MARSDEN JACOB ASSOCIATES

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Climate Change Asset Vulnerability Assessment

Case study: Natural disaster relief and recovery provided by community assets in Site B and Site A: Updated

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Prepared for South East Councils Climate Change Alliance and [redacted] Council
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Executive Summary

Introduction

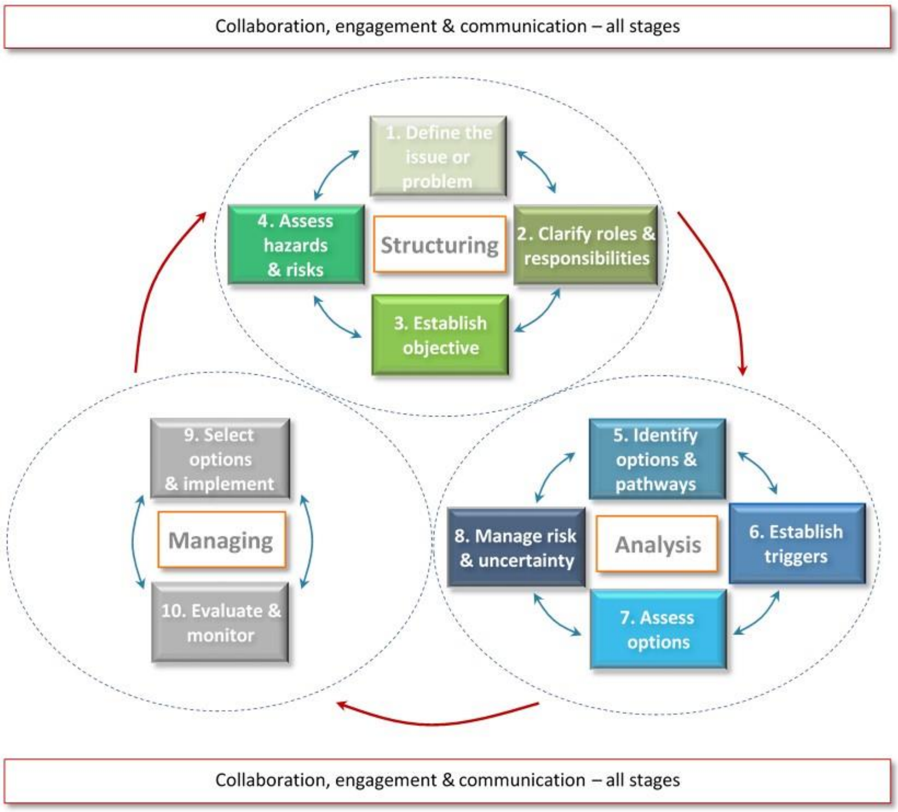
SECCCA member councils aim to better understand how their buildings, roads, drainage, and other assets will be impacted by climate change and associated extreme weather events. The Climate Change Asset Vulnerability Assessment project seeks to provide councils with this information. The case study phase of the project focusses on the financial and economic implications of climate change impacts on council assets and planning for those impacts.

This case study focusses on upgrades needed to two key council owned, multiple-use community assets - the Site A Community Centre and the Site B Community Complex - to ensure that they are fit for purpose for relief, recovery and co-ordination during and following major natural disasters such as bushfires and storms.

The climate change adaptation decision making process

A sound decision-making process provides the foundation for effective climate change adaptation. Figure ES 1 identifies the key stages and steps comprising 'good practice' adaptation decision making.

Figure ES 1: Stages in the decision-making process



Working with the council in a series of workshops, we have undertaken preliminary analysis relating to Steps 1 through 8 in that process, however the primary focus of our analysis has been on options assessment (Step 7).

Analysis of options using CBA and threshold analysis

The case study assesses three short term adaptation options and compares them against a base case, or business as usual scenario. The options are summarised as:

- **Business as usual (Base Case) –** no change to the current situation, other than ongoing maintenance.
- **Option 1, Facility upgrades** – This option will include improvements to facilities to increase their functionality for relief and recovery efforts. The option will also include basic education and training.
- **Option 2, Building upgrades** – This option will include the improvements made in Option 1, with the addition of improvements to the building shell and energy efficiency rating. Education and training will extend to include information of the upgrades and why they are valuable.
- **Option 3, Redesign and rebuild** – This option involves a complete redesign and rebuild of the facilities, including the surrounding landscape. A more detailed education and training program will be developed to inform the community of the benefits of building resilience and sustainability.

A modified form of cost-benefit analysis (CBA), known as threshold analysis has been used to assess the options. CBA is a method that compares monetary costs and benefits associated with each option. The scope of CBA is on social costs and benefits as opposed to the private cost and benefits assessed in a financial evaluation. Quantifying the benefits of upgrading the Centres is a difficult task given information that is readily available. Instead, we undertaken a modified version of CBA referred to as threshold analysis. The threshold analysis is being used to answer the following question:

"*By how much will upgrades to the Centres need to contribute to reducing the impacts of natural disasters on the communities of Site B and Site A to justify investments in the upgrades?"*

Analysis results, applying a medium emissions climate change scenario, are summarised in Table ES 1.

The table show the present value costs of each option over 20 years from 2021-2041 and the threshold benefit required for the investments under each option to be justified. The analysis assumes that the future average annual damage cost of bushfires by 2050 will increase linearly, consistent with a medium emissions scenario (RCP 4.5).

We estimate the total economic costs of bushfires on the communities of Site B and Site A to be about $93 million in present value terms over the next 20 years. 20% of those costs or $18.5 million in present value terms, could be avoided by effective relief and recovery efforts ($11.8 million in Site B and $6.8 million in Site A).

