Unimutual Risk Management Services

Building Risk Assessment and Resilience Guideline

Unimutual Limited Suite 11.02, Level 11, 56 Pitt Street, Sydney NSW 2000 | PO Box H96, Australia Square NSW 1215
T: 02 9169 6600 | service@unimutual.com.au | www.unimutual.com
Unimutual Limited ABN: 45 106 564 372 AFS Licence No: 241142

Background and Purpose

Buildings are critical to the ongoing operation of university functions as they house the activities which are at the core of learning, research, and administration. This building risk assessment guideline is designed to assist facilities managers to assess, quantify and mitigate building risks associated with bushfire and flooding. The process involves the following steps:

1. Perform a desktop review to identify buildings which may be at risk from natural perils including bushfire, flooding and windstorms.

2. Inspect those buildings that may be exposed to natural perils and verify the location exposure.

3. Determine which buildings should be subject to a "rapid" COPE based risk assessment.

4. Perform a "rapid" COPE based risk assessment.

5. Undertake a more detail risk assessment of "at risk" buildings.

6. Identify specific risk mitigation strategies, their costs and benefits.

The initial rapid assessment is based on an understanding of a building's exposure to bushfire or flooding, its construction, occupancy and the protection measures already in place. Where a building is assessed as potentially "at risk", a methodology for more detailed risk analysis is provided as well as a cost benefit process for prioritising and justifying the allocation of funds for bushfire and flood mitigation works.

COPE – Construction, Occupancy, Protection and Exposure

The COPE risk assessment methodology examines four key elements of a building including:

1. Construction – the materials used in the construction of the building with a focus on their resistance to fire and flood.

2. Occupancy – the nature of activities being undertaken and equipment housed in the building such as laboratories, offices or high value research equipment.

3. Protection – the adequacy of firefighting infrastructure including sprinklers, water flow rates, pressure and supply as well as distance to the nearest fire station; and

4. Exposure – to a range of different hazards associated with the occupancy (such as storage of hazardous or flammable chemicals and gases), natural hazards or hazards presented by neighbouring facilities.

Climate change and weather event intensity

The recent claims experience of the mutual indicates that significant losses arising from weather events are becoming more frequent. Of concern is the increasing intensity of these events resulting in more severe losses and at locations that have never been subject to weather related losses in the past. Weather patterns are changing and much of the scientific (and insurance) literature has identified a causal link between more damaging storms and climate change, particularly increases in global temperature and sea level rise.

We are now operating under a "new weather paradigm" where past classification of weather events is becoming less relevant, exposure to severe weather more frequent and existing infrastructure "less likely to cope" increasing event magnitude.

Rainfall

The Bureau of Meteorology (BOM) expect cyclones to be less likely in the future, though the intensity and impact of extreme weather will be greater with cyclones holding more moisture and dumping more rainfall. The same is true of extra-tropical cyclones, as the atmosphere warms, these systems can hold the more moisture and more energy resulting in more intense events. Storm surges are also likely to become worse because with sea levels rising at 3.4 millimetres per year.

In summary, the key points from the recent Climate Council report on intense rainfall and flooding are:

1. Climate change is influencing all extreme rainfall events. The warmer atmosphere holds more moisture, about 7% more than previously. This increases the risk of heavier downpours.

