AMGC #35

PREFAB HOUSING SOLUTIONS FOR BUSHFIRE AND DISASTER RELIEF FINAL REPORT

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EXECUTIVE SUMMARY

The 2019-20 Australian bushfires destroyed over 5,900 buildings, including 2,779 homes, and killed at least 34 people. Numerous communities already devastated by the bushfires are now suffering further due to the health, economic and psychological impacts of the COVID-19 virus. Based on the experience from the recent disasters such as the 2019-20 Australian bushfires and Black Saturday, suitable temporary accommodation options and timely reconstruction are crucial to helping communities recover and thrive.

Unfortunately, the traditional model of re-building in Australia and other countries can be extremely slow and complex. One year after Black Saturday only around 100 homes had been rebuilt. Based on later Government surveys, it was estimated that 23% of homes had been rebuilt after two years and 44% after three years.

This study has investigated the potential for prefabrication and advanced manufacture to be an alternative to traditional construction in the provision of both short-term and long-term housing solutions for those affected by bushfires and other disasters. Through the research we have presented the complexities and barriers to designing, manufacturing and installing prefabricated modular homes and units to bushfire impacted regions around the country.

In particular the study has:

- Established a framework of objectives for a prefabricated housing solution for bushfire and disaster. The framework is characterised as a 'system' diagram, listing objectives within the prefab industrialised housing system as well as the wider whole system components at play. This diagram can be used as a conceptual tool when considering the development of new prefabricated housing solutions for this bushfire and disaster affected areas, establishing the specific 'settings' or components required.

- Created a Design Template Solution. This explores, proposes and tests the objectives to create a flexible 'kit of parts' or 'product platform' approach using different elements of the platform, from volumetric modular pods, to panel components, to traditional construction. In particular, this proposition presents and explores a product platform for immediate post-disaster housing that can be incrementally expanded to create a permanent home, addressing one of the critical gaps in current provision.

- Understanding the wider and complex contexts, scenarios and conditions that impact upon prefab housing solutions for bushfire and disaster affected areas in regard to finance, building regulation, land-use control, highway regulation, time and community. CRC #35 proposes a second stage of this project, engaging with industry, government and community partners to prototype and test the design.

CHAPTER 1

Introduction, background and methodology

Introduction

Climate change is influencing the volume and severity of extreme wildfire events globally, to the extent that they may become regularly experienced events for many countries. Australia's bushfire season of 2019/2020 in particular indicates this, and the ecological and human consequences of this season have been unprecedented. A total of 18,983,588 hectares were burned, 3,113 houses and 33 lives lost in the 15,344 bushfires in the Black Summer fires alone.

Recent studies of high-level trends in NSW and Victoria around the number of fires, burned area, houses lost, and the financial and environmental impacts supports the likelihood that for all these categories the values will continue in the future in these states.[1] Understanding these trends has established the overall need and rationale for this study, which is to consider the ways in which industrialised prefabricated housing solutions could address the loss of housing infrastructure across the spectrum of accommodation needs created by disaster events. In particular this includes from immediate emergency response accommodation, to recovery housing as well as long-term permanent rebuilding.

Background
Prefabricated construction (also known as off-site fabrication, modular construction or prefab) refers to the manufacture of buildings or other construction components in a workshop or a factory. Elements are then transported to the construction site, where they are incorporated and installed to create a completed building. The types of prefabricated construction methods (listed below) range from a high level of prefabrication (a complete building manufactured off-site) to a low level of prefabrication (where components are simply pre-cut or assembled off-site).

- Complete: Completed buildings delivered to a building site
- Modular: Volumetric, potentially fitted-out units delivered and joined together onsite
- Pods: Volumetric units connected to a structural frame onsite, such as bathroom or kitchen pods
- Panels: Structural, non-volumetric frame elements, such as timber/steel framed panels, structural insulated panels (SIPs) and precast concrete panels
- Component: Pre-cut, pre-assembled components, such as doors and trusses, which are unfeasible to produce on site.

Prefabrication in Australia
Australia's prefabrication industry is still relatively young and is currently dominated by integrated firms that operate using high levels of prefabrication, producing and installing modules and houses. In a recent study , a total of 83 firms were identified Australia-wide as manufacturing and delivering prefabricated volumetric structures to end users. Although they use varying terminology, their processes typically involved prefabricated houses transported to the building site by road either as a whole unit or as a series of between two and four large modules ultimately joined together on site to form a single dwelling. These suppliers offer a range of upper mid-market premium homes (Habitech or Ecoliv) as well as some more affordable options (Anchor Homes).

Prefabricated construction is increasingly attracting attention in the market for its benefits, from speed of construction and labour savings, to waste reduction and energy saving. Yet despite these benefits, and the volume of firms involved in the sector, prefabrication is estimated to account for less than 5% of Australia's $150 billion building and construction industry. There are a range of complex reasons for this. Affordability benefits are more varied in Australia, where a small market makes economies of scale harder to achieve, and increased costs of production often outweigh any labour-saving economies. Also, Australia's focus on modular forms of production may be one potential reason for the current low uptake. This is because modular construction has higher levels of 'novelty' which can clash with existing systems. The housing industry in particular is a 'complex product system' that employs site-based construction methods. Prefabricated housing is a promising way of producing housing in factories, but it represents a more disruptive innovation to the current system. Less sophisticated prefabricated products, such as panel systems are less disruptive than more elaborate products such as modules and pods and this explains their greater uptake.

There are also wider issues that present challenges for prefabrication related to the provision of housing. Housing affordability, for example, is now commonly referred to as a 'wicked' problem meaning that it is dynamic, contingent, interdependent and constantly changing.[2] Industrialised platforms of manufacture usually rely on significant standardisation, and the products, even those with higher levels of customisation, rely on broad similarities. In contrast, housing is sited in diverse contexts subject to a myriad of quite specific regulatory, climatic, cultural, supply and market differences. Trying to create a standard solution is prone to failure, and loose fit approaches tend to be more common . In this sense, "conceptualizing ventures in industrialized housing is an exercise in diversity, not similarity".[3] Of course this means that prefabricated housing solutions are difficult to transfer between places, and between contexts. As Aitchison states:

> *Each prefab company embarks on a venture with a series of 'settings' in place, some of which may be the givens of a particular circumstance, others simply arbitrary. Settings may be implicit or explicit, known or unknown, but they are ever present. These could include the target market, or the location, the techniques and materials to be used in fabricating the parts, the business model, the cost structure, the mode of sales and distribution or planning and land-use issues, to name a few. These myriad settings provide the scaffolding within which the company is built.*[4]

What is clear is that the broader barriers to prefabrication in housing need to be considered in this study as a context for establishing potential. Since the particularities of housing, especially in post-bushfire and disaster contexts present a very specific problem with a very particular series of 'settings', establishing the settings that are needed for prefabricated housing in bushfire and disaster affected areas will be an important goal for this study.

Prefabricated Housing in bushfire-affected areas
The devastating 2019/20 bushfire season has highlighted the critical role that prefabricated construction could play in the post-disaster rebuilding process, providing timely short-term, and potentially long-term, solutions. As a recent Feasibility Report by PrefabAus states:

> *Prefabricated construction has the proven potential to reduce the time required to deliver housing solutions, business premises, and community infrastructure. A variety of prefab solutions can be utilised to support the bushfire rebuilding process, including temporary shelters and permanent buildings. Temporary shelters may be provided within a matter of days as immediate disaster relief. In this scenario, the flexible nature of prefab construction allows for additional modules to be easily added over time, or decommissioned, as required.*[5]

The benefits of response time in the provision of housing are critical for communities affected by disasters and might point to prefabrication as an obvious answer. But there are broader contextual challenges to the provision of recovery housing that have emerged through experiences in recent bushfire history.

The Bushfire Homes Service, initiated by Victorian Government Architect together with the AIA, was an initiative designed to coordinate the efforts of volunteer architects after the 2009 Fires. An evaluation in 2014 identified that the service had experienced a poor take-up for a range of reasons including the fact that people were simply not ready to rebuild; that the concept of using architects was alien to their way of thinking; that designs were a challenge to existing housing which was more traditional; and that residents were seeking comfort in the familiar. Not least, it was observed that residents saw themselves as agents of the rebuilding, and that participation was critical. The designs offered by the service were progressive, but they were not necessarily what people had in mind. Not least, in the context of cost and affordability, many of the house designs were beyond the reach of residents. Though these reflections are made in relation to template designs provided for traditional forms of housing construction delivery, many parallels can be drawn in respect to prefabricated models of housing, which are often similarly progressive in design terms, not flexible for adaptation, and which arrive ready-made on site.

According to those reporting on the lived experience of bushfire recovery, particularly via community-led recovery organisations in Mallacoota like MADRA (Mallacoota and District Recovery Association), housing supply is completely out of balance with housing need. This relates not just to home ownership, but also to rental supply for those people who are not fortunate enough to have been land and home owners. Over two years later in Mallacoota some 30 families are still in need of replacement rental accommodation, and there are currently no systemic solutions offered by government authorities to increase stocks of rental or public housing in areas of bushfire recovery. There are complex needs for communities in both the provision of immediate short-term accommodation, as well as the transition to longer-term rebuilt solutions. The scenario of short-to-long-term housing is subject to a range of practical and regulatory difficulties caused by planning and building permits, bushfire overlay regulations and costs, and not least the shortage of tradespeople and construction services in bushfire affected areas.

In relation to the technical and material opportunities of prefabrication in bushfire recovery settings, the bushfire policy and building regulations that have emerged since 2009 (specifically Australian Standard 3959) can certainly be satisfied effectively in prefabrication. Supported by advanced manufacturing processes, prefabricated construction can enable better building performance against bushfires via R&D, product design, and utilising the latest fire-resistant and fire-retardant materials, making it able to achieve the highest fire safety ratings. However, approaching the provision of homes in bushfire affected locations through the technical performance of built fabric alone is problematic.