Table ES 1: Threshold analysis summary results by Centre (present value $'000s – 4% discount rate)

	Option 1		Option 2		Option 3	
	Site B	Site A	Site B	Site A	Site B	Site A
Upfront costs - Total	$103.9	$84.7	$222.7	$203.5	$3,517.3	$2,814.6
Ongoing costs - Total	$20	$20	$38.6	$38.6	$0	$0
Avoided costs	$16.3	$16.3	$16.3	$16.3	$16.3	$16.3
Total PV costs	**$110.5**	**$91.2**	**$247.8**	**$228.6**	**$3,503.8**	**$2,801.2**
Expected benefit (avoided cost) of effective bushfire resilience, relief and recovery					$11,794	$6,790
Benefit threshold (%)[1]	**0.9%**	**1.3%**	**2.1%**	**3.4%**	**29.7%**	**41.3%**

* The lower the threshold, the more likely the investment can be justified

Based on these estimates and the estimated net costs of facility upgrades, the threshold analysis indicates that for Option 1 to be justified (i.e. have a net benefit) the facility upgrades would need to contribute to 1.1% or more of the benefits (avoided costs) that effective resilience, relief and recovery will provide. With Option 2 (Building upgrade) and Option 3 (Redesign and rebuild), the threshold values are 2.6% and 33.9% respectively.

While upgrades to Site B cost more in PV terms, the threshold required for the investment to be worthwhile is lower. This reflects a greater expected cost of bushfires in Site B than in Site A.

Conclusions and next steps

Our conclusions from the CBA and threshold analysis are:

- There is a strong case for implementing Option 1 upgrades to both the Site B Community Complex and the Site A Community Centre, in the short term.
- There is also a strong case for implementing Option 2, but further analysis could be worthwhile to better quantify the cost of outlays and to better understand the potential benefits of the outlays.
- The evidence for implementing Option 3, involving a complete redesign and rebuild, is less clear.
- Building resilience measures into natural disaster planning is critical for reducing the long-term cost of natural disasters.

Notwithstanding the prima facie case for implementing either Option 1 or Option 2 in the short term, further analysis could be warranted in some areas before decisions are made on implementation.

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1. Introduction

SECCCA member councils aim to better understand how their buildings, roads and drainage, and other assets will be impacted by climate change and associated extreme weather events, and how, in turn, related councils' income and expenditure will be impacted.

By having a greater understanding of asset vulnerability and the potential financial impacts of climate change, councils will improve their understanding of how climate change is likely to impact the delivery of community services. This will assist in planning for delivery of those services.

Case studies have been prepared by Marsden Jacob Associates (Marsden Jacob) as part of the SECCCA Assessment Vulnerability Assessment project.

The purpose of the case studies is to:

- Provide a focus for efforts to achieve a more detailed vulnerability assessment, analysis of adaptation options and hence the provision of a more valuable set of outcomes.
- Provide the basis of mentoring sessions that aim to develop council capability in assessing adaptation options.
- Provide practical exemplars for future reference by councils when undertaking future assessment of adaptation options.

To these ends, the case studies will:

- step through the process with practical and relevant examples.
- package up the process so that it can be reapplied and is translatable.

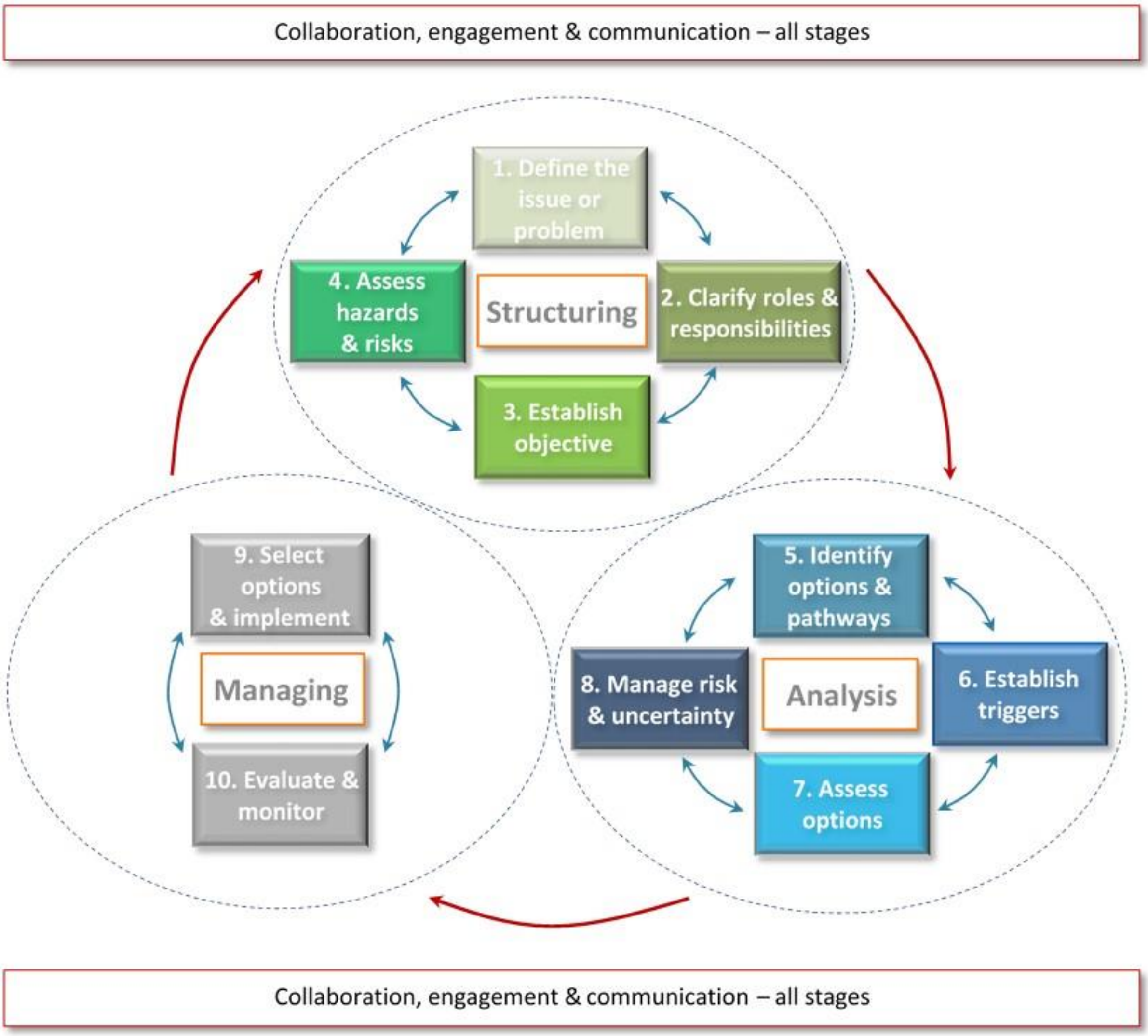
This case study focusses on upgrades needed to two key council owned, multiple-use community assets - the Site A Community Centre and the Site B Community Complex - to ensure that they are fit for purpose for relief, recovery and co-ordination during and following major natural disasters such as bushfires and storms.