2. Extreme rainfall events are expected to increase in intensity in Australia.

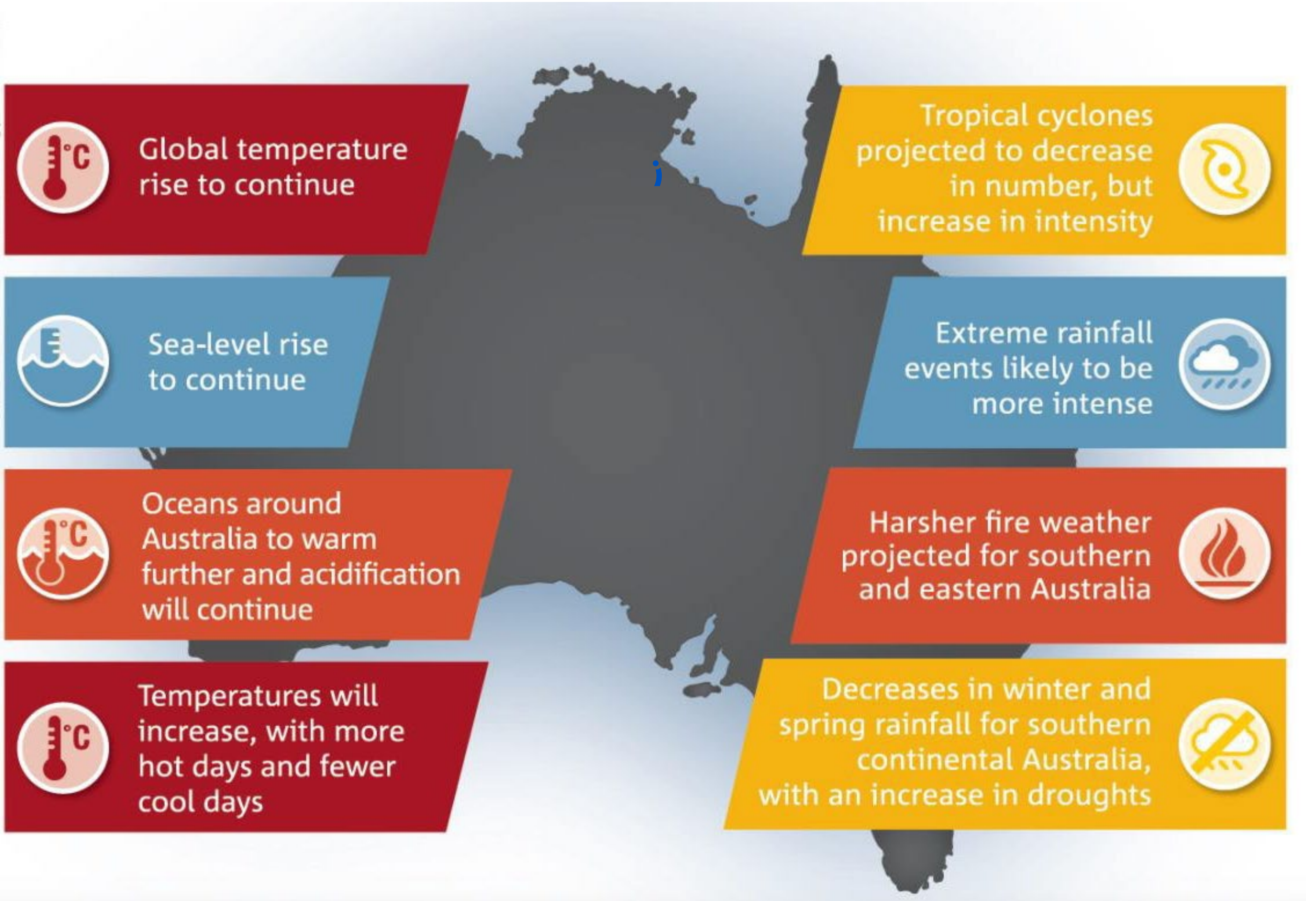
3. Extreme rainfall events are likely to worsen in New South Wales and Queensland, where maximum one-day rainfall is expected to increase by up to 17% and 18% respectively.

4. It is critical that communities and emergency services have access to information about rainfall in a changing climate to ensure they can prepare for the future, particularly when rebuilding damaged infrastructure.

Bushfire

Australian temperatures are projected to continue increasing with more extremely hot days and fewer extremely cool days. Heat waves are becoming hotter, longer and more frequent, add to this a drying trend (declining rainfall and soil moisture), a southward shift of fronts which bring rain to southern Australia, low relative humidity, increased dry fuel loads and the conditions are in place for the perfect fire storm. All that is required is an ignition source, be that arson, lightning or a powerline fault. Studies have confirmed that in most cases, years with drought conditions resulted in greater areas of burnt land.

The BOM advise that Australia's Forest Fire Danger Index has been rising and, with fire danger likely to increase throughout the 21st century due to climate change. An increase in the number of days with weather conducive to fire in southern and eastern Australia is projected. The adjacent infographic provides some "quick facts" about bushfire in Victoria.



The Bureau of Meteorology and CSIRO have summarised their joint climate outlook in the infographic above.

How to use this guideline

Step 1 – Perform a desktop review.

Reviewing incident records and loss history will help identify those buildings that may have been the subject of a loss or near miss in the past. Aerial photographs, topographical maps and hazard maps (bushfire and flood) will assist to identify bushland campus interfaces and buildings located in bushfire risk zones. Similarly, the aerial photographs and maps will indicate the location of buildings in relation to rivers, creeks, drainage lines, roads and paths. Further, they will provide an indication of the nature of the catchment and the hardstand areas upstream of buildings. The information obtained from this desktop exercise can be used to quickly identify buildings potentially at risk from both bushfire and flooding.

Step 2 – Inspect those buildings that may be exposed to natural perils and verify the location exposure.

For bushfire risks, determine the nature and density of the vegetation and its distance from buildings. Has

an APZ (Asset Protection Zone) been established? Has it been maintained? What is the height of the canopy and the density of the understorey? Is there a heavy fuel load on the ground?