Geoff Hanmer has argued in relation to the Standard 3959:

> *Although this Standard is designed to improve the performance of buildings when subjected to bushfire attack in designated bushfire-prone areas, there can be no guarantee that a building will survive a bushfire event on every occasion. This is substantially due to the unpredictable nature and behaviour of fire and extreme weather conditions.*[6]

If there is no such thing as a 'bushfire-proof house' it is clear that a focus on broader objectives including site location strategy, vegetation and fuel load, evacuation protocols, and protective shelter or bunker provision may need as much attention as the final fire-resistant performance of the housing product.

This broader approach is also evident in the Royal Commission Report (2020). In 'Principles of Resilience' (Point 55) the report's findings conclude that there needs to be a fundamental shift in strategic thinking about national natural disaster management, encapsulated by the word 'resilience':

> *To think broadly about how to make the nation more resilient to natural disasters is to think about all of the different hazards we might face, all of the complex consequences of natural disasters, and all of the interrelated policy measures necessary to mitigate, prepare for, respond to, and recover from disasters. A narrow focus on response and recovery will leave Australia vulnerable.*[7]

A 'resilience' approach to bushfire is certainly an argument for the development of prefabricated bushfire housing models, including robust product-supply chain systems which are available and ready to be deployed for future events. But it is also an argument for consideration of land-use planning approaches, which necessitates a broader understanding of the location and vulnerability to bushfire attack and defence, and whether to rebuild in areas of high vulnerability.

Beyond land-use planning lie even more complex systemic aspects to consider including finance and insurance issues. Access to finance for prefabricated products sits outside conventional forms of borrowing, and affordable access to insurance for new homes is often impossible. Not least, framing recovery through rebuilding only addresses the tip of the iceberg. The problem of existing home rebuilds and upgrades are significant.

The Bushfire Building Council has noted that 90% of buildings in bushfire-prone areas were built before bushfire planning and construction regulations came in, and therefore up to one million homes in bushfire-prone areas have little or no fire protection; in some cases it would be cheaper to knock down and rebuild them than upgrade them.

Methodology

Structure

Set against these complex contexts, this study intends to investigate the potential for prefabrication and advanced manufacture to be an alternative to traditional construction in the provision of both short-term and long-term housing solutions, and also through the provision of interconnected 'short-to-long-term' solutions - for those affected by bushfires. The initial focus has been to understand the complexities and barriers to using prefabricated modular homes and units in bushfire impacted regions around the country, through:

- A review of existing case study housing provision
- A review of the relevant transport and assembly approaches
- A review of the relevant policy and regulatory frameworks.

The approach of the review stage has been to begin to establish some of the 'settings' that are at play when providing housing in these contexts, understanding that "industrialized housing is not merely a technological system but a total system" (Herbert 1984 p321). What is clear from the outset is that the components of this system are extremely diverse and wide-ranging from:

- the short-term needs of post-disaster emergency shelter to the long-term needs of rebuilding and reconstruction of home
- from the challenges of site location and the difficulties of logistics, to supply chain and transportation to remote and mountainous areas
- from the technical, material and energy specification of fire-resistant or resilient forms of construction to the regulatory constraints
- from the economic and financial aspects of recovery for individual householders to the social and cultural dimensions of recovery including the formal and aesthetic preferences for new housing form and functionality, and the desire for agency and participation by those affected in the process of rebuilding.

Through identifying these critical 'settings'- via reference to existing precedent projects and scenarios - the review stage is intended to provide a brief or 'framework of objectives' for the second stage of the project, creating a set of designs and template designs.

The design templates will serve as a means of demonstrating the important, and complementary role, prefab construction can play in the timely provision of more liveable temporary family accommodation solutions at scale; and in rapidly rebuilding sustainable, high-quality and fire-safety compliant permanent homes, businesses and much needed community infrastructure.

Research Methodology
The methodology of this study to enable knowledge production via design research. The knowledge produced in this study is less about 'new knowledge' than the combination of existing knowledge in new and perhaps more productive ways. In particular, by engaging trans-disciplinary knowledge more holistically across the architecture and engineering disciplines we aim for useful learnings and design outcomes for real-word application in industrialised housing production.

Design research will be the predominant methodology, and is well suited to the topic because it is integrative and iterative in nature, with the capacity to synthesize a range of incongruous and even conflicting inputs and still generate a solution. We will employ a range of design research techniques including:

- precedent analysis
- problem solving through design, and
- design prototyping.

As such we will adopt a hybrid method which can accommodate variation and diverse inputs. In summary the methodological process for this project will be to:

- Identify, through review, all the parts of the system that come to bear on housing needs for bushfire and disaster affected regions
- Determine the various 'settings' or 'objectives' or 'ends' for each of these parts – to satisfy the needs identified
- Develop or design possible solutions for the parts of the system, integrating these with the goal of creating a 'scenario' approach.

Endnotes

1 Alexander I. Filkov, Tuan Ngo, Stuart Matthews , Simeon Telfer , Trent D. Penman (2020) 'Impact of Australia's catastrophic 2019/20 bushfire season on communities and environment. Retrospective analysis and current trends' in Journal of Safety Science and Resilience 1 (2020) 44–56

2 Adams, D. (2011) The 'wicked problem' of planning for housing development in the UK. Housing Studies, 26(6), pp. 951-960.

3 Aitchison, M., et al. (2018). Prefab Housing and the Future of Building: Product to Process. Lund Humphries.

4 ibid, p56.

5 AMGC Prefab Innovation Hub Feasibility, p. 8

6 Geoff Hanmer, 'Building Standards give us false hope', The Conversation, January 2020

7 The Royal Commission into National Natural Disaster Arrangements, Commission Report, October 2020

CHAPTER 2

A Review of Existing Designs of Prefab Housing for Bushfire Relief

Introduction

This chapter represents the outcome of Project #35 Work Package 1 - A review of existing designs of prefab housing for bushfire relief. Work package 1 analysed existing literature and precedent projects for prefabricated (prefab) housing and disaster relief accommodation, with a particular focus on the Australian context. In order to facilitate a broader understanding, the analysis is not only framed within the more common contexts of construction methods, material products and functional and design performance but has been expanded to include the social, economic and regulatory processes surrounding prefabricated housing as well as on-site delivery and implementation. The reasoning is that this expanded framing of the project will help deliver a relevant and applicable response that considers not just the design and construction of prefab housing units but the environmental, economic and cultural contexts in which the housing will be commissioned, procured and used and experienced. This chapter comprises the following sections:

- Introduction
- Methodology
- Analysis and Content
- Recommendations
- Appendix and References.

Methodology

This work package uses the methods of a literature review as well as a case study comparative review, firstly through cataloguing and secondly through the development of an analytical methodology for assessment and comparison. The consideration of literature and precedents is crucial to help understand the existing framework for the project including: the number of specific examples currently available and types of industry/practice which has developed them; whether they tend to be speculative, one-off built, and or implemented more extensively. As Matthew Aitchison states: "Precedents, like prototypes and MVPs, have the power to demonstrate the successful resolution of multiple criteria and trade-offs in a tangible way. They are proxy resolutions that are transportable and graspable".[1]

Literature Review and Overview
A literature review has been undertaken of existing academic papers, journals, newspaper articles and other sources. This review has considered prefab housing across a number of areas including architecture, building technology, building standards, social and community involvement, planning and policy, indigenous knowledge and practices and insurance. See Appendix 01 for full review.

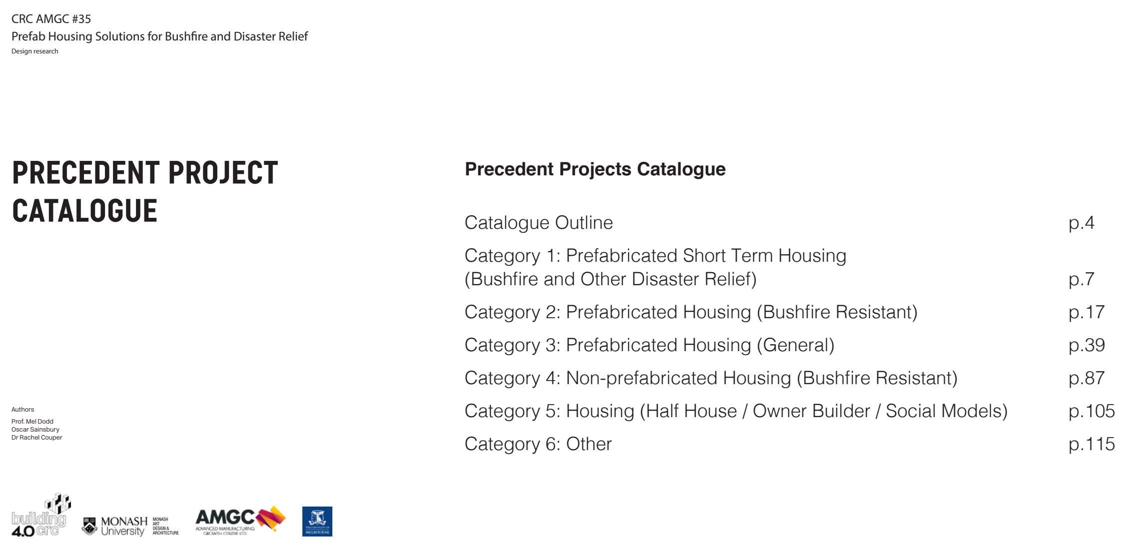
Precedent Project Review
A review has been undertaken of existing prefab housing projects, considering the design, construction and delivery methods with a particular consideration of those communities affected by bushfires. More broadly the review has considered housing (both prefab and non-prefab) from a range of scenarios in the aim of gathering a deeper understanding of the opportunities for the project. Projects were sourced from books, journal and academic articles, magazines, newspaper, online media and existing knowledge from the research team.

The geographical scope of inclusion was global but particular focus was given to Australian projects that are responding to the local environmental context, existing regulatory framework and extent of the construction industry capacity. Projects that lack applicable learnings for the framework and deliverables of the research project were excluded. Once a series of projects had been selected, categories were established in which the projects were located. These categories were refined as more projects were included.