We emphasize that this case study presents a preliminary assessment of adaptation options and, as such, provides guidance on the potential direction of future adaptation. Decisions on adaptation options, especially longer-term options, may need to be accompanied by more detailed analysis at different stages of the decision-making process.

2. The climate change adaptation decision making process

A sound decision-making process provides the foundation for effective climate change adaptation. Figure 1 identifies the key stages and steps comprising 'good practice' adaptation decision making. Working with the council in a series of workshops, we have undertaken some preliminary analysis relating to Steps 1 through 8 in that process, however the primary focus of our analysis has been on assessing the short-term options (Step 7) and consideration of uncertainties in the analysis (Step 8). Steps 1 to 6 are discussed briefly, in turn in this section, with more detailed discussion of Steps 7 and 8 provided in the following section.

Figure 1: Adaptation analysis process



Source: Marsden Jacob Associates

2.1 Statement of the problem

Site B is highly vulnerable to and has a history of bushfires. Site A township is less vulnerable to bushfires, but the surrounding area has a history of bushfires. The fire history of both assets is shown in Figure 2.

Figure 2: Fire history of community assets in [redacted]

REDACTED IMAGE

Source: Spatial Vision analysis

The two community assets that are the focus of this case study are used extensively by the local community on an ongoing basis. However, they are likely also to be needed for community relief and recovery in the event of major shocks such as bushfires and storms. The two Centres were used for this purpose as recently as June 2021, when a severe storm hit the region. Experience from the storm however, indicates that the assets need significant improvements to ensure that they are fit for purpose for relief, recovery and co-ordination in the event of major future shocks.

Upgrades may be needed to ensure the buildings:

- are protected from ember attacks during bushfires (note, the Site B Complex does have a thermal protection rating);
- can function in the event of power outages resulting from bushfires and storms (power, water supply, communications);
- have suitable thermal comfort; and
- can perform other functions required as recovery Centre's (e.g. kitchen facilities, showering).

Emphasis of any upgrades needs to be on maximising flexibility of the assets in the event of shocks and changes that will be useful for a range of scenarios.

2.2 Roles and responsibilities

Council has sole responsibility for managing its Community Centres. Since the facilities are not and will not be used as refuges during a natural disaster, Emergency Management organisations outside of the Council do not have a role or responsibility for the management of the facilities.

2.3 Objective of the upgrading the Community Centres

Before councils can identify and assess adaptation options it is important that they have a clear objective against which options will be assessed. A clearly defined objective will be critical to identifying the 'decision rule', which in turn will provide the basis for selecting the preferred option. The objective is also important for assisting with the process of identifying, filtering and assessing options and selecting thresholds and triggers.

The primary objective of upgrading the buildings is to enhance their capacity to provide relief and recovery to community members during and following disasters such as bushfires and storms, while also maintaining or improving their functionality as community centres for an array of other purposes on an ongoing basis. It is important to note that neither of the buildings is a designated Community Fire Refuge or is intended to perform that function in the future[2].

A holistic approach to upgrading buildings, facilities and landscape needs to be taken, ensuring that:

- The functionality and versatility of the facilities is maximised for an array of purposes
- They provide a safe and comfortable place for the community to undertake relief and recovery
- Local priorities, contemporary expectations and needs, and Council and state government policies are reflected including:
  - *Council's* [redacted] *Plan*, and actions relating to the Housing liveability goals;
  - Efficient building design principles, NatHERs ratings, and other sustainable building standards;
  - Australian Standard AS 3959-2018 – *Construction of buildings in bushfire-prone areas* and NASH Standard 2014 – *Steel Framed Construction in Bushfire Areas; and*
  - Other expectations and needs relating to community facilities, community wellbeing and sustainable building design
- Council and the community receive value for money based on cost effective upgrades, and
- The communities understanding of building adaptation / design and its role in increasing resilience against natural disasters and overall sustainability is increased.

2.4 Hazard assessment

We have relied on historical bushfire burn areas, historical facility usage data and to inform the hazard assessment for the facilities. This level of information is deemed suitable for a preliminary analysis of this nature. More detailed analysis however, especially of more substantial longer term options, will benefit from further hazard assessment of the level and probability of risk posed by bushfires to the Centres and the areas that they service, which incorporates climate change projections.

2.5 Adaptation options

The case study assesses three short term adaptation options and compares them against a base case, or business as usual scenario. The options are summarised as:

- **Business as usual (Base Case) –** no change to the current situation, other than ongoing maintenance. No significant facility upgrades and no additional measures targeting community resilience beyond what is already taking place.
- **Option 1, Facility upgrades** – This option will include improvements to facilities to increase their functionality for relief and recovery efforts. The option will also include basic education and training on

[2] The carpark adjoining the Site A Community Centre is designated as a Neighbourhood Safer Places – Bushfire Place of Last Resort.

facility usage.

- **Option 2, Building upgrades** – This option will include the improvements made in Option 1 with the addition of improvements to the building shell and energy efficiency rating. Education and training will extend to include information of the upgrades and why they are valuable.
- **Option 3, Redesign and rebuild** – This option involves a complete redesign and rebuild of the facilities, including the surrounding landscape. A more detailed education and training program will be developed to inform the community of the benefits of building resilience and sustainability in addition to using the facilities.

Details of how the options would be implemented, and how they compare are shown in Table 1.