For riverine flooding risks, compare the floor level of the building in relation to the current 1% flood level, identify any nearby or downstream structures which may trap debris and cause water to "back up". Are there any upstream dams or impoundments that could overflow and cause flash flooding? Do buildings in potentially flood affected areas have a lower ground floor or basement level?

For overland, flash or pluvial flooding, consider the proximity of buildings to creeks, artificial waterways or open storm water drains and the direction in which they may overflow. Consider the extent of hardstand surfaces such as carparks, paved areas, roads and footpaths and their positioning within the catchment and in relation to buildings. Identify the location of pit and envelope drains in relation to buildings. Consider the amount of detritus that may be washed into the stormwater system from natural or landscaped areas and the potential for blockage of stormwater infrastructure. Do buildings subject to flash flooding have a lower ground floor or basement level?

Step 3 – Determine which buildings should be subject to the COPE risk assessment.

Having undertaken a desktop assessment of the loss history, aerial photographs, topographical and hazard maps and completed on-site verification of buildings potentially subject to natural perils, compile a list of building to be assessed.

Step 4 – Perform a rapid COPE risk assessment of the building(s) for bushfire risk or flood.

The rapid COPE risk assessment tables for bushfire are provided in Appendix 1 and for flood in Appendix 2. Follow the prompts provided.

Step 5 – Perform a detailed risk assessment.

A detailed risk assessment should be performed on those buildings that scored 6 or more in the rapid COPE risk assessment. The methodology for conducting a detailed risk assessment is provided in Appendix 3. The risk assessment is based on an estimate of the cost of losses associated with a specified chance of a defined magnitude event occurring.

Step 6 – Determine treatment or mitigation options and prepare a cost benefit analysis.

In some cases, the risk may require mitigation which in the case of bushfire and flood, will likely involve capital expenditure. A cost benefit analysis of the available treatment options will help identify the most cost-effective deployment of scarce capital

Appendix 1

Rapid COPE Risk Assessment - BUSHFIRE

Record the building inspection details in **Table 1BF**

To assess the bushfire risk, select a rating from each of the tables 2, 3, 4 and 5. Add the scores together to obtain a Rapid COPE risk score and record this score in Table 1.

Table 1BF – Building Inspection Details

Name of the building	
Asset number and/or address	
Estimated value of the building	
Estimated value of the contents	
Date of review	
Rapid COPE Risk Score for Bushfire	If the score is 6 or above – undertake a detailed risk assessment
Name and positions of person(s) conducting the review	

Exposure to Bushfire

The exposure to bushfire rating scale below is based on consideration of the building's proximity to bushland, the extent of the Asset Protection Zone (APZ), perceived fuel levels, varying levels of ember attack, heat flux or direct exposure to flames. It is loosely based upon the Bushfire Attack Levels (BALs) described in Australian Standard 3959 Construction of Buildings in Bushfire-Prone Areas.

Table 2BF – Bushfire Exposure Rating

Score	Exposure to Bushfire
1	a. The building is located at the bushland interface but is between 50 and 100 metres from bushland. b. It is protected by a maintained Asset Protection zone with relatively low fuel levels. c. It may be subject to low level ember attack and heat flux up to 12.5kW/m^2 d. The building is not located at the bushland interface but is near trees and "bush landscaping" internally within the campus.
2	a. The building is located at the bushland interface with a maintained Asset Protection Zone of 20 - 50 metres with moderate fuel levels. b. It has a westerly or north westerly or northerly aspect and may be subject to increasing levels of ember attack and burning debris ignited by windborne embers. c. Heat flux may increase up to 29kW/m2 d. There is an increasing likelihood of exposure to flames.
3	a. The building is located at the bushland interface with an Asset Protection Zone of less than 20 metres containing moderate to high fuel levels. b. It has a westerly or north westerly aspect and may be subject to increasing levels of ember attack and burning debris ignited by windborne embers. c. It is likely to be directly exposed to flames.

Table 3BF - Building Construction

The following table is indicative only. For detailed combustibility assessment refer to FM global standards

Score	Building Construction
1	The building is constructed of non-combustible materials. Examples of non- combustible construction include: Floors – concrete Walls – masonry (brick or block), concrete or structural steel with steel column Roofs – concrete, metal deck with steel beams and steel bar joists
2	The building is constructed with a combination of combustible and non-combustible materials described above and below.
3	The building is constructed of combustible materials. Examples of fire combustible construction include: Floors – wood or ply board on timber joists Walls – EPS, wood or hard plank sidings, brick veneer, wood frames Roofs – tiles, shingles, single ply membrane, steel sheet with wood frame

Table 4BF - Occupancy

Score	Occupancy
1	Office spaces, teaching spaces, meeting rooms. Not critical to normal operations with only minor potential for business interruption.
2	Large lecture halls, storage, student hubs, cafes and restaurants, sports centres teaching laboratories, boilers or chillers, emergency power generators. Not critical to normal operations but would be inconvenient and have moderate business interruption impacts.
3	Chemical research laboratories, high value research sample storage, high value research equipment, data centres and super computers, and libraries. Critical to operations and strategic objectives with potential for significant business interruption.