Analysis and Content

Cataloguing of Precedent Projects
The selected precedent projects have been catalogued into a series of categories for evaluation and analysis (figure 1). This serves as a way of understanding the commonalities and differences of the various projects under consideration. Projects were categorized through a number of factors;

- Type. Are they a permanent house, short term housing, community building?
- Method of construction. Are they prefabricated, traditional construction or owner builder?
- Relationship to bushfire. Are they constructed as a response to bushfire prone context?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Prefab Housing Solutions for Bushfire and Disaster Relief
Design research

PRECEDENT PROJECT CATALOGUE

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Precedent Projects Catalogue

Figure 1: Precedent catalogue

For the purpose of this research project prefabricated was defined as modular, panel or kit of parts and bushfire resistant was defined as projects with a BAL rating of BAL 40 or BAL FZ. Projects with a BAL rating of BAL 29, BAL, 19 or BAL 12 were categorized as general housing.

Catalogue Content and Information
The catalogue uses consistent content and information to represent each project (figure 2). The project name, architect, location and date introduce the case study and a project summary from the architect / builder is shown alongside architectural drawings such as plans, elevations and sections as well as photographs. Additionally, a table describes in more detail the key project information, including:

- Built / Unbuilt – whether the project has been built and if so, how many
- Architect / Designer – who was the architect or designer
- Construction Company – who was the architect or designer
- Manufacture – was the project manufactured using modules, panels or a kit of parts
- Assembly – was the project assembled in a factory, on site or a mix of both
- Structure – what is the main structural system
- Materials – what are the main materials
- Transport Requirements – what are the transportation requirements
- Onsite Lift Requirements – what are the onsite lifting requirements
- BAL Rating – what is the BAL rating if applicable
- SQM – what is the square meter area of the project
- Cost – what was the project cost (either sqm rate or total)
- Construction Time – what was the construction time.

Catalogue Contents

Category 1: Prefabricated Short-Term Housing (Bushfire and Other Disaster Relief)
Projects in this category, while not bushfire resistant, are used as temporary housing for people affected by bushfire and other disasters such as flood, tsunami and earthquake. The small size of the units allows them to be transported to a variety of sites meaning people can continue living on their land even after their home has been damaged or destroyed. While the accommodation may be connected to mains services, it is not seen as a permanent house and in some cases, there is a time limit associated with its use.

Category 2: Prefabricated Housing (Bushfire Resistant)
This category contains prefabricated permanent housing built with bushfire resistance that reaches the two highest levels of resistance in Australia being BAL FZ and BAL 40. The types of prefabrication include: modular construction where the complete house is constructed off site and then delivered to site in modules as a finished product, prefabricated panels which is defined by panels being a structural element, as well as component or 'kit of parts' construction where various elements are prefabricated off site and then delivered for assembly and completion on site. Some projects are a combination of these three categories. Different structural and material systems are also investigated through these projects including lightweight timber frame, steel and aluminium structures, SIPS (structurally insulated panel systems) and CLT (cross laminated timber).

Category 1: Prefabricated Short Term Housing (Bushfire / Disaster Relief)
Short-Term Modular Housing
Bushfire Recovery Victoria (BRV)
Various, Victoria, 2020 - 2022

1, 2, 3 bed plans

project images

Project Information

Built / Unbuilt:	Built (multiple)	Onsite Lifting Req:	Med-heavy capacity crane (10-30T)
Architect / Designer:	BRV	Transport Req:	Semi-trailer oversized; 3.5+m width restriction (4.3m)
Construction Company:	Ausco and Modular System		
Manufacture Type:	Modular	BAL Rating:	BAL 29
Assembly Process:	Factory	SQM	32 sqm
Structure:	Timber frame	Cost (per sqm):	unknown
Materials:	Cement cladding, metal windows	Construction Time:	12 - 24 hrs for site preparation and assembly

Project Summary (from BRV)

Short-term modular housing is an option available for a number of families who lost their primary place of residence in the 2019/20 Victorian Bushfires.

The housing will be delivered to your property, or another location as agreed by authorities, property owners and the resident. You will be able to live in these homes for a period of up to three years while you progress your permanent rebuild. Short-term modular housing is a 'bridge' between accommodation provide in the weeks and months after the fires, and the long-term rebuild of your home.

Everyone who lost their primary place of residence in the bushfires can access emergency accomodation by contacting the Victorian Bushfires Case Support Program.

8 9

Figure 2: Precedent analysis

Category 3: Prefabricated Housing (General)
Projects in this category range from guest accommodation suites, off-grid cabins to permanent housing but are distinguished from Category 1 as they are not occupied on a short-term basis. The types of prefabrication, structural and material systems are the same as listed in Category 2 but these projects are more general in their focus and only achieve a lower level of bushfire resistance being BAL 12.5, BAL 19 or BAL 29.

Category 4: Non-Prefabricated Housing (Bushfire Resistant)
This category contains permanent houses that have been designed and constructed to respond directly environments affected by bushfire. The response may be different depending on the site conditions, regulatory requirements and client needs but each project has a direct relationship with bushfire through their site access, structural systems and material use.

Category 5: Housing (Half-house / Owner Builder / Social Models)
These projects may be individual houses but are often multi-residential developments where a number of houses are constructed simultaneously. These projects are defined by the involvement of the client and broader community in both the design and construction process. These projects also show a more flexible approach to construction timing giving owners the option to build the project in stages depending on their financial, spatial and emotional needs.

Category 6: Other
This category contains projects that don't easily fit in the proceeding five categories. Rather than housing they may be projects such as community buildings, tourist accommodation or infrastructures, yet still contain learnings or examples of value – such as prefabricated construction techniques, minimal accommodation requirements or a particular relationship to bushfire conditions and environments.

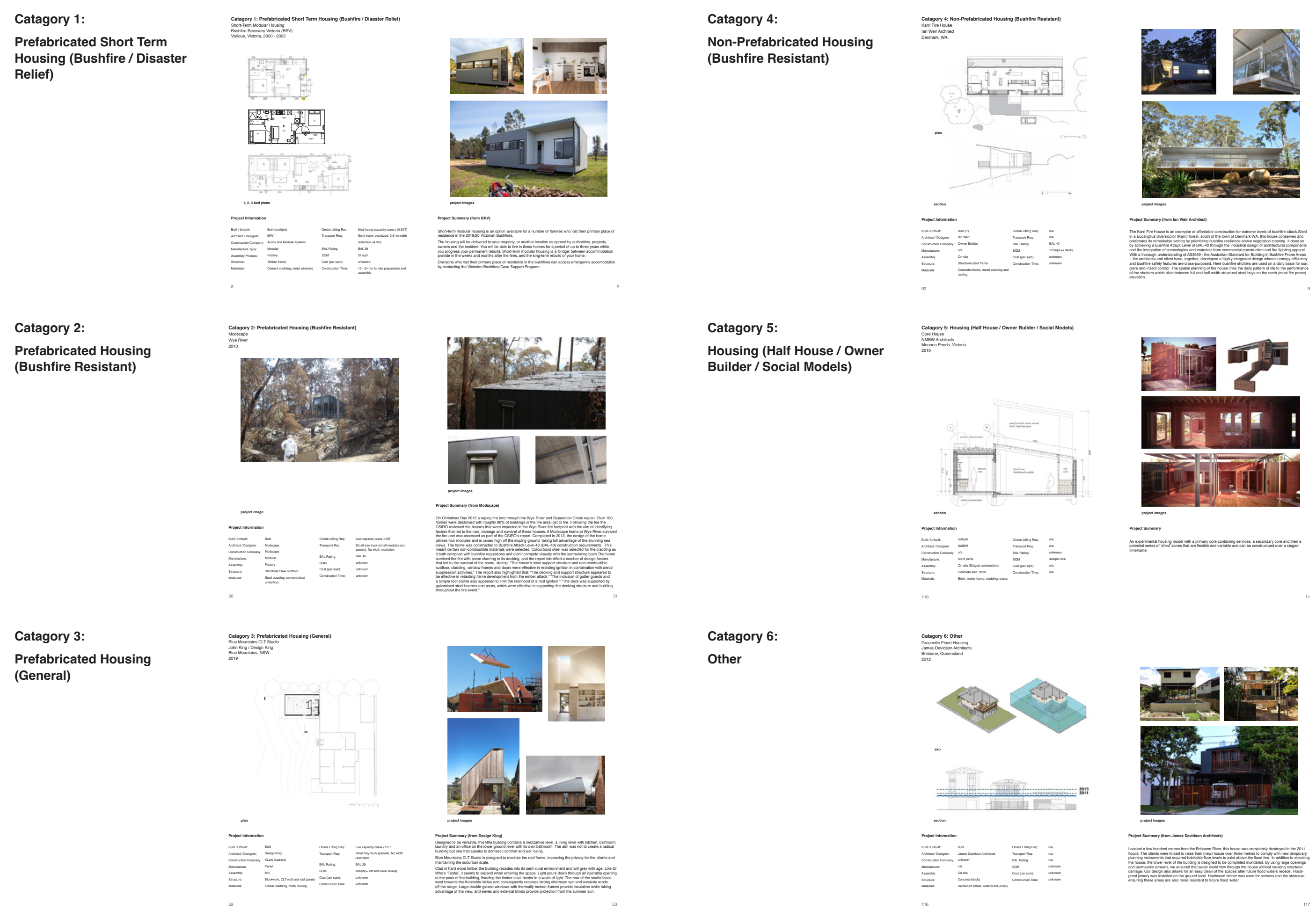

Figure 3: Precedent Catalogue categories

Evaluation Framework Table
Once the initial catalogue stage was completed, the precedent projects were assessed using an evaluation framework (Appendix 03). This framework allowed a consistent analysis of the projects, both individually and as a group within their categories. It's important to note that the catalogue is an ongoing document and further examples have been added as the project has progressed, however these later examples are not represented in the evaluation framework and analysis. The evaluation criteria were framed around four key themes that each contained eight questions (figure 4). Projects were scored with a 0,1 or 2 for each question based on whether the project contained the element, or engaged with the idea in question. 0 = no, 1 = some, 2 = high. The key themes are as follows:

Theme 1: Prefabricated Construction Methods.
- Prefab: Modular
- Prefab: Panel
- Prefab: Flatpack/Kit of Parts
- Fast Construction
- Available Trade Team
- Self-Build
- Utilises existing and available materials
- Ease of Delivery

Theme 2: Response to Social, Economic and Regulatory Process.
- Bushfire Specific Design / Project
- Disaster Relief Specific / Project
- Addresses Housing Regulations or Codes
- Addresses Infrastructure/Services
- Affordable/Economical
- Addresses Finance and Tenure
- Flexible Procurement and Delivery Approaches
- Responds to Neighbourhood Character

Theme 3: On Site Delivery and Implementation.
- Immediate Response
- Long-term House (as well as transition housing)
- Permanent (as well as temporary)
- Social Engagement in Design Process
- Social Engagement in Construction Process
- Site Specific Design
- Fast on-site installation
- Built Project

Theme 4: Design, Program and Performance.
- Flexible Spatial Design
- Flexible Site Response
- Threshold / Outdoor Spaces
- Bedrooms
- Environmentally Sustainable Services
- Orientation / Access to solar gain
- Cross Ventilation / Shading (0- none, 1 - either, 2-both)
- Shed / Storage.