Table 1: Detailed option description

Category	Option 1 – Facility Upgrades	Option 2 – Building Upgrades	Option 3 – Redesign and rebuild
Facilities / Building			
Audit	• Stormwater management system – roof drainage and surrounding • Facility audits to determine future upgrades to building shell		
Electricity supply and service	• solar system at Site B • battery for emergency circuits only ((alarms, kitchen, auto doors, bank of GPOs) • back-up portable generator points	• Permanent electricity supply – solar and battery. • Generator on standby in the long term if access becomes an issue.	Permanent generator OR electricity supply and battery for year-round usage.
Water	Provision of alternative emergency water supplies – rainwater tanks with filters and flushing capacity.		WSUD principles to maximise water reuse and increase self-sufficiency.
Communication	Wiring/connections for mobile services		
Building	• Improved ventilation/exhausts and sealing of external walls and floor • Disability access in and out of building at Site B	Upgrade to current bushfire (BELLs) and building standards: • Replacement of flammable components • Improved roofing	• Redesign and rebuild to go beyond current standards for bushfire and energy. • German passive house standard – high

Category	Option 1 – Facility Upgrades	Option 2 – Building Upgrades	Option 3 – Redesign and rebuild
	• Accessible services within the building	• Thermal comfort measures (passive cooling, insulation, glazing and sharing)	insulation, heat exchange, thermal mass. • Green star energy rating.
Security	Battery and wireless connection to improve access for doors		
Vegetation	No change	Minimal vegetation maintenance – e.g., trimming overhanging branches	Landscaping strategy to minimise fire risk and increase functionality for broad community use
Community resilience / Education			
Resilience	Guidelines and training on how to use the facilities features including: Electricity system, Ventilation/exhaust, Water system and back up supply points	Guidelines and training on increasing resilience of housing to natural disasters	Community events to promoting passive cooling in households
Sustainability	Resources (signage etc) on how to use the facilities	Guidelines and training on increasing sustainability of housing (energy / water efficiency, waste management?	

2.6 Adaptation pathways

While the focus of this preliminary analysis is on assessing the desirability and feasibility of implementing options ion the short, the analysis should be considered in the context of future adaptation pathways. There is an array of medium- and long-term adaptation pathways available to Council depending on which option Council moves forward with in the short-term.

Some pathways indicate a delay in investment, while others make different incremental improvements. The choice of pathway is most likely to be influenced by financial constraints, Council resource allocation, and community preference for change.

Different adaptation pathways are shown in Figure 3 and Table 2. Given the substantial investment involved in completely redesigning and rebuild the facilities (Option 3) and given the not insignificant scale of investment involved in Option 2, it is unlikely that Option 3 would be implemented in the medium term if a decision was made to implement Option 2 or even Option 1 in the short term. For this reason, Option 3 is only presented as a short-term option or as long-term option if there has been no or minimal short-term investment.

Figure 3: Adaptation pathways

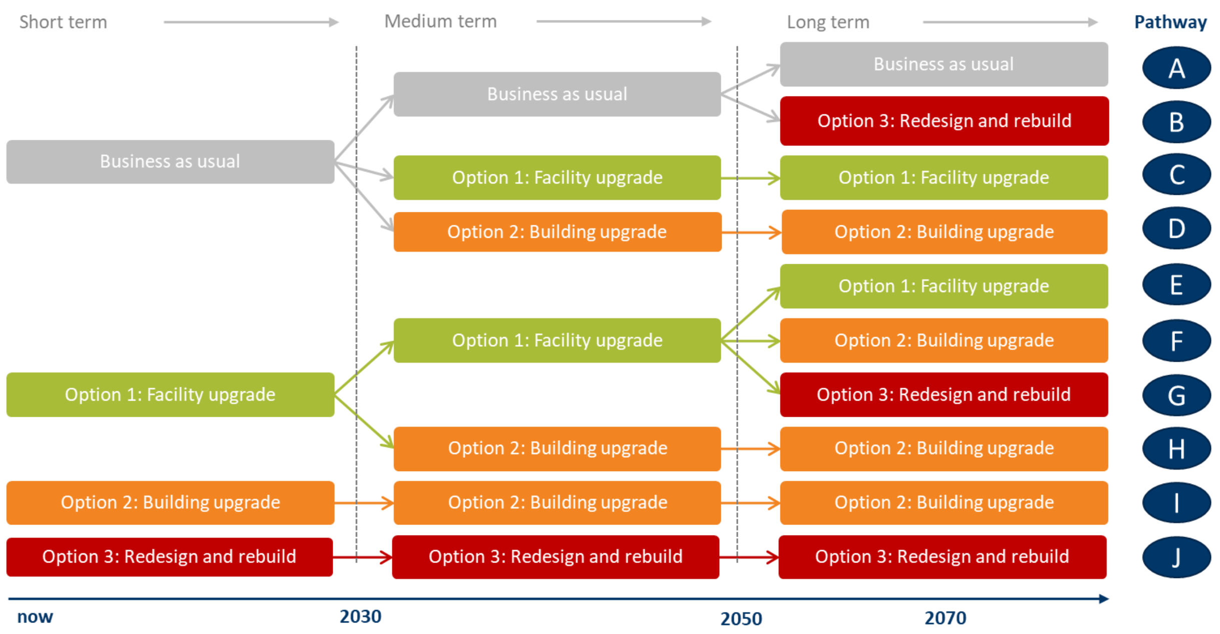


Table 2: Adaptation pathways

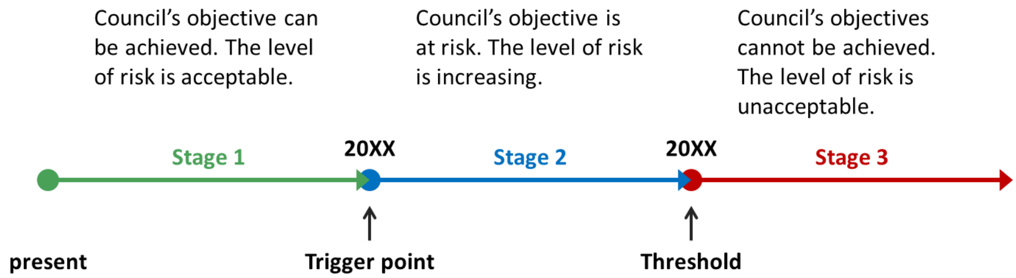
Short term (e.g. <10 years)	Medium term (e.g. 10-30 years)	Long term (e.g. >30 years)
Business as usual – no building upgrades, continuation of existing community resilience education	• Facility upgrade and facility education • Building upgrade and facility education	• Redesign and rebuild
Facility upgrade and facility usage education	• Building upgrade and facility usage education	• No change
Facility upgrade and facility usage education	No change	Redesign and rebuild and resilience, sustainability and functionality education
Building upgrade and facility usage education	No change	No change
Redesign and rebuild and resilience, sustainability and functionality education	No change	No change

2.7 Trigger points

Climate change poses significant uncertainties, with a range of plausible future scenarios for climate related hazards. Climate change projections on the local and regional level are being continually revised as new information and data become available. This calls for a flexible and adjustable approach to climate change adaptation to avoid premature redundancy of valuable infrastructure and putting communities and assets at risk.