Table 5BF – Protection

Score	Protection
1	a. 50 – 100 metres maintained low fuel APZ. In-ground sprinklers in the APZ. b. Roof and wall mounted external drenchers. c. Ember guards on windows and other building apertures. d. Mobile firefighting appliances are available on site. e. Independent (of mains) water supplies. f. Adequate mains pressure and flow. g. Internal sprinklers, hose reels and hand-held extinguishers.
2	a. 20 – 50 metres maintained APZ. Ember guards on some windows. b. Rural or country fire service response available within 5kms. c. Adequate mains pressure and flow with external hydrant points at the fire interface or nearby. d. Internal hose reels and hand-held extinguishers.
3	a. Less than 20 metre APZ or no discernible APZ. b. Rural or country fire service station greater than 15kms away. c. External hydrant points nearby. d. Internal hose reels and hand-held extinguishers

Appendix 2

Rapid COPE Risk Assessment - FLOOD

Firstly, record the building inspection details in **Table 1F**.

To assess the flood risk, select a rating from each of the tables 2, 3, 4 and 5. Add the scores together to obtain a Rapid COPE risk score and record this score in Table 1.

Table 1F – Building Inspection Details

Name of the building	
Asset number and or address	
Estimated value of the building	
Estimated value of the contents	
Date of review	
Rapid COPE Risk Score for Flood	If the score is 6 or above – undertake a detailed risk assessment
Name and positions of person(s) conducting the review	

Exposure to Flooding (Riverine and Overland)

The exposure to flooding rating scale below addresses both riverine and overland flooding.

When deciding the exposure to **riverine** flooding the main consideration will be the building's proximity to a river, large creek or concrete lined channel, its position in the catchment or flood plain and the historical flood levels in relation the floor level. Other factors should include the location of any upstream dams or impoundments, which if breached, could cause inundation as well as any nearby or downstream structures which may catch debris causing water to "back-up".

Exposure to overland flooding is not as clear cut as exposure to riverine flooding as the confluence of several conditions will be required for significant overland flow to occur. These conditions may include a combination of:

- Intensity and duration of rainfall.
- Location of stormwater drainage lines (inground and open channel).
- Increases in "hardstand" areas such as carparks, roads and paved areas.
- Hydraulic capacity and complexity of inground stormwater drainage.
- Available detritus from landscaped and natural areas which could block drains.
- Frequency and effectiveness of pit and drain maintenance.
- Location of buildings in relation to overland flow direction and volume.
- The relative floor levels of the basement, lower ground and ground floors when compared against flow heights.

Using historical events as a measure of discharge volumes and flow heights may be misleading when assessing exposure to overland or flash flooding as even slight changes in any of the abovementioned conditions, particularly intensity and duration of rainfall, increases in hardstand area and available detritus could result in significantly different flow behaviour.

Table 2F – Flood Exposure Rating

When assigning a flood exposure rating, take a conservative approach to selecting a score.

Score	Exposure to Flooding (Riverine and Pluvial)
1	**(Riverine)** a. The building is located either within or outside the historical 0.2% AEP or 1:500-year flood envelope. b. There are no dams or impoundments upstream and no downstream structures **(Overland)** a. The building has never been affected by water ingress. b. There is no or only small areas of hardstand adjacent to or upstream of the building. c. In-ground stormwater infrastructure is less than 20 years old. d. There is some detritus (landscaped and natural) available to potentially block drainage systems. e. The building is NOT near a major stormwater drainage line (either natural or man-made). f. The building is NOT near an overland flow path. g. The lower floors of the building have an RL (Reduced Level) greater than nearby envelope and pit drains.

2	**(Riverine)** a. The building is located within the historical 1.0% AEP or 1:100-year flood envelope. b. There are nearby or downstream structures. **(Overland or Flash flooding)** a. The building has NOT previously been affected by water ingress. b. Some areas of hardstand have been recently installed adjacent to or upstream of the building. c. In-ground stormwater infrastructure is over 20 years old. d. There is some detritus (landscaped and natural) available to potentially block drainage systems. e. The building is nearby a major stormwater drainage line (either natural or man-made). f. The building is nearby an overland flow path. g. The lower floors of the building are equal to the RL of nearby envelope and pit drains.
3	**(Riverine)** a. The building is located within the historical 1.0% - 5.0% AEP or 1:100 to 1:20-year flood envelope. b. There is a dam or impoundment located upstream and/or there are downstream or nearby structures. **(Overland or Flash flooding)** a. The building has previously been affected pluvial flooding. b. New and significant areas of hardstand have been installed adjacent to or upstream of the building. c. In-ground stormwater infrastructure is more than 50 years old. d. There are significant amounts of detritus (landscaped and natural) available to potentially block drainage systems. e. The building is located adjacent to or directly downstream of a major stormwater drainage line (either natural or man-made). f. The building is in an overland flow path. g. The lower floors of the building have a RL less than nearby envelope and pit drains.