Analysis of Projects Through the Evaluation Framework
The evaluation framework allowed for a maximum score of 64 points (4 themes x 8 questions x 2 points). The results show that 13 projects scored between 40 - 50 points and 1 additional project scored above 50 points. From the 14 projects that scored over 40 points, 5 came from Category 2: Prefabricated Housing (Bushfire Resistant), 4 from Category 3: Prefabricated Housing (General), 4 from Category 5: Housing (Half-house / Owner Builder / Social Models) and 1 from Category 6: Other. Of note, every project from Category 5 scored over 40 and was represented consistently across the 4 themes.

When considering the distribution of scores across the themes, the highest score was Theme 4: Design, Program and Performance (498 points) followed by Theme 1: Prefabricated Construction Methods (396 points) and Theme 2: Response to Social, Economic and Regulatory Process. (399 points) which scored similar numbers, while Theme 3: On Site Delivery and Implementation (352 points) was the lowest score. This result justifies the project's expanded framing from the more common contexts of construction methods and quality of design to include the social, economic and regulatory process as well as on-site delivery and implementation.

Certain questions across all the themes had low scores. Each of the eight questions within the four themes had the possibility of scoring 92 points (46 projects x 2 points per question). Of the 32 questions, 25 scored above 46 points (50%) and 7 scored below. The 7 are as follows:

- Prefab: Flatpack/Kit of Parts (16/92)
- Prefab: Panel (11/92)
- Self Build (31 / 92)
- Disaster Relief Specific Design / Project (15/92)
- Immediate Response (27/92)
- Social Engagement in Design Process (28/92)
- Social Engagement in Construction Process (25/92).

These 7 lowest scoring questions could be summarised in three areas: prefabricated projects that require on site installation (kit of parts / panels) or self-build, projects that have provision for immediate response and disaster relief and projects that require broader social engagement in the design and construction process. This suggests that future projects need more flexibility for 'on-site' engagement and construction as well as flexibility for immediate responses to bushfire and other disaster relief.

EVALUATION CRITERIA	Element / Idea	Evaluation
Prefabricated Construction Methods	Prefab: Modular	Finished product delivered to site
	Prefab: Flatpack/Kit of Parts	Various components delivered for site for installation
	Prefab: Panel	Finish structural panels delivered to site for installation
	Fast Construction	Fast construction or premade and ready for delivery
	Available Trade Team	Work required for manufacturing can be achieved efficiently by small number of trades
	Self-Build	Good self-build potential
	Utilises existing and available materials	All materials locally accessible (Bunnings)
	Ease of Delivery	Ease of Delivery - truck size allows access to all areas.
Response to Social, Economic and Regulatory Context	Bushfire Specific Design / Project	Incorporates Bushfire requirements within broader design
	Disaster Relief Specific / Project	Designed / Built for specific disasters
	Addresses Housing Regulations or Codes	Addresses broader planning codes and other regulations for permanent housing
	Addresses Infrastructure/Services	Plumbing / electrical services etc. already included - only connection required to existing services. Option to be off-grid.
	Affordable/Economical	Design is a cost-effective response to brief
	Addresses Finance and Tenure	Is there are clear plan (and multiple options) for finance and delivery of the model. (eg. Government funding, rent to buy, insurance, different options for different budgets)
	Flexible Procurement and Delivery Approaches	Development Model can be finished or part built.
	Responds to Neighbourhood Character	Design responds to existing built fabric in urban (AND REGIONAL) environments
Site Implementation and Engagement	Immediate Response	Available for immediate delivery
	Long Term House (as well as transition housing)	Could be used as a long-term housing solution as well as transition housing
	Permanent (as well as temporary)	Could be used as a permanent housing solution as well as temporary accommodation
	Social Engagement in Design Process	Local community can be involved in the design process
	Social Engagement in Construction Process	Local community can be involved in the construction process
	Site Specific Design	Design has a variety of footing / slab systems that can respond to specific site conditions
	Fast on site installation	Can be installed fast on site
	Built Project	Design has been built (1) Multiple Examples (2)
Design, Program and Performance	Flexible Spatial Design	Design has flexible spatial arrangements to accommodate a variety of uses over time
	Flexible Site Response	Design can be flexible to accommodate a variety of sites and locations (eg orientations for views and sunlight / response to particular weather patterns)
	Threshold / Outdoor Spaces	Design contains verandas, decks, courtyards, external covered areas or other outdoor spaces
	Bedrooms	Design can flexibly accommodate 1,2,3 bedroom or sleeping configurations (single, shared and family options)
	Environmental Sustainable Services	On site water collection and use. Provision for solar panels. Potential off-grid services.
	Orientation / Access to solar gain	Position and orientation of a dwelling allows for thermal comfort and energy efficiency
	Cross Ventilation / Shading (0- none, 1 - either, 2-both)	Windows / openings on two sides of a room to allow good cross- ventilation / Appropriate thermal mass and adequate shading from the direct sun on the east and west sides.

Figure 4: Precedent evaluation criteria

Outcomes and Deliverables

Deliverable 01 - Catalogue of Precedent Projects
See appendix

Deliverable 02 - Evaluation Framework and Results
See appendix

Recommendations

Based on the review of literature and precedent projects, the cataloguing of precedent projects into relevant categories and the analysis of projects through the evaluation framework, a selection of case studies to further analyse for Work Package 4 was recommended. This selection was made based on the above methods and also by ensuring a representation through the various catalogue categories, as well as using local (Australian) examples where possible to best understand the conditions for housing within Australia. We analysed the selected case studies from an engineering perspective with a particular focus on the structural, performance, fire rating, sustainability, transport, logistics and financial elements.

Case Study Selection
Short-Term Modular Housing. Bushfire Recovery Victoria (Category 1)
Camera Botanica. Ian Weir Architect (Category 2)
Wye River House. Modscape (Category 2)
EcoShelta. Steven Sainsbury Architect (Category 3)
Blue Mountains CLT Studio. Design King (Category 3)
Karri Fire House. Ian Weir Architect (Category 4)
Core House. NMBW Architects (Category 5)

In summary, when looking at the Evaluation Framework scores category by category we have observed that Category 3 - Site Implementation and Engagement is typically the lowest score (except in Half House / Social Models). In addition, Category 4 - Design, Program, Performance is typically the highest scoring category (except in Short-Term Housing). This reinforces the notion that prefab housing models often focus on the design and functional aspects to create 'products' that appeal to the market. The exception being the 'emergency' models which dispense with design quality in favour of constructional logistics. This suggests that design flexibility and an incremental approach to construction is a gap in the current prefab housing market. The review of case studies therefore recommends considering a focus on a design which can achieve a high-quality design outcome in design, construction and occupation with a staged approach across the 'short-term to long-term'.

Appendix

01 - Catalogue of Precedent Projects (full catalogue at end of report)
02 - Evaluation Framework
03 - Catalogue of Precedent Literature

Endnotes

1 Aitchison, M, et al. *Prefab Housing and the Future of Building: Product to Process*, Lund Humphies 2018, p106.

Appendix

01 - Catalogue of Precedent Projects (full catalogue at end of report)

