen as very unattractive, stagnant and unable to support its community	Major widespread loss of environmental amenity and progressive irrecoverable environmental damage	Public administration would fall into decline and cease to be effective
Major	Extensive injuries	Isolated instances of serious injuries or loss of lives	Major financial loss > or equal to $1m(~2.5% rate revenue)	Regional stagnation such that businesses are unable to thrive and employment does not keep pace with population growth	Severe and widespread decline in services and quality of life within the community	Severe loss of environmental amenity and danger of continuing environmental damage	Public administration would struggle to remain effective and would be seen to be in danger of failing completely
Moderate	Medical treatment required	Small number of injuries	High financial loss > or equal to $500,000	Significant general reduction in economic performance relative to current forecasts	General appreciable decline in services	Isolated but significant instances of environmental damage that might be reversed with intensive efforts	Public administration would be under severe pressure on several fronts
Minor	First aid treatment	Serious near misses or minor injuries	Medium financial loss > or equal to $50,000	Individually significant but isolated areas of reduction in economic performance relative to current forecasts	Isolated noticeable examples of decline in services	Minor instances of environmental damage that could be reversed	Isolated instances of public administration being under severe pressure
Insignificant	No injuries	Appearance of threat but no actual harm	Low financial loss < or equal to $5,000	Minor shortfall relative to current forecasts	Minor areas in which municipality unable to maintain current services	No environmental damage	Minor instances of public administration being under more than usual stress but it could be managed

Council specified project risk consequence criteria

RATING		Financial	Project Timeframe (extension measured in days)	Project Objectives
Insignificant	**1**	Risk event results in increased funding required to meet project objectives by up to 5% of original project budget	Risk event results in project timeframe extended by up to 10% of original project duration	Risk event does not have any major impact on the achievement of key project objectives
Minor	2	Risk event results in increased funding required to meet project objectives by 5-10% of original project budget	Risk event results in project timeframe extended by 10-20% of original project duration	Risk event impacts isolated key project objectives. Additional minor effort is required to ensure that all objectives are met
Moderate	**3**	Risk event results in increased funding required to meet project objectives by 10-20% of original project budget	Risk event results in project timeframe extended by 20-35% of original project duration	Risk event impacts numerous key project objectives. Considerable effort including some change to the scope of the project is required to achieve required outcomes
Major	**4**	Risk event results in increased funding required to meet project objectives by 20-35%% of original project budget	Risk event results in project timeframe extended by 35-50% of original project duration	Risk event impacts a significant portion of key project objectives requiring major changes to project scope and work to achieve required outcomes
Severe	**5**	Risk event results in increased funding required to meet project objectives by more than 35% of original project budget	Risk event results in project timeframe extended by more than 50%% of original project duration	Risk event results in failure of the project to meet all required objectives.

Council specified overall risk ratings

Likelihood	Consequence				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	Medium	Medium	High	Extreme	Extreme
Likely	Low	Medium	High	High	Extreme
Possible	Low	Medium	Medium	High	High
Unlikely	Low	Low	Medium	Medium	Medium
Rare	Low	Low	Low	Low	Medium