Table 3F - Building Construction

The following table is indicative only. Building materials are considered flood resistant if they can withstand direct contact with flood waters for at least 72 hours without being significantly damaged. "Significant damage" means any damage that requires more than low cost, cosmetic repair (such as painting).

Score	Building Construction
1	The building is constructed of flood-resistant materials. Examples of flood- resistant materials include: **Floors** – concrete, ceramic tiles, vinyl, and rubber sheets and tiles, pressure- treated (PT) or decay resistant wood products, cold-formed steel. **External and Internal Walls and ceilings** – brick, metal, concrete, concrete block, porcelain, slate, glass block, stone, and ceramic and clay tile, cement board, cold- formed steel, and reinforced concrete, polyester epoxy painted gyprock, foam and closed-cell insulation.
2	The building is constructed of a combination of flood-resistant materials and non- flood resistant materials as described in 1 above and 3 below.
3	The building is constructed of non-flood resistant materials. Examples of non- flood resistant materials: **Floors** – wooden floorboards, chipboard, carpet etc. **External and internal walls and ceilings** – weatherboard, plasterboard, timber, timber veneer products, untreated gyprock on wooden frame.

Table 4F - Occupancy

Score	Occupancy
1	Office spaces, teaching spaces, meeting rooms. Not critical to normal operations with only minor business interruption.
2	Large lecture halls, storage, student hubs, cafes and restaurants, sports centres teaching laboratories, boilers or chillers. HVAC is located on the roof but main switchboards, FIPs, emergency power generators and communications infrastructure is located on the ground or lower ground floors.
3	Chemical research laboratories, high values research sample storage, high value research equipment data centres and super computers, libraries. There is high value equipment and any combination of HVAC plant, main switchboards, FIPs, emergency power generators and communications infrastructure which is located on the ground or lower ground floors or within flood reach.

Table 5F - Protection

Score	Protection
1	**Riverine** a. man-made permanent levees. b. flood doors. c. no lower ground doors, windows or vents. d. emergency generators outside flood prone area. e. sump pumps. f. ground floor and lower ground floor wet rooms only. g. tested Flood Emergency Response Plan (FERP). **Overland or flash flooding** a. flood doors. b. no lower ground doors, windows or vents. c. stormwater detention. d. emergency generators outside flood prone area. e. sump pumps. f. ground floor and lower ground floor wet rooms only. g. tested Flood Emergency Response Plan (FERP).
2	**Riverine** a. no lower ground doors, windows or vents. b. untested Flood Emergency Response Plan (FERP). c. mix of wet and dry rooms. **Overland or flash flooding** a. ground floor and lower ground floor wet rooms only. b. limited stormwater detention. c. untested Flood Emergency Response Plan (FERP). d. mix of wet and dry rooms.
3	**Riverine** Limited if any protection **Overland or flash flooding** Limited if any protection

Appendix 3 – Detailed Risk Assessment

Justifying the expenditure of scarce resources to protect against low-probability, high-consequence events can be difficult if not impossible amidst the plethora of competing organisational budget priorities. These events are rarely at the forefront of management consciousness or in a strategic risk register, consigned largely to the realm of emergency management and business continuity specialists.

Common responses to a new budget item for natural hazard mitigation sound something like "the chance of it happening is so remote - we don't have the budget for this - and that's why we buy insurance". Not unreasonable responses in the context of historical weather and climate patterns; however, changes in the magnitude, intensity and frequency of extreme weather events may render these responses increasingly invalid. Further, a hardening of the global ISR markets and exclusions in policy wordings, limits or caps on cover relating to some perils strengthens the argument for a reasoned approach to natural hazard exposed asset loss mitigation strategies.

Unfortunately, many business cases are based on the outcome of a qualitative risk analysis and do little to instil decision making confidence nor convince management of the merits of natural hazard risk mitigation funding. What follows is a method which may assist risk practitioners gain traction with the finance department and senior management by providing a more technical approach supported by substantive asset and loss values.

Things to consider when analysing the risk include:

- The frequency of a given magnitude of event.
- The nature of the risk exposure (people, property, infrastructure, business continuity).
- The consequences of a given magnitude event.
- The financial (monetary) cost of the losses.