CRC AMGC #35

Prefab Housing Solutions for Bushfire and Disaster Relief

Design research

PRECEDENT PROJECT CATALOGUE

Authors

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Appendix

02 - Evaluation Framework

PROJECT #35 CASE STUDY MAPPING	International	Australia (State if applicable)	Summary Description of Project	Prefab: Modular	Prefab: Flatpack/Kit of Parts	Prefab: Panel	Fast Construction	Available Trade Team	Self Build	Utilises existing and available materials	Ease of Delivery	Bushfire Specific Design / Project	Disaster Relief Specific Design / Project	Addresses Housing Regulations or Codes	Addresses Infrastructure/Services	Affordable/Economical	Addresses Finance and Tenure	Flexible Procurement and Delivery Approaches	Responds to Neighbourhood Character	Immediate Response	Long Term House (as well as transition housing)	Permanent (as well as temporary)	Social Engagement in Design Process	Social Engagement in Construction Process	Site Specific Design	Fast on site installation	Built Project	Flexible Spatial Design	Flexible Site Response	Threshold / Outdoor Spaces	Bedrooms	Environmental Sustainable Services	Orientation / Access to solar gain	Cross Ventilation / Shading	Shed / Storage	Overall Score	Score (Construction) (WP1 & WP2)	Score (Context) (WP1, WP2 & WP3)	Score (Site) (WP1, WP2 & WP3)	Score (Architectural) (WP1 & WP3)	Evaluation Notes
				Prefabricated Construction Methods								Response to Social, Economic and Regulatory Context								Site Implementation and Engagement								Design, Program and Performance													
Prefabricated Short Term Housing (Bushfire / Other Disaster Relief)																																									
Short-Term Modular Housing. Bushfire Recovery Victoria		VIC		2	0	0	2	2	0	2	1	1	1	0	1	2	2	1	0	2	0	0	0	0	1	2	2	1	1	1	2	1	1	1	1	33	9	8	7	9	
Temporary Accommodation Pods. Minderoo Foundation				2	0	0	2	1	0	1	2	0	2	0	2	2	2	0	0	2	0	0	1	0	0	2	2	0	1	1	1	2	1	1	0	30	8	8	7	7	
Disaster Relief Housing. Sam Crawford Architects.	Indonesia			0	2	0	1	2	2	2	2	0	2	0	1	2	1	1	1	2	0	0	1	1	1	2	1	1	2	1	1	1	1	1	0	35	11	8	8	8	
																																					28	**24**	**22**	**24**	
																																					9.33	**8**	**7.33**	**8**	Score (averaged per project #)
Prefabricated Housing (Bushfire Resistant)																																									
Tucker House. Arkit		VIC		2	0	0	1	2	0	2	1	2	0	2	1	1	2	1	1	0	1	1	0	0	1	2	1	1	1	2	2	1	1	1	1	34	8	10	6	10	
Make Remake. Arkit		VIC		2	0	0	1	2	0	2	1	2	0	2	1	1	2	1	1	0	1	1	0	0	1	2	1	1	1	2	2	1	1	1	1	34	8	10	6	10	
Bushfire Proof House. Built by Joost		VIC		1	1	0	1	1	2	2	1	2	0	2	2	1	1	2	1	0	1	1	2	2	1	1	1	1	1	2	2	2	2	2	1	42	9	11	9	13	
Monbulk House. Built by Joost		VIC		1	1	0	1	1	2	2	1	2	0	2	2	1	1	2	1	0	1	1	2	2	1	1	1	1	1	2	2	2	2	2	1	42	9	11	9	13	
Camera Botanica. Ian Weir Architect		WA		1	1	0	1	2	2	2	2	2	0	1	2	2	1	2	2	1	1	1	2	2	2	1	1	1	2	1	1	2	1	2	1	45	11	12	11	11	
Wye River House. Modscape		VIC		2	0	0	2	2	0	2	1	2	0	2	1	1	2	1	1	0	1	1	0	0	1	2	1	1	1	2	2	1	1	1	1	35	9	10	6	10	
Daylesford House. Prebuilt		VIC		2	0	0	2	2	0	2	2	2	0	2	1	1	1	1	1	0	1	1	0	0	1	2	1	1	1	2	2	1	2	2	1	37	10	9	6	12	
House 28. Studio Edwards		VIC		2	0	0	2	1	1	2	2	2	1	2	1	2	2	2	1	1	2	2	1	1	1	2	1	1	2	1	1	1	1	1	1	43	10	13	11	9	
FZ House. Archiblox		AU		2	0	0	1	2	0	2	1	2	0	1	1	1	1	1	1	0	1	1	0	0	1	2	0	1	1	1	2	1	1	1	1	30	8	8	5	9	
																																					82	**94**	**69**	**97**	
																																					9.11	**10.44**	**7.66**	**10.77**	Score (averaged per project #)
Prefabricated Housing (General)																																									
Marysville. Anchor Homes		NSW		2	0	0	2	2	0	2	1	1	0	2	1	1	1	0	1	0	1	1	0	0	1	2	1	1	1	1	2	1	1	1	1	31	9	7	6	9	
Hunter Valley. Blok Modular		NSW		2	0	0	2	2	0	2	2	1	0	1	1	1	1	1	1	0	1	1	0	0	1	2	1	1	1	1	1	1	1	1	0	30	10	7	6	7	
Adaptable Living. Breathe Architects / Spacecube		AU		2	0	0	2	2	0	2	2	1	0	1	2	1	1	1	0	2	1	1	0	0	1	2	1	2	2	2	2	2	2	1	1	39	10	7	8	14	
Multiple Designs. EcoShelta		AU		1	1	0	2	1	1	1	2	1	2	1	2	2	1	2	1	2	2	2	1	1	2	2	2	2	2	2	2	2	2	2	1	50	9	12	14	15	
ehabitat		TAS		1	2	0	1	1	2	2	2	1	0	1	1	1	1	2	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	1	45	11	8	11	15	
Blue Mountains CLT Studio. John King / Design King		NSW		0	0	2	2	1	1	2	2	1	0	1	1	1	1	1	2	2	1	1	1	1	2	2	1	1	2	1	1	1	1	2	1	39	10	8	11	10	
Courtyard House. Fabprefab / Chrofi		NSW		2	0	1	2	1	0	2	1	1	0	1	1	2	1	1	1	0	1	1	1	1	1	2	1	1	2	2	2	2	2	2	1	39	9	8	8	14	
Clovelly. MAAP		NSW		2	0	0	2	2	0	2	1	1	0	1	1	1	1	1	1	0	1	1	0	0	1	2	1	1	1	1	1	1	1	1	1	30	9	7	6	8	
Warrander Studio. Makers of Architecture / Makers Fabrication	NZ			0	1	1	1	1	1	2	2	1	0	2	1	1	1	1	1	2	2	2	1	1	1	2	1	1	1	1	1	1	1	2	1	38	9	8	12	9	
Minimod. Mapa	Brazil			2	0	0	2	1	0	2	2	1	0	2	2	1	1	2	0	2	2	2	0	0	1	2	2	2	2	2	2	1	1	1	1	41	9	9	11	12	
Met-Kit Homes. PAAL		AU		0	2	0	1	1	2	2	2	1	0	2	1	2	1	0	1	1	1	1	0	0	0	1	2	1	0	1	2	0	1	1	1	31	10	8	6	7	
Elizabeth Beach House. Mode Homes		NSW		2	0	0	2	2	0	2	1	1	0	2	1	1	1	1	1	0	1	1	0	0	1	1	2	1	1	2	2	1	1	1	1	33	9	8	6	10	
Modern Beach House. Mode Homes		NSW		2	0	0	2	2	0	2	1	1	0	2	1	1	1	1	1	0	1	1	0	0	1	1	2	1	1	1	2	1	1	1	1	32	9	8	6	9	
Habitat. Prebuilt		AU		2	0	0	2	2	0	2	1	1	0	2	1	1	1	1	2	0	1	1	0	0	1	2	2	1	1	1	2	1	1	1	1	34	9	9	7	9	
Eco Modular. Strine Environments / Ric Butt		ACT		2	1	0	1	1	1	2	2	1	0	2	2	1	1	2	1	0	1	1	0	0	1	1	2	2	1	1	2	2	1	2	1	38	10	10	6	12	
Krawarree. Strine Environments / Ric Butt		ACT		0	1	2	1	1	1	2	2	1	0	2	2	2	1	1	1	0	1	1	1	0	2	1	1	1	1	1	1	2	2	2	1	38	10	10	7	11	
Tranmere. Valley Workshop		TAS		2	0	0	2	1	0	2	1	1	0	2	1	1	1	1	1	0	1	1	0	0	1	2	1	1	1	1	2	1	2	2	1	33	8	8	6	11	
Minima. Trias / Fabprefab		AU		2	0	0	2	1	0	2	1	1	0	1	2	1	1	2	0	2	2	2	0	0	1	2	2	1	2	1	2	1	1	1	1	37	8	8	11	10	
Fox. Archiblox		AU		2	0	0	2	2	0	2	1	1	0	1	1	1	1	1	0	2	1	1	0	0	1	2	0	2	2	1	2	1	2	2	1	35	9	6	7	13	
The Shephard. Small not Tiny		VIC		2	0	0	2	2	0	2	1	1	0	1	1	1	1	2	1	0	1	1	0	0	1	2	0	2	1	1	2	1	1	2	1	33	9	8	5	11	
Atomic 6		NSW		2	0	0	2	2	0	2	1	1	1	2	1	1	1	2	0	0	1	1	0	0	1	2	0	1	1	1	2	2	1	1	0	32	9	9	5	9	
																																					195	**173**	**165**	**225**	
																																					9.28	**8.23**	**7.85**	**10.71**	Score (averaged per project #)
Housing (Bushfire)																																									
Off Grid House. Anderson Architecture		NSW		0	0	1	0	2	1	2	1	2	0	2	1	1	1	1	1	0	1	1	1	0	2	0	1	1	1	1	2	2	1	2	1	33	7	9	6	11	
Karri Fire House. Ian Weir Architect.		WA		0	0	1	0	2	1	2	1	2	0	2	1	1	1	1	1	0	1	1	1	1	2	1	1	1	1	1	1	1	2	2	1	34	7	9	8	10	
A020 Wye River House. Matt Goodman Architect		VIC		0	0	0	0	2	1	2	0	2	0	2	1	1	1	1	1	0	0	0	0	0	2	0	1	1	1	1	2	1	1	2	1	27	5	9	3	10	
Rosedale Beach House. Thomas Caddaye Architects		NSW		0	0	0	0	2	1	2	1	2	0	2	1	1	1	1	2	0	1	1	1	0	2	0	1	1	1	1	1	1	2	1	1	31	6	10	6	9	
Nornalup House. Ian Weir Architect		WA		0	0	1	0	2	1	2	1	2	0	2	1	1	1	1	1	0	1	1	1	1	2	1	0	2	1	2	2	1	2	2	1	36	7	9	7	13	
Overlook. Ian Weir Architect		WA		0	0	1	0	1	0	1	1	2	0	2	1	0	1	1	1	0	1	1	0	0	1	0	0	1	1	2	1	1	2	2	1	26	4	8	3	11	
																																					36	**54**	**33**	**64**	
																																					6	**9**	**5.5**	**10.66**	Score (averaged per project #)
Housing (Half House / Owner Builder / Social Models)																																									
Quinta Monroy Social Housing. Elemental	Chile			0	0	0	0	2	1	2	1	0	1	2	1	2	2	2	2	0	1	1	2	2	1	0	2	2	1	2	2	1	1	1	2	39	6	12	9	12	
Monterrey Social Housing. Elemental	Mexico			0	0	0	0	2	1	2	1	0	1	2	1	2	2	2	2	0	1	1	2	2	1	0	2	2	1	2	2	1	1	1	2	39	6	12	9	12	
Core House. NMBW Architects		AU		0	1	1	1	2	1	2	1	0	0	2	2	2	1	2	2	0	1	1	2	2	2	1	0	2	2	2	2	1	1	1	2	42	9	11	9	13	
120 Incremental Homes	Peru			1	1	0	2	2	1	2	2	0	1	1	1	2	1	2	2	2	2	2	0	1	1	1	0	2	1	2	2	1	1	1	1	41	11	10	9	11	
																																					32	**45**	**36**	**48**	
																																					8	**11.25**	**9**	**12**	Score (averaged per project #)
Other																																									
Graceville Flood House. James Davidson Architect.		QLD		0	0	0	0	2	1	2	1	0	2	2	1	1	2	1	2	0	2	2	1	1	2	0	1	1	2	2	2	2	1	1	1	38	6	11	9	12	
Shack 14. Ken Latona		TAS		0	1	0	1	2	2	2	1	0	0	2	1	1	1	1	2	0	1	1	1	1	2	1	2	1	2	2	1	2	2	2	1	39	9	8	9	13	
Krakani Lumi. Taylor Hinds Architects.		TAS		1	0	0	1	2	1	2	1	1	0	1	2	1	1	1	2	1	1	1	1	1	2	1	1	1	2	2	2	2	2	2	2	41	8	9	9	15	
																																					23	**28**	**27**	**40**	
																																					7.67	**9.33**	**9**	**13.33**	Score (averaged per project #)
Totals				**53**	**16**	**11**	**59**	**76**	**31**	**89**	**61**	**53**	**14**	**72**	**58**	**58**	**55**	**58**	**50**	**27**	**49**	**49**	**28**	**25**	**58**	**64**	**52**	**57**	**60**	**67**	**79**	**60**	**62**	**67**	**46**		**396**	**418**	**352**	**498**	