Appendix I

NERAG Consequence / Likelihood Tables and Risk Rating Matrix

Consequence Level	People	Environment	Economy	Public Administration	Social Setting	Infrastructure
Catastrophic	Widespread multiple loss of life (mortality > 1 in ten thousand), health system unable to cope, displacement of people beyond ability to cope	Widespread severe impairment or loss of ecosystem functions across species and landscapes, irrecoverable environmental damage	Unrecoverable financial loss > 3% of the government sector's revenues[1], asset destruction across industry sectors leading to widespread business failures and loss of employment	Governing body unable to manage the event, disordered public administration without effective functioning, public unrest, media coverage beyond region or jurisdiction	Community unable to support itself, widespread loss of objects of cultural significance, impacts beyond emotional and psychological capacity in all parts of the community	Long-term failure of significant infrastructure and service delivery affecting all parts of the community, ongoing external support at large scale required
Major	Multiple loss of life (mortality > 1 in one hundred thousand), health system over-stressed, large numbers of displaced people (more than 24 hours)	Severe impairment or loss of ecosystem functions affecting many species or landscapes, progressive environmental damage	Financial loss 1-3% of the government sector's revenues[1] requiring major changes in business strategy to (partly) cover loss, significant disruptions across industry sectors leading to multiple business failures and loss of employment	Governing body absorbed with managing the event, public administration struggles to provide merely critical services, loss of public confidence in governance, media coverage beyond region or jurisdiction	Reduced quality of life within community, significant loss or damage to objects of cultural significance, impacts beyond emotional and psychological capacity in large parts of the community	Mid- to long-term failure of significant infrastructure and service delivery affecting large parts of the community, initial external support required
Moderate	Isolated cases of loss of life (mortality > than one in one million), health system operating at maximum capacity, isolated cases of displacement of people (less than 24 hours)	Isolated but significant cases of impairment or loss of ecosystem functions, intensive efforts for recovery required	Financial loss 0.3-1% of the government sector's revenues[1] requiring adjustments to business strategy to cover loss, disruptions to selected industry sectors leading to isolated cases of business failure and multiple loss of employment	Governing body manages the event with considerable diversion from policy, public administration functions limited by focus on critical services, widespread public protests, media coverage within region or jurisdiction	Ongoing reduced services within community, permanent damage to objects of cultural significance, impacts beyond emotional and psychological capacity in some parts of the community	Mid-term failure of (significant) infrastructure and service delivery affecting some parts of the community, widespread inconveniences
Minor	Isolated cases of serious injuries, health system operating within normal parameters	Isolated cases of environmental damage, one-off recovery efforts required	Financial loss 0.1-0.3% of the government sector's revenues[1] requiring activation of reserves to cover loss, disruptions at business level leading to isolated cases of loss of employment	Governing body manages the event under emergency regime, public administration functions with some disturbances, isolated expressions of public concern, media coverage within region or jurisdiction	Isolated and temporary cases of reduced services within community, repairable damage to objects of cultural significance, impacts within emotional and psychological capacity of the community	Isolated cases of short- to mid-term failure of infrastructure and service delivery, localised inconveniences
Insignificant	Near misses or minor injuries, no reliance on health system	Near misses or incidents without environmental damage, no recovery efforts required	Financial loss < 0.1% of the government sector's revenues[1] to be managed within standard financial provisions, inconsequential disruptions at business level	Governing body manages the event within normal parameters, public administration functions without disturbances, public confidence in governance, no media attention	Inconsequential short-term reduction of services, no damages to objects of cultural significance, no adverse emotional and psychological impacts	Inconsequential short-term failure of infrastructure and service delivery, no disruption to the public services

Impact Category Definitions	
People	Relates to the direct impacts of the emergency on the physical health of people/individuals and emergency services' (i.e. health system) ability to manage Mortality defined as the ratio of deaths in an area to the population of that area; expressed per 1000 per year
Environment	Relates to the impacts of the emergency and its effects on the ecosystem of the area, including fauna and flora
Economy	Relates to the economic impact of the emergency on the governing body as reported in the annual operating statement for the relevant jurisdiction, and Industry Sectors as defined by the Australian Bureau of Statistics
Public Administration	Relates to the impacts of the emergency on the governing body's ability to govern
Social Setting	Relates to the impacts of the emergency on society and its social fabric, including its cultural heritage, resilience of the community
Infrastructure	Relates to the impacts of the emergency on the area's infrastructure/lifelines/utilities and its ability to service the community Long-term failure = Repairs will take longer than 6 months Mid- to long-term failure = Repairs may be undertaken in 3 to 6 months Mid-term failure = Repairs may be undertaken in 1 to 3 months Short- to mid-term failure = Repairs may be undertaken in 1 week to 1 month Short-term failure = Repairs may be undertaken in less than 1 week

Likelihood Level	Frequency	Average Recurrence Interval	Annual Exceedance Probability
Almost Certain	Once or more per year	< 3 years	> 0.3
Likely	Once per ten years	3 – 30 years	0.031 – 0.3
Possible	Once per hundred years	31 – 300 years	0.0031 – 0.03
Unlikely	Once per thousand years	301 – 3,000 years	0.00031 – 0.003
Rare	Once per ten thousand years	3,001 – 30,000 years	0.000031 – 0.0003
Very Rare	Once per hundred thousand years	30,001 – 300,000 years	0.0000031 – 0.00003
Almost Incredible	Less than once per million years	> 300,000 years	< 0.0000031

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