Events will occur with varying magnitude and frequency; in general terms larger magnitude and consequence events will occur less frequently but will have significantly greater impacts. For example, a flood with an Annual Return Interval (ARI) of 20 years, has a 5% chance of occurring in any given year (also known as the Annual Exceedance Probability – AEP). A flood of this magnitude may only rise to a level that impacts 2% of buildings on the campus, where a flood with a 100-year flood ARI (which has a 1% AEP) may impact 10% of buildings and a 500-year flood or 0.2% AEP could impact 40% or more of buildings.

The Quantitative Process

The process for undertaking a quantitative assessment includes

1. Describe the risk scenario.
2. Define the frequency or AEP of the event (use 5%, 2% or 1%).
3. Determine the assets exposed to a bushfire or flood event (see rapid COPE risk assessment summary). This may be one or more buildings and other assets such as an outdoor research plot or environmentally sensitive area AND estimate their total value (see table 6 below).
4. Estimate the extent and value of damage commensurate with the AEP considering the protection in place for the asset (refer to the protection tables in the rapid COPE risk assessment).
5. Estimate the business interruption costs.
6. Calculate the value at risk.
7. Determine the treatments.
8. Calculate the value of the reduced risk and cost benefit ratios.

Conduct the detailed risk analysis

Step 1 – Describe the risk scenario.

For example, overland flow from a severe storm enters the ground floor and lower ground floor areas of buildings A, B and C causing damage to [list the items] or a bushfire leads to the destruction of building A and its contents.

Step 2 - Define the frequency or AEP of the event (use 5%, 2% or 1%).

Extreme rainfall events that lead to flooding are likely to become more intense (high confidence). As a general rule, bushfire exposed campuses can reasonably use a 1% AEP, however where assets are in isolated bushland settings, a 2% AEP would be more appropriate.

Step 3 - Estimate the value of damage to the assets at risk.

Use Table 1DRA below to list the buildings and the contents that will be affected. Also estimate the nature and cost of business interruption and any other unique assets which may be adversely impacted. Remember, when assigning flood related "damage estimates" to the varying AEP's, we are in a new climate "paradigm" and that extreme rainfall events are expected to increase in intensity as is the intensity and frequency of bushfires.

Percentage of the asset subject to damage refers to how much of the asset(s) is likely to be adversely impacted.

For bushfire, the percentage of the asset subject will always be 100%, that is the entire building is potentially subject to damage.

For flood it will range between **10% to 20%** on the basis that the structural elements of a building buildings tend to be more resilient to flood than to fire. The Mutual's experience in relation to clean up costs and reinstatement of building damage reflects costs in the order of 10% to 20% of the total building value. Costs in relation to contents damage will vary depending upon the number of levels and the nature and spread of contents on each floor. For a single level building, it is likely that 100% of the contents will be subject to damage. For multi-level buildings the percentage of contents subject to damage will vary in accordance with the nature and spread of contents across the various levels.

In general terms, in a multi-storey building, only the basement, lower ground or ground floors will be inundated by floodwater. The damage tends to be wall linings, doors, architraves, floor coverings, electrical wiring and data services as well as plant rooms, electrical switchboards, chillers or boilers and other building infrastructure systems installed at these lower levels. Development and spread of mould is a typical and costly problem in water affected buildings.

Protection effectiveness is an estimate of how effectively mitigation and response measures already in place are likely to minimise damage to the asset.

In a bushfire scenario, a building with roof top sprinklers, external drenchers, ember guards and 100 metre well maintained asset protection zone may suffer only minor damage. In this instance, protection effectiveness could be as high as 80%.

In a flooding scenario, protection revolves around preventing water entering a building. Floor doors and shutters, an effective flood emergency response plan or not having entry points in the building design; controlling flow via retention or detention structures or diverting flow around a building are examples of flood protection measures. In some instances, where flood affected levels are of "wet construction", it may be a valid response to permit water to flow through the building.

Table 1DRA – Value of damage to the assets at risk (Normal Loss Expectancy)

Asset type	Description	Value of asset	Percentage of the asset subject	Protection effectiveness	Value of damage
Buildings					
Contents					
Business Interruption					
Other Assets					
Total A (Normal Loss Expectancy)					$

Step 4 - Determine the value of asset risk.

Asset Total A (Normal Loss Expectancy)	X the AEP%	= $Value of Asset Risk

Step 5 - Calculate the cost of treatment.

Table 2DRA – Treatment options and costs.

Treatment description	Cost of treatment	Life of treatment (years)	Annual maintenance cost	Annualised cost
Treatment 1				
Treatment 2				
Total				

Step 6 – Calculating the reduced value of asset risk (B).