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- Uninsurable houses due to climate risks https://www.abc.net.au/news/2019-10-23/the-suburbs-facing-rising-insurance-costs-from-climate-risk/11624108?nw=0

CHAPTER 3

A Review of the Transport, Logistic and Assembly Approaches

Introduction

This report represents the work belonging to work package 2 of Project #35 of the Building 4.0 CRC. This work package aims to provide a review of the transport, logistic and assembly approaches to assist the design and development of prefab housing solutions for bushfire and disaster relief. The focus of this report is on the design aspects of prefab housing solutions, thereby, only relevant information that may affect the design and development of prefab housing solutions for bushfire and disaster relief will be discussed. The report comprises the following sections:

- Introduction: Project overview
- Methodology: Methods to conduct the study
- Analysis and Content: Detailed information
- Outcomes and Deliverables
- Appendix and References.

Methodology

The review of the transport, logistic and assembly approaches is conducted using the information obtained from several resources. The first main resource for the transport regulations is the Heavy Vehicle Law and Regulations published by National Heavy Vehicle Regulator (NHVR). State government agencies such as the Victorian Department of Transport and the Transport for NSW are also the secondary sources for transport regulations since these agencies represent the NHVR in the local areas. These sources are reviewed to outline the constraints and requirements on the size and weight of prefab modules in order to maximise the serviceability of future designs of prefab housing for bushfire relief. The second main source for the review comes from handbooks, published recommendations for prefab construction, modular construction, factory-built housing and case studies. These sources are reviewed to propose manufacturing and assembly methods, and also engineering considerations for the transport, logistics and assembly.

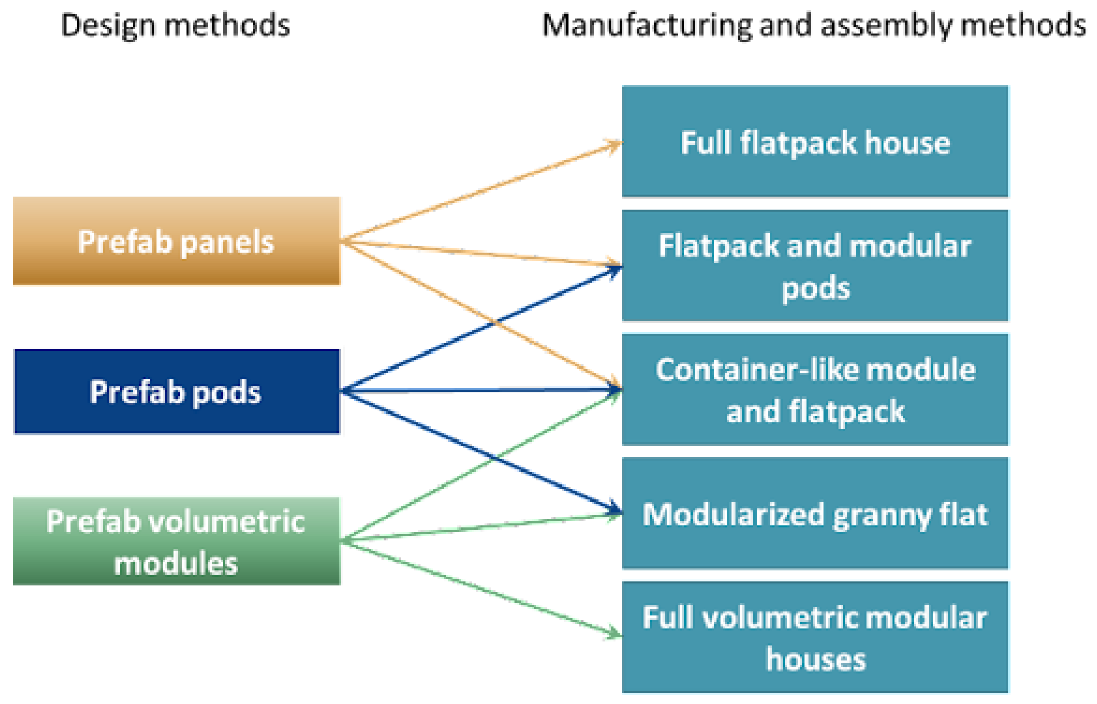


Figure 1: Design methods and manufacturing and assembly methods

Analysis and Content

Manufacturing and assembly methods

In terms of prefab housing, there are three levels of design levels namely prefabricated panels, prefabricated pods and prefabricated modular homes (see Figure 1). As their names indicate, the prefab housing is either a combination of prefabricated panels, prefabricated pods, prefabricated modules or a mix between these components. Each design method has a number of advantages and disadvantages outlined in Table 1.

There is a trade-off between on-site labour requirements and transportation costs. As the level of prefabrication raises from panels to volumetric modular homes, the transportation costs increase due to the higher volume of the prefab structures. However, the on-site labour is reduced due to the higher level of pre-finished components and structures. The greater degree of on-site assembly also lowers the quality control of the prefab housing. On the other hand, a higher level of prefabrication in factories requires extra quality control during transportation. The pros and cons of these three design levels are outlined in Table 1.

	Advantages	***Disadvantages***
Prefabricated Panels	+ Easy to stack on truck + Lower transportation cost	- Increase labour cost for onsite assembly
Prefabricated Pods	+ Ready to use pre-finished pods	- Higher transportation cost - Requires quality control during transportation - Normally does not comprise structural members
Prefabricated Modular Homes	+ Lower labour cost + Fast onsite assembly	- Higher transportation cost - Require quality control during transportation

Table 1: The pros and cons of different design levels of prefab housing

The manufacturing and assembly methods are closely related to the design methods. Manufacturing and assembly methods of modular housing concepts can be categorised into volumetric, flatpack, hybrid and other approaches. A flatpack prefab housing will save transportation costs since it is easy to stack on a truck. However, it will require higher labour costs on-site assembly. On the contrary, a volumetric prefab module will minimise on-site labour and assembling time, but it requires higher crane capacity and transportation costs.

Besides volumetric and flatpack manufacturing and assembly methods, there are hybrid methods to utilise and combine the advantages of these two methods. Prefab housing can be manufactured as a combination of flatpack and modular pods or a combination of volumetric modules and flatpack (see Figure 1). Modular pods are usually created for wet areas such as a bathroom or a kitchen as these areas always require the involvement of a high number of trades and skilled labour. The remaining areas are manufactured as a flatpack to be assembled on-site.

Figure 2 represents a comparison between different assembly methods. It can be observed that a module with a higher level of prefabrication such as a full volumetric modular house will increase the transportation cost and limit the site access due to its size. However, it reduces the on-site labour cost and minimises defects due to on-site construction. Oppositely, a full flatpack house can be transported easily and has higher accessibility to more bushfire prone areas, whereas it requires more skilled labour and on-site quality control.