Thresholds and triggers carefully selected to fit given circumstances and options, can serve as 'red flags and prompt management response and/or implementation of a predefined option or set of options at an appropriate time. Thresholds and triggers support adaptation strategies that maintain the acceptable level of risks and only implement adaptation actions if actual changes in risk start to eventuate. Triggers can be linked to physical, social or planning/policy changes.

Figure 4: Appropriate timing of adaptation options



Source: Marsden Jacob after "The Time Continuum Model" (Fisk and Kay, 2010)

In the case of the [redacted] Community Centres, possible trigger points are shown in Table 3Table 3. Further effort will be devoted to identifying specific triggers, although we note that the potential timing of Options 1 and 2, at least, is likely to be soon given that the climate change, community and policy changes have already occurred.

Table 3: Possible trigger points

Option	Possible trigger points	Indicative timing
Option 1	• Increasing frequency of climate related events (e.g. storms, power outages, heatwaves, days/yr) • Available grant funding (e.g. community climate adaptation funding), in conjunction with development of an adaptation strategy – adoption in 2022 second half.	Need for action soon considering climate changes that are already occurring Possibly as early as 2022-23
Option 2	• As above	As above
Option 3	• Asset life/ condition assessment, functionality / asset management planning • Population growth • Climate threshold (e.g. projections of FFDI extreme days/ year)	More likely to be medium or longer term (e.g. > 10 years)

3. Analysis of options using CBA and threshold analysis

3.1 Overview of approach

Cost-benefit analysis (CBA) is a method that compares monetary costs and benefits associated with each option. The scope of CBA is on social costs and benefits as opposed to the private cost and benefits assessed in a financial evaluation. This broad scope makes it well suited to measuring adaptation options from a community perspective, as will often be the basis for decision-making by local councils.

CBA enables comparison of alternative options to determine which options will provide net benefits to society and the option that will contribute the greatest net benefit (i.e. after assessing all costs and benefits over time). The method can also be used to compare projects of different scales and timeframes.

A partial CBA has been undertaken to assess the three options in the short term:

- Option 1 - Facility upgrades
- Option 2 - Building upgrades
- Option 3 - Redesign and rebuild

We have not assessed the cost of the Business-as-Usual option, instead measuring all costs and benefits incrementally to Business-as-Usual. Therefore, ongoing operating costs that would appear in both cases are not included in the analysis unless there is an incremental difference.

Quantifying the benefits of upgrading the Centres is a difficult task given information that is readily available for this analysis. To fully quantify the benefits provided to the community by the Centres would likely require a choice modelling study. This would involve a survey-based analysis of the values the community attaches to the Centres and their willingness to pay (WTP) to improve the Centres, especially for relief and recovery.

In the absence of this information, we have instead undertaken a modified version of CBA referred to as threshold analysis. This approach is discussed in more detail below.

3.1.1 Threshold analysis

A key benefit being sought from proposed upgrades to the Centres is improved wellbeing and amenity to community members through them having access to quality relief and recovery facilities and services following a natural disaster. As discussed above, the best way to answer this question is to undertake a survey based WTP study that asks the community to value the facilities and upgrades to the facilities. In the absence of a WTP study, threshold analysis provides a means of understanding the benefits the facilities would need to provide to justify investments in the proposed upgrades. In effect, the threshold analysis is being used to answer the following question:

"By how much will upgrades to the Centres need to contribute to reducing the impacts of natural disasters on the communities of Site B and Site A to justify investments in the upgrades?"

This in turn requires two questions to be answered:

1. "What are the likely impacts and associated economic costs to the communities of Site B and Site A from natural disasters in the future?" This itself, is a very uncertain proposition as it relies on projecting the frequency and severity of future disasters, such as bushfires and storms, which although likely to increase under a future climate, are very uncertain. Nevertheless, we have been able to derive an order of magnitude estimate of future total economic costs of natural disasters to the communities of Site B and Site A drawing on a recent study of the total economic costs of bushfires impacting Melbourne's outer metropolitan and peri-urban communities (DAE 2015, 2015b - see section 3.6.2.). We have also been able to derive an order of magnitude estimate of the future total economic costs under alternative climate change scenarios (DAE 2021).
2. "What proportion of natural disaster costs could be avoided by effective relief and recovery efforts?" This question is also not easy to answer since, as noted in previous studies, the intangible costs of natural disasters, although likely to be very substantial, are very difficult to quantity (AIDR 2018, Young and Jones 2018). Again, we have drawn on a recent study to provide an estimate of the reduction in the costs of natural disasters associated with implementing resilience measures, which include effective relief and recovery – approximately 20% of the total economic costs of a disaster (DAE, 2013).

3.2 Summary results

The results of the analysis are summarised in Table 4 and Table 5. The results are based on the following generic assumptions:

- 4% real discount rate
- 20-year analysis period, with investment occurring in 2022
- All cost and benefit values are in 2020 dollars
- A medium climate change scenario (average of RCP 2.6 and RCP 8.5 scenario results – approximately RCP 4.5).

The tables show the present value costs of each option over 20 years from 2021-2041 and the threshold benefit required for the investments under each option to be justified. Table 4 shows results for the two Centres combined, with Table 5 detailing costs and threshold benefits for the two Centres separately.

For example, we estimate the total economic costs of bushfires on the communities of Site B and Site A to be about $93 million in present value terms over the next 20 years. 20% of those costs, or $18.5 million in present value, could be avoided by effective relief and recovery efforts ($11.8 million in Site B and $6.8 million in Site A).