The AEP of the event will remain the same. The treatment will only serve to better protect the asset and in some case reduce the percentage of the asset subject to the peril. In the treatment example above.

Table 3DRA – Reduced or adjusted loss expectancy

Asset type	Description	Value of asset	Percentage of the asset subject	Protection effectiveness	Value of damage
Buildings					
Contents					
Business Interruption					
Other Assets					
Total B (Reduced or adjusted Loss Expectancy)	$				

Step 7 - Determine the value of reduced asset risk (after treatment).

Asset Total B (Reduced or Adjusted Loss Expectancy)	X the AEP%	= $Value of Reduced Asset Risk

Step 8 – Calculate the value of risk reduction.

The value of risk reduction is the value of the existing risk (Step 4) minus the value of the reduced or adjusted risk (Step 6).

Step 9 - Determine the cost benefit ratio.

The cost benefit ratio is calculated by dividing the cost of mitigation by the value of risk reduction.

Appendix 4 –Detailed Risk Assessment for Rural Campus Bushfire

Step 1 - Describe the risk scenario.

A large out of control bushfire 15 kms to the west of Rural campus is resulting in increasing ember attack and development of spot fires in the outer asset protection zone.

Step 2 - Define the frequency or AEP of the event The bushfire is a 1% AEP event.

Step 3 - Estimate the value of damage to the assets at risk (Normal Loss Expectancy).

In the event of a bushfire at "Rural Campus", I have assumed that the two main buildings located adjacent each other, are at the bushland interface and have a westerly aspect (buildings A and B). Both buildings house laboratories and high value research equipment.

Building C is the environmental research station and associated infrastructure which is located at the inner edge of the Asset Protection Zone (APZ) which serves several purposes including habitat for a threatened species of plant, Corunastylis insignis (the variable Midge-orchid) and high-end monitoring equipment for the measurement of CO_2 levels. The equipment and infrastructure are valued at $15,000,000 and the threatened species have been assigned a nominal value of $5,000,000. This location is highly exposed to bushfire.

Building A is the newer of the two buildings and is relatively well protected. Protection includes 20-50 metre maintained, low fuel APZ, roof and wall mounted external drenchers, ember guards on windows and other building apertures, adequate mains pressure and flow and internal sprinklers, hose reels and hand- held extinguishers. Building B is 20 years older and has only basic fire protection.

Table 1DRA - Value of damage to the assets at risk (Normal Loss Expectancy)

Asset type	Description	Value of asset	Percentage of the asset subject	Protection effectiveness	Value of damage
Buildings	Building A	$100M	100%	70%	$30M
	Building B	$60M	100%	20%	$48M
	Building C – Environment Research facility	$13M	100%	20%	$10.4M
Contents	In Building A	$30M	100%	70%	$3M
	In Building B	$10M	100%	20%	$8M
	In building C (and associated infrastructure)	$2M	100%	20%	$1.6M
Business Interruption		$2m	100%	0%	$2M
Other Assets	Rare and endangered species	$5m	100%	0%	$5M
Total A					**$108M**

Step 4 - Determine the value of asset risk.

Asset Total A = $108M	X the AEP% = 1%	= $1, 080,000

Step 5 - Calculate the cost of treatment.

To improve the effectiveness of protection, it is proposed to install ember guards on all west facing windows on building B as well as install roof and wall drenchers. In addition, 200,000 litres of water supply, independent of the mains will be installed to supply drenchers on both buildings A and B. The APZ will be extended to encompass a low fuel zone 100 metres from buildings A and B and 50 metres from the research station. The environmental research facility will have new water tanks and APZ wetting sprinklers installed and a mobile firefighting appliance deployed.

Table 2DRA - Treatment options and costs

Treatment description	Cost of treatment	Life of treatment (years)	Annual maintenance cost	Annualised cost
Install roof and wall drenchers on Building B and independent water supply for both buildings A and B	$1,000,000	20	$2000	52,000
Ember guards on Building B	50,000	20	$1500	$4,000
Extend APZ to 100 metres	30,000	20	$3000	$4,500
Research facility water tanks and pop-up sprinklers in the APZ	250,000	20	$2000	$14,500
Mobile firefighting appliance	150,000	10	3000	$18,000
Total	**$1,480,000**			**$94,000**

Table 3DRA – Reduced or adjusted loss expectancy (after treatment)

Asset type	Description	Value of asset	Percentage of the asset subject	Protection effectiveness	Value of damage
Buildings	Building A	$100M	100%	70%	$30M
	Building B	$60M	100%	70%	$18M
	Building C – Environment Research facility	$13M	100%	50%	$6.5M
Contents	In Building A	$30M	100%	70%	$3M
	In Building B	$10M	100%	70%	$3M
	In building C (and associated infrastructure)	$2M	100%	50%	$1M
Business Interruption		$2m	100%	50%	$1M
Other Assets	Rare and endangered species	$5m	100%	30%	$3.5M
Total A	**$66M**				

Step 6 - Determine the value of reduced asset risk (after treatment).