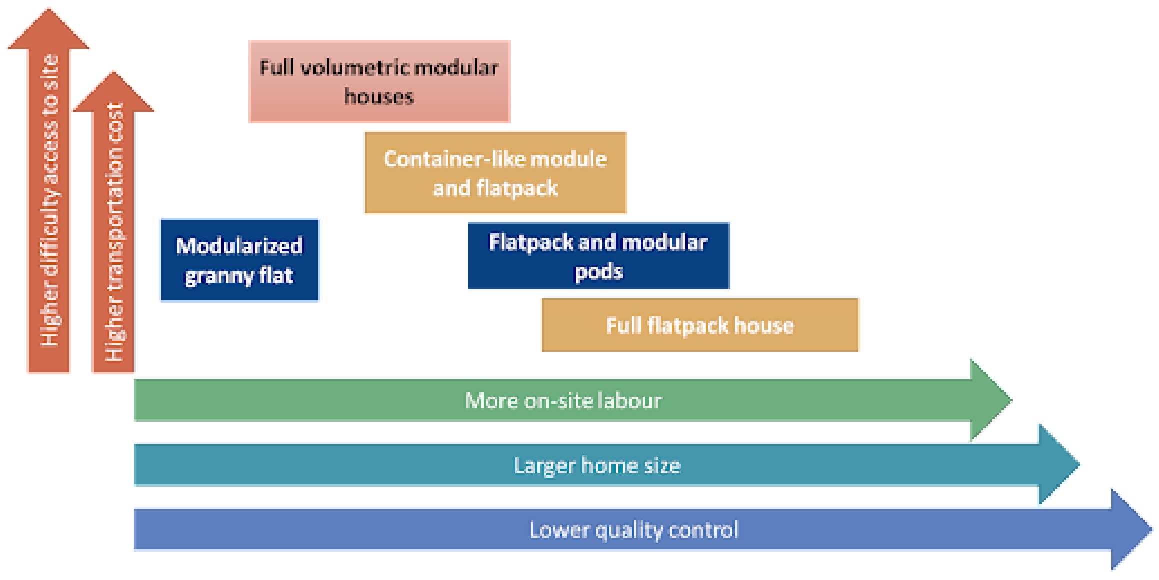


Figure 2: Manufacturing and assembly methods

By combining the benefits from both the flatpack and full volumetric option, a hybrid approach using modular pods in wet areas and flatpack for the remaining parts can reduce on-site labour and increase quality control. It is due to the fact that a wet area such as a bathroom requires a high number of trades compared to other areas. Therefore, completing these areas as prefab pods will ensure the quality control of the prefab housing solution.

Transport Regulations

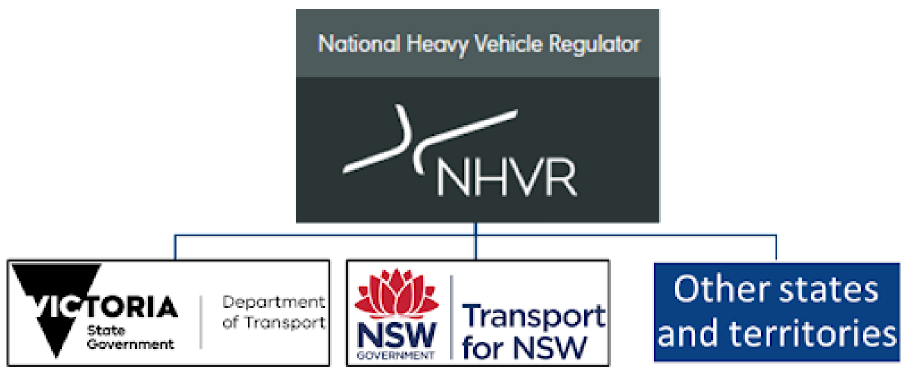


Figure 3: Regulatory bodies for heavy vehicles in Australia

At the national level, the transportation of heavy vehicles is regulated by National Heavy Vehicle Regulator (NHVR).[1] NHVR provide regulations on safety, accreditation and compliance, road access, and law and policies to ensure a safe, efficient and productive heavy vehicle industry in Australia. Under NHVR, there are state road transport authorities and government agencies that are in charge of delivering many services on behalf of NHVR (see Figure 3).[2,3] In this section, the regulations on the size and weight are discussed. These limitations in size and weight will ensure an adequate and effective design of prefab housing for bushfire relief.

General Access Vehicles

The NHVR provides the definitions of vehicles and their size and weight limits. These vehicles can be divided into two categories namely general access vehicles and limited access vehicles.[4] General access vehicles have their sizes and weights that comply with requirements.

Therefore, a notice or permit is not required for general access vehicles to operate on the road network. On the other hand, limited access vehicles can only travel on certain parts of the road network. Limited access vehicles also need notice or permit to travel, limiting their access to several regions.

To maximise the accessibility to construction sites, vehicles with general access are recommended as a means of transportation. According to NHVR, common rigid trucks and semitrailer combinations [5] (see Figure 4) are recommended for the transportation purpose of prefabricated houses for bush-fire relief because they only require general access to the transportation network. In other words, no permits are required for common rigid trucks and semitrailer combinations to travel on accessible roads. Therefore, it increases the accessibility of the transportation of prefab houses to more areas prone to bushfires and also reduces delivery time since no permit applications are required.

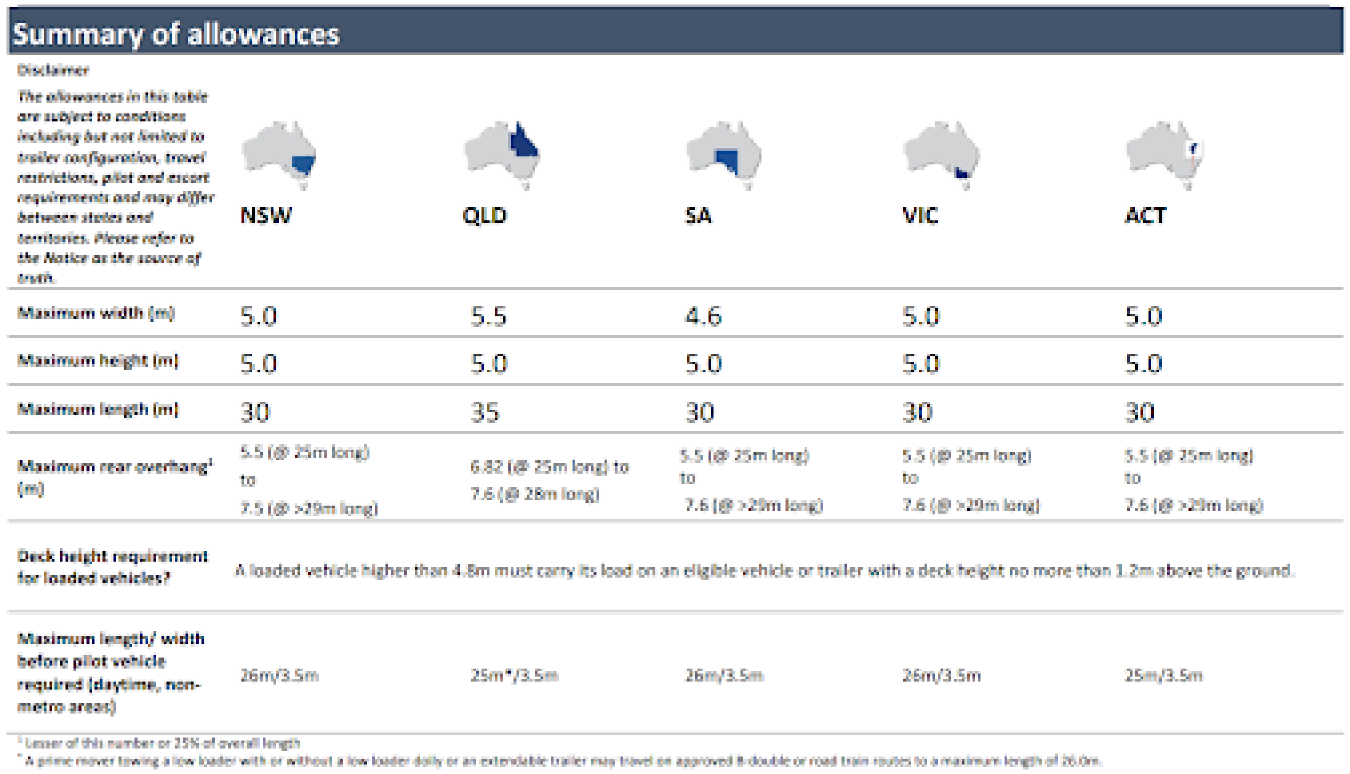
		Axles	Maximum Length (m)	GML (t)	CML (t)	HML (t)
rigid trucks		2	12.5	15.0	-	-
		3	12.5	22.5	23.0	-
		4	12.5	26.0	27.0	-
		4	12.5	26.5	27.0	-
		5	12.5	30.0	31.0	-
semitrailers		3	19.0	24.0	-	-
		4	19.0	31.5	32.0	32.0
		5	19.0	35.0	36.0	37.5
		5	19.0	39.0	40.0	40.0
		6	19.0	42.5	43.5	45.5

GML: General Mass Limit, **CML:** Concessional Mass Limit, **HML:** Higher Mass Limit

Figure 4: General access heavy vehicles according to NHVR [5]

According to NHVR, the weight and size of rigid trucks and semitrailer combinations having general access are presented in Table 2. The total values stated by NHVR indicate the size and weight constraints of a vehicle under the general access category (see Figure 4). The equipment values are taken from the common values of a semitrailer following a conservative approach.

Finally, the cargo values, which are the constraints of a prefab house module, are calculated based on the total and equipment size and weight. The suggested maximum cargo weight is 28.0 tonnes. In terms of the size of a module, the overall dimension of a module can reach up to 2.8 metres in height, 2.5 metres in width and 13-15 metres in length. With a low deck trailer, the maximum height of a module can be up to 3.3 metres, allowing extra room for the prefab module.



Summary of allowances

Disclaimer *The allowances in this table are subject to conditions including but not limited to trailer configuration, travel restrictions, pilot and escort requirements and may differ between states and territories. Please refer to the Notice as the source of truth.*	NSW	QLD	SA	VIC	ACT
Maximum width (m)	5.0	5.5	4.6	5.0	5.0
Maximum height (m)	5.0	5.0	5.0	5.0	5.0
Maximum length (m)	30	35	30	30	30
Maximum rear overhang[1] (m)	5.5 (@ 25m long) to 7.5 (@ >29m long)	6.82 (@ 25m long) to 7.6 (@ 28m long)	5.5 (@ 25m long) to 7.6 (@ >29m long)	5.5 (@ 25m long) to 7.6 (@ >29m long)	5.5 (@ 25m long) to 7.6 (@ >29m long)
Deck height requirement for loaded vehicles?	A loaded vehicle higher than 4.8m must carry its load on an eligible vehicle or trailer with a deck height no more than 1.2m above the ground.				
Maximum length/ width before pilot vehicle required (daytime, non-metro areas)	26m/3.5m	25m*/3.5m	26m/3.5m	26m/3.5m	25m/3.5m

[1] Lesser of this number or 25% of overall length
* A prime mover towing a low loader with or without a low loader dolly or an extendable trailer may travel on approved B-double or road train routes to a maximum length of 26.0m.