Based on these estimates and the estimated net costs of facility upgrades, the threshold analysis reveals that for Option 1 to be justified (i.e. have a net benefit) the facility upgrades would need to contribute to 1.1% or more of the benefits (avoided costs) that effective resilience, relief and recovery will provide. With Option 2 (Building upgrade) and Option 3 (Redesign and rebuild), the threshold values are 2.6% and 33.9% respectively.

The results by facility (Table 5) show that while upgrades to Site B cost more in PV terms, the threshold required for the investment to be worthwhile is lower. This reflects a greater expected cost of bushfires in Site B than in Site A, which in turn reflects a larger population exposed to bushfires in Site B.

Table 4: Threshold analysis summary results (present value $'000s – 4% discount rate)

	Option 1	Option 2	Option 3
Upfront costs - total	$188.7	$426.3	$6,331.9
Ongoing costs - total	$40.1	$77.1	$0
Avoided costs	-$26.9	-$26.9	-$26.9
Total PV costs	**$201.9**	**$476.5**	**$6,305.0**
Expected benefit (avoided cost) of effective bushfire resilience, relief and recovery – average emissions scenario			**$18,583.8**
Benefit threshold (%)	**1.1%**	**2.6%**	**33.9%**

Table 5: Threshold analysis summary results by Centre (present value $'000s – 4% discount rate)

	Option 1		Option 2		Option 3	
	Site B	Site A	Site B	Site A	Site B	Site A
Upfront costs - Total	$103.9	$84.7	$222.7	$203.5	$3,517.3	$2,814.6
Ongoing costs - Total	$20	$20	$38.6	$38.6	$0	$0
Avoided costs	$16.3	$16.3	$16.3	$16.3	$16.3	$16.3
Total PV costs	**$110.5**	**$91.2**	**$247.8**	**$228.6**	**$3,503.8**	**$2,801.2**
Expected benefit (avoided cost) of effective bushfire resilience, relief and recovery - average emissions scenario					$11,794	$6,790
Benefit threshold (%)*	**0.9%**	**1.3%**	**2.1%**	**3.4%**	**29.7%**	**41.3%**

*The lower the threshold, the more likely the investment can be justified

Detailed results are presented in section 3.5.

3.3 Uncertainties

These results are subject to significant uncertainties. The impact of some of those uncertainties on results of the analysis, including costs and timing of investments, have been tested through sensitivity analysis, and are shown to not fundamentally affect the results (see section 3.4). Nevertheless, more detailed analysis of the investment costs involved under each of the options should be undertaken if a decision to proceed with any of the options is made, especially Option 3.

Key uncertainties include the expected costs of bushfires and the benefits (avoided costs) linked to effective resilience, relief and recovery measures. These values have not been tested though sensitivity analysis. We note however, that the way in which we have derived estimates of the costs of natural disasters from the Deloitte Access Economics Study (DAE 2013, 2015, 2015b, 2021) is quite robust. It is also likely to be conservative, as it does not capture the economic costs of other natural disasters, notably storms. Although storm-related costs are unlikely to be as substantial as bushfires, they could still be significant. Also, our analysis does not capture the co-benefits, unrelated to relief and recovery services, that the Centres provide, such as their ongoing use by community groups.

3.4 Sensitivity analysis

The cost benefit analysis is based on a series of assumptions, which means that there is a degree of uncertainty around the results. Sensitivity testing has been undertaken to clarify which assumptions can materially change the results. The following sensitivity tests have been undertaken:

- Discount rates of 2% and 7%
- Change in analysis period to 15, 30 and 45 years
- Change in upfront costs by increasing and decreasing by 30%
- Delaying the investment by 5 and 10 years
- Climate change - Low and high emission scenarios.

Sensitivity analysis results are presented in Table 6. Climate change sensitivities are presented in Table 7 and are discussed in separately in section 3.6. The results show that:

- **Option 1 is not very sensitive to changing assumptions**. Under all sensitivity tests, the benefit threshold only changes by +/- 0.6% from the base assumptions which return 1.4%. This is expected because of the present value of the Option and suggests an investment of this scale is highly beneficial.
- **Option 2 is somewhat sensitive to changing assumptions.** Increased upfront costs and a higher discount rate see the benefit threshold increase just above 4%. Extending the analysis period to 45 years has the largest positive impact on the benefit threshold reducing it to 1.9%. This could suggest that an adaptation pathway of Option 1 in the short term and Option 2 in the medium term is worth consideration.
- **Option 3 is highly sensitive to all assumptions**. The discount rate and analysis period assumptions show that the high investment is very sensitive to timing assumptions. If the investment was delayed to

the medium term, or the analysis period is extended to 45 years the benefit threshold falls from 42.6% to around 28.8%. Further analysis would be required to determine whether the option could deliver sufficient benefit to alleviate the natural disaster costs by such a proportion.

Table 6: Summary of sensitivity analysis results

	Option 1		Option 2		Option 3	
	Total PV costs	Benefit threshold	Total PV costs	Benefit threshold	Total PV costs	Benefit threshold
Base assumptions (4%)	**$201,800**	**1.4%**	**$476,400**	**3.2%**	**$6,304,900**	**42.6%**
Discount rate 7%	$194,000	3.8%	$453,800	8.4%	$6,133,700	54.6%
Discount rate 2%	$207,800	2.8%	$494,600	6.0%	$6,423,200	35.4%
Analysis period 30 years	$204,800	2.9%	$489,500	6.3%	$6,297,000	30.4%
Analysis period 45 years	$207,600	2.3%	$501,700	4.9%	$6,289,700	23.6%
Upfront costs +30%	$258,400	3.9%	$604,300	8.7%	$8,204,500	55.4%
Upfront costs -30%	$145,200	2.4%	$348,600	5.2%	$4,405,400	29.8%
Investment delay 2027	$164,200	1.1%	$384,400	2.6%	$5,186,500	35.0%
Investment delay 2032	$133,300	0.9%	$308,800	2.1%	$4,267,300	28.8%

Table 7: Summary of climate change sensitivity analysis results ($'000s)

Emissions scenario	PV of expected benefit* ($'000s)	Benefit threshold (%)		
		Option 1	Option 2	Option 3
Average	**$18,583.8**	1.1%	2.6%	33.9%
Low (RCP 2.6)	$14,803.3	**1.4%**	**3.2%**	**42.6%**
High (RCP 8.5)	$22,364.2	0.9%	2.1%	28.2%

*Note: *The expected benefit (avoided cost) of effective bushfire resilience, relief and recovery*

3.5 Detailed results

All costs and benefits have been calculated separately for Site A Community Centre and Site B Community Complex as upgrade costs are not necessarily equivalent where we have higher quality data. Table 8 details the results for both buildings under all options. The detailed analysis shows that the upgrades of the Site B Community Complex are more beneficial, even though they have higher costs. This is because the population of Site B is double that of Site A, and thus the benefits of the facilities are felt by a larger group. We discuss this in more detail in Section 3.6.1.