Asset Total B = $66M	X the AEP% = 1%	= $660,000

Step 7 – Calculate the risk reduction.

The risk reduction is the existing risk of $1,080,000 minus the reduced risk of $660,000 which equals **$420,000.**

Step 8 - Determine the cost benefit ratio.

In this example, the risk reduction of $420,000 divided by the cost of mitigation $94,000 produces a **cost to benefit ratio of 1:4.6**

Appendix 5 – Detailed Risk Assessment for Valley Campus Flood

Step 1 - Describe the risk scenario.

"Valley campus" is located at the lower end of reasonably large coastal catchment. Over the past 5 years there have been several east coast low events which caused localised flooding. They were classified as 50-year ARI events (2% AEP). The campus and surrounds have undergone upstream development since these storm events with extensive hard stand recently installed to cater for an additional 2000 carparking spaces as well as the completion of a council approved retail and housing development comprising a further 2 hectares of hard surfaces (outside the campus boundary). These developments have the potential to significantly increase stormwater runoff, and it is feared that similar magnitude and intensity storm events will exceed the hydraulic design capacity of inground, overland drainage and water detention/retention infrastructure.

Two buildings, the antiquities library (a three-storey building) and the biochemistry building (a four-storey building) have previously been subject to minor stormwater inundation, however in this scenario both ground or lower ground floors are flooded to a depth of approximately 1 metre.

Step 2 - Define the frequency or AEP of the event.

The storm and associated flooding represent a 2% AEP event

Step 3 - Estimate the value of damage to the assets at risk (The Normal Loss Expectancy).

Table 1DRA - Value of damage to the assets at risk (Normal Loss Expectancy)

Asset type	Description	Value of asset	Percentage of the asset subject	Protection effectiveness	Value of damage
Buildings	Antiquities Library	$60M	10%	0%	$6M
	Biochemistry building	$80M	10%	0%	$8M
Contents	Journals and rare books on the lower GF	$20M	30%	0%	$3M
	Research samples in TCE	$30M	50%	0%	$8M
	Electron microscopes X2				
Business Interruption		$1m	100%	0%	$1M
Other Assets	Nil	$0m	0%	0%	$0
Total A					**$26M**

Step 4 - Determine the value of reduced risk.

Asset Total A = $26M	X the AEP% = 2%	= $520,000

Step 5 - Calculate the cost of treatment.

Keep water out - install flood doors, vent covers and flood proof window shutters on both the Antiquities library and the Biochemistry building.

Table 2DRA – Reduced or adjusted loss expectancy

Treatment description	Cost of treatment	Life of treatment (years)	Annual maintenance cost	Annualised cost
7 x custom flood doors on Antiquities library	$105,000	10	$5000	$15,500
20 x custom flood shutters on Antiquities library windows	$40,000	10	$2000	$6,000
35 vent protectors on Antiquities library vents	$7000	10	$500	$1,200
8 x custom flood doors on Biochemistry building	$120,000	10	$5500	$17,500
20 x custom flood shutters on Biochemistry building windows	$40,000	10	$2000	$6,000
35 vent protectors on biochemistry building vents	$7000	10	$500	$1,200
Relocate switchboards, HVAC and essential building infrastructure to higher levels (either roof or first floor separate electrical circuits)	$600,000	30	0 (already accounted for)	$20,000
Total	**$919,000**			**67,400**

Table 3DRA – Reduced or adjusted loss expectancy (after treatment)

Asset type	Description	Value of asset	Percentage of the asset subject	Protection effectiveness	Value of damage
Buildings	Antiquities library	$60M	10%	50%	$3M
	Biochemistry building	$80M	10%	50%	$4M
Contents	Journals and rare books on the lower GF	$20M	30%	50%	$1.5M
	Research samples in TCE Electron microscopes X2	$30M	50%	80%	$3M
Business Interruption		$1m	100%	50%	$0.5M
Other Assets	Nil	$0m	0%	0%	$0
Total B					**$12M**

Step 6 - Determine the value of reduced risk.

Asset Total B = $12M	X the AEP% = 2%	= $240,000

Step 7 – Calculate the risk reduction.

The risk reduction is the existing risk of $520,000 minus the reduced risk of $240,000 which equals **$280,000.**

Step 8 - Determine the cost benefit ratio.

In this example, the risk reduction of $280,000 divided by the cost of mitigation $67,400 produces a **cost to benefit ratio of 1:4.2**