Figure 5: Maximum dimensions of Class 1 load carrying vehicle according to NHVR

Oversize overmass (OSOM) requirements.
It can be noted that the mass of a vehicle is not discussed in this section due to the fact that increasing the mass of a module will require higher crane capacity for on-site construction and assembly. The mass and size of a crane can exceed the size and weight limit of general access vehicles, thereby, limiting its site access.

As a result, reducing the mass of a module is preferable as higher mass will result in a higher capacity of the crane, leading to the crane access issue. Furthermore, the maximum weight of a general access vehicle is 42.5 tonnes, resulting in a mass of a prefab module or a combination of modules mass on a vehicle of approximately 28.0 tonnes (Table 2). This value will be taken as the recommendation for the mass limit of a prefab module.

*Table 2: Maximum weight and dimensions of semitrailer combinations that have general access according to NHVR. * Values of a low deck (drop deck) vehicle*

Size and weight	Limits according to NHVR	Common vehicle values	Cargo limits (net)
Weight (tonnes)	42.5	14.5	28
Height (metres)	4.3	1.5 (1.0*)	2.8 (3.3*)
Width (metres)	2.5	2.5	2.5
Length (metres)	19	19	14 (11*)

Table 3: OSOM network map and restricted area in Victoria and New South Wales.

State	Link to OSOM network map	Restricted area
VIC	https://nhvr.maps.arcgis.com/apps/webappviewer/index.html?id=3bc2b185071147eda470e86e02f7885b	Mountainous Area and the Otway Area (if the vehicle is over 2.5 metres in width and/or 19 metres in length); Gippsland Ranges Area and Colac–Surf Coast Area (if the vehicle is over 3 metres in width and/or 22 metres in length)
NSW	https://roads-waterways.transport.nsw.gov.au/business-industry/heavy-vehicles/maps/nsw-load-carrying-network/map/index.html	Limited in size and travel time on specific routes (such as Princes Highway, Pacific Highway, Burley Griffin Way, Snowy Mountain Highway, Lachlan Valley Way, The Putty Road, Bells Line Of Road, Great Western Highway, Hunter Expressway, New England Highway, Oxley Highway etc.)

As aforementioned, if a module is manufactured with the size constraints as presented in Table 2, no extra requirements are needed. However, the size of the module stated in Table 2, especially the width of 2.5 meters, may limit the number of possible design options for the bushfire relief housing that is suitable for long-term uses.

Therefore, the size of a module may exceed those values. When the size and mass of a vehicle exceed the limit for general access, it is listed as a limited access vehicle and will need a gazette notice or a permit to travel. For the purpose of transporting prefab housing, the vehicle is categorised as an oversize overmass (OSOM) vehicle within Class 1.[4] OSOM vehicles can only travel in OSOM networks such as the Oversize/Overmass (OSOM) Network in Victoria [6] or NSW Oversize Overmass Load Carrying Vehicles Network (includes 4.6m High Vehicles Network) [7] (see Table 3).

*Table 4: Maximum weight and dimensions of semitrailer combinations that can travel without a permit according to NHVR. * Values of a low deck (drop deck) vehicle*

Size	Dimension limits according to NHVR	Common vehicle dimensions	Cargo dimensions (net)
Height (metres)	4.6	1.5 (1.0*)	3.1 (3.6*)
Width (metres)	3.5	3.5 (2.7*)	3.5 (2.7*)
Length (metres)	25	25	20 (17*)

Depending on the size and weight of an OSOM vehicle, pilot/escort vehicles may be required. The maximum dimensions of a vehicle in different states are presented in Figure 5. It can be noted that the maximum width of a vehicle that can travel without an escort or a pilot vehicle is 3.5 meters. This value is consistent among all states in Australia.

For vehicles used to transport prefabricated buildings, a Class 1 permit from NVHR may be required to travel on OSOM network. For designing purposes, Table 4 presents the dimension limits of semitrailer combinations that can travel without a permit.

*Table 5: Maximum weight and dimensions of semitrailer combinations that have general access according to NHVR. * Values of a low deck (drop deck) vehicle*

Width of vehicles (W)	W ≤ 2.5 m	2.5 m < W ≤ 3.5 m	W > 3.5 m
Length of vehicles (L)	**L ≤ 19 m**	**19 m < L ≤ 26 m**	**L > 26 m**
Require warning devices	No	Yes	Yes
Require gazette notice	No	Yes	Yes
Require permit	No	No	Yes

Table 6: OSOM network map and restricted area in Victoria and New South Wales.

State	Link to OSOM network map	Restricted area
VIC	Victoria Class 1 Load Carrying Vehicle and Special Purpose Vehicle Mass And Dimension Exemption Notice 2019 (No. 1) [8]	New South Wales Class 1 Load Carrying Vehicle Operator's Guide [11]
	Oversize load carrying vehicles - Information bulletin [9]	Limits on dimensions and weights. Travel conditions and restrictions. Maps of restrictions and limits.
NSW	New South Wales Class 1 Load Carrying Vehicle Exemption Notice 2019 (No.1) [10]	Limits on dimensions and weights. Travel conditions and restrictions.
	New South Wales Class 1 Load Carrying Vehicle Operator's Guide [11]	Restrictions and limits on each area. Maps of restrictions and limits.

Similar to Table 2, the values of cargo are calculated from the total dimension using the common vehicle dimension. These values should be higher or lower depending on the model of the chosen vehicle. For oversize vehicles, using a low deck will increase the height limit of the prefab module up to 3.6 m, but also reduce the width of the module down to the maximum of 2.7 m due to the requirement of NHVR.

Although a permit is not required for vehicles satisfying the requirement in Table 4, a gazette notice and warning devices must be carried as presented in Table 5. However, considering the design aspects, these requirements are not significant. The corresponding documents for the requirement in dimensions, weights, travel conditions, restrictions, road network, and maps of travel restrictions and limits are listed in Table 6. The majority of this information can be found directly on NHVR website.

Table 7: Recommendation for the design of prefab module

Category	Weight (tonnes)	Width (metres)	Height (metres)	Length (metres)
General access	28.0	2.5	2.8	14.0
General access (low deck)	28.0	2.5	3.3	11.0
Oversize vehicles without permit	28.0	3.5	3.1	20.0
Oversize vehicles without permit (low deck)	28.0	2.7	3.6	17.0

Oversize overmass (OSOM) requirements.
It can be noted that regions prone to bushfires are normally located in mountainous areas, thereby having limited access for large vehicles. As a result, based on the requirements from NHVR, and regulations in Victoria and New South Wales, it is recommended that a module size should not exceed 2.5 m in width, 3.3 m in height and 11m in length (Table 2) to maximise the access to bushfires prone areas. If these constraints are too tight for the design, the width can be eased up to 3.1 m and height up to 3.6m corresponding to vehicle dimensions of 3.5m wide and 4.6m high. Vehicles with a module complying with these dimensions can travel with a gazette notice on the OSOM network.

A vehicle's width wider than 3.5m is not recommended due to the limited access to mountainous areas and several roads and the requirements of permits, escort and pilot vehicles. These recommended limits are presented in Table 7.

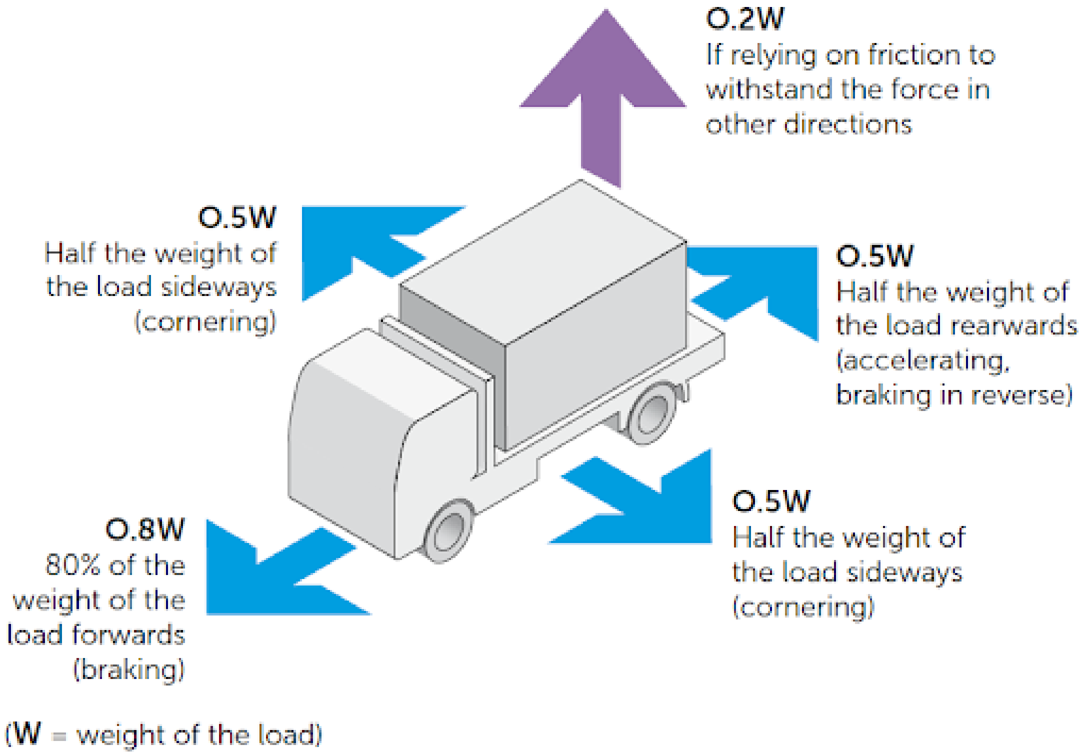