Table 8: Detailed CBA analysis results for each facility (4% discount rate)

	Option 1		Option 2		Option 3	
	Site B	Site A	Site B	Site A	Site B	Site A
Upfront costs - Total	**$103,900**	**$84,700**	**$222,700**	**$203,500**	**$3,517,300**	**$2,814,600**
Solar System	$19,200	$0	$57,700	$38,500	$0	$0
Battery	$21,600	$21,600	$64,900	$64,900	$0	$0
Electricity Grid	$19,200	$19,200	$19,200	$19,200	$0	$0
Structural performance	$14,400	$14,400	$14,400	$14,400	$0	$0
Thermal comfort	$0	$0	$19,200	$19,200	$0	$0
Rainwater tank	$10,200	$10,200	$10,200	$10,200	$0	$0
Disabled access review	$19,200	$19,200	$19,200	$19,200	$0	$0
Fire standard compliance upgrades	$0	$0	$17,800	$17,800	$0	$0
Redesign and rebuild	$0	$0	$0	$0	$3,517,300	$2,814,600
Ongoing costs - Total	**$20,000**	**$20,000**	**$38,600**	**$38,600**	**$0**	**$0**
Training and education	$3,700	$3,700	$18,600	$18,600	$0	$0

	Option 1		Option 2		Option 3	
Vegetation management	$0	$0	$3,600	$3,600	$0	$0
Internet	$16,300	$16,300	$16,300	$16,300	$0	$0
Avoided costs - electricity	**-$13,500**	**-$13,500**	**-$13,500**	**-$13,500**	**-$13,500**	**-$13,500**
Total PV costs	**$110,400**	**$91,200**	**$247,800**	**$228,600**	**$3,503,800**	**$2,801,100**
Expected benefit (avoided cost) of effective bushfire resilience, relief and recovery					**$11,793,800**	**$6,790,000**
Benefit threshold*	**0.9%**	**1.3%**	**2.1%**	**3.4%**	**29.7%**	**41.3%**

*The lower the threshold, the more likely the investment can be justified

3.6 Underlying assumptions

The following sections set out the major underlying assumptions applied to the analysis.

3.6.1 Natural disaster costs in [redacted] and Site A

To quantify the benefit of the Community Centre upgrades we have taken a two-step, top down approach, drawing on evidence compiled on the cost of natural disasters from Deloitte Access Economics (DEA) (2013) *Building our nation's resilience to natural disasters* and follow up reports (DEA 2015, 2015b, 2017 and 2021). The initial 2013 report estimates the average annual economic cost of Bushfires in Melbourne from 2013 to 2050. The more recent 2021 report builds on this previous analysis by factoring in more recent estimates of climate change on the future cost of natural disasters across Australia. The more recent study also applies more up to date data to estimate average annual damages and social costs associated with natural disasters. While the most recent report doesn't provide a clear estimation of the future cost of bushfires in Melbourne, it provides a strong indication of the likely range of costs. Drawing on this, we assess that the 2013 study reflects a low emissions scenario, where strong action is taken on climate change and global warming is limited to 1.7 degrees above pre-industrial levels. The more recent, 2021 study, provides estimates that are indicative of medium and high emissions scenarios.

The two-step approach is as follows:

1. **Estimate the average annual total economic of bushfires on the communities of Site B and Site A to create our base line natural disaster cost**. To do this we have used an average annual expected total economic cost of bushfires in the Melbourne fringe of $51 million in 2013 ($59.6 million in 2020 dollars) and $165 million in 2050 estimated by DAE (2015, 2015b). These figures give a low emission scenario baseline. We calculated a high emissions 2050 cost by extrapolating the low emissions 2050 cost by 69%, in line with the difference in future costs for bushfires by 2060 resulting from climate change presented in DAE (2021). We apportioned a share of those costs to the communities of Site B and Site A based on exposed populations in Site B and Site A to bushfires (based on populations subject to bushfire overlays) proportional to the population in Melbourne's urban fringe and peri-urban areas who are exposed to bushfires.

   The analysis suggests that the average annual expected cost of bushfire risks in Site B and Site A to be $1.7 million and $1.0 million in 2020, respectively. By 2050 the average annual expected cost could be between $5.5 million - $7.4 million in Site B and $3.2 - $4.2 million in Site A for low and high emission scenarios.

   It is important to note that annual average expected costs are probabilistic derived and do not reflect costs that would occur year on year. In reality, in most years, cost are likely to be low or zero, with substantial costs occurring in a small number of years when a significant bushfire occurs.

2. **Estimate how much resilience and relief and recovery measures can reduce natural disaster costs to generate the likely maximum benefits (avoided costs) of relief and recovery initiatives.** The DAE study suggests the annual reduction in bushfire costs from resilience, relief recovery is about 20% of the total

economic costs of bushfires. Applied to our analysis this equates to between $301,200 and $523,000 per year in 2022 growing to between $536,900 to $932,700 by 2042 in a low emission scenario. In a high emission scenario this equates to between $549,000 and $953,600 by 2042. Thus, the maximum potential reduction in bushfire costs that could be achieved through resilience and relief and recovery measures is $5.4 million in Site A (in present value terms) and $9.4 million in Site B over the 20-year analysis period in a low emission scenario. In a high emission scenario, the maximum potential reduction increases to $14.2 million (in present value terms) in Site B and $8.2 million in Site A for a 20 year analysis period using a 4% discount rate.

The threshold analysis then compared the size of the total investment, for each community, to the maximum likely reduction in bushfire risk from resilience and recovery measures. A judgement call is then required to determine if it is feasible that the investment would deliver the scale of benefit required.

3.6.2 Upfront and ongoing costs

The cost items detailed for Option 1 (facility upgrades) and Option 2 (building upgrades) are shown in Table 9. The table includes a summary of the per unit cost assumptions, a description of the line item and the source of assumptions where applicable. Quantity assumptions are used to apply costs between the two facilities. All costs that appear in Option 1 also appear in Option 2.

For the CBA we have used the replacement values of the buildings as an estimate of the costs associated with Option 3, redesigning and rebuilding the facilities to meet high bushfire safety, environmental and sustainability guidelines and standards (Table 10).

Table 9: Cost items included in the analysis

Line item	Unit	Value	Description and Source
Solar System	$/Kw	$1,333	• Based on cost estimates provided by Council • $20,000 for 15 KW solar system.
Battery	$/Kw	$1,000	• Estimate for solar size based on online calculators. • https://solarcalculator.com.au/battery-storage/size/
Electricity Grid	$/unit	$20,000	• Determining the electrical needs at the building and costs to provide • Adapted from: Shalekoff, A. (2021) Building Vulnerability Assessment (BVA) of Emergency Relief Centres, Example City Council, Final Report. Eastern Alliance for Greenhouse Action
Structural performance	$/unit	$15,000	• Check foundations, ground slab, window, door, roof, gutters and drainage system, floor, balcony and wall design, construction and structural condition. Identify actions , feasibility and costs to bring them up to requirements. • Adapted from: Shalekoff, A. (2021) Building Vulnerability Assessment (BVA) of Emergency Relief Centres, Example City Council, Final Report. Eastern Alliance for Greenhouse Action • Note high degree of uncertainty depending on upgrades required

Line item	Unit	Value	Description and Source
Thermal comfort	$/unit	$20,000	• Improve drought sealing and loss of heat • Adapted from: Shalekoff, A. (2021) *Building Vulnerability Assessment (BVA) of Emergency Relief Centres, Example City Council, Final Report*. Eastern Alliance for Greenhouse Action.
Rainwater tank	$/unit	$10,600	• Marsden Jacob estimate for an above ground steel tank based on quote from Heritage Water Tanks
Disabled access review	$/unit	$20,000	• Marsden Jacob estimate • Note high degree of uncertainty depending on upgrades required
Fire standard compliance upgrades	$/unit	$18,559	Deloitte Access Economics (DEA) (2013) *Building our nation's resilience to natural disasters*. Australian Business Roundtable for Disaster Resilience and Safer Communities.
Training and education	$/FTE	$100,000	• Marsden Jacob salary and on cost estimate • Scaled for the amount of time required for different training and education activities
Vegetation management	$/year/ facility	$267	Deloitte Access Economics (DEA) (2013) *Building our nation's resilience to natural disasters*. Australian Business Roundtable for Disaster Resilience and Safer Communities.
Internet	$/year/ facility	$1,200	Marsden Jacob estimate

Table 10: Redesign and rebuild costs

Facility	Insured value	Replacement cost
Site B Community Complex	$2,813,800	$3,657,940
Site A Community Centre	$2,251,700	$2,927,210

Source: Marsden Jacob Estimates

3.6.3 Avoided costs – electricity

The annual cost of electricity has been estimated using 6 months of electricity bill data from January 2018 to July 2018 for Site A Community Centre. We estimate the total bill to be in the order of $5,300 per year and assume the Site B Community Complex will have a similar energy bill.

The introduction of solar panels and energy efficiency measures under all options will lead to reductions in annual operating costs, specifically the electricity bill at both centres. We have conservatively estimated a total annual energy bill reduction of 20%.

4. Conclusions and next steps

4.1 Conclusions

Our conclusions from the CBA and threshold analysis are:

- **There is a strong case for implementing the Option 1 upgrades to both the Site B Community Complex and the Site A Community Centre, in the short term**. The low cost of the investment means relatively small benefits in terms of avoided costs of bushfires (and other natural disasters) would be required to justify the investment costs of the option. In other words, the upgrades to the facilities would not need to contribute much to the resilience, relief and recovery efforts towards natural disaster response to justify the outlays.
- **There is also a strong case for implementing Option 2, but further analysis could be worthwhile to better quantify the cost of the outlays.** Additionally, to better understand the potential benefits of outlays under this option, it might be useful to undertake stakeholder engagement to gauge how and how much the community values the Centres. This would create a qualitative and quantitative evidence base for the investments.
- **Upgrading the Site B Community Complex is more readily justified than upgrading the Site A Community Centre.** Since Site B services a larger population, the per unit upgrade costs are lower. The larger population also means only a marginal benefit is required for the annual bushfire cost, and in turn the reduction in costs associated with relief and recovery measures, to be net beneficial.
- **The evidence for implementing Option 3, involving a complete redesign and rebuild, is less clear**. Option 3 is unlikely to be justified in the short term. Consideration of whether the option should be instigated in the medium or long term, will rest on a number of factors including:
  - better understanding and quantifying the potential benefits that would result from implementing this option;
  - whether a suitable funding source could be secured; and
  - the useful life of the existing assets.
- **Climate change alone could increase the future cost of bushfires and other natural disasters by up to 50% depending on emissions reductions.** While this presents a somewhat alarming finding for the community and council, research has found that resilience measures are critical and can reduce the cost of natural disasters much more than the conservative 20% estimate used in this report. This research and the findings of this paper suggest the educational funding aspect of these options could be critical to ensuring the community can directly reduce the cost of natural disasters in [redacted].

4.2 Next steps

Notwithstanding the prima facie case for implementing either Option 1 or Option 2 in the short term, further analysis could be warranted in some areas before decisions are made on implementation. These include reviewing the financing available to undertake the facility upgrades and then consulting with the community stakeholders to better understand what values they derive from the facilities, both as relief and recovery centres during following disasters and on a day-to-day basis.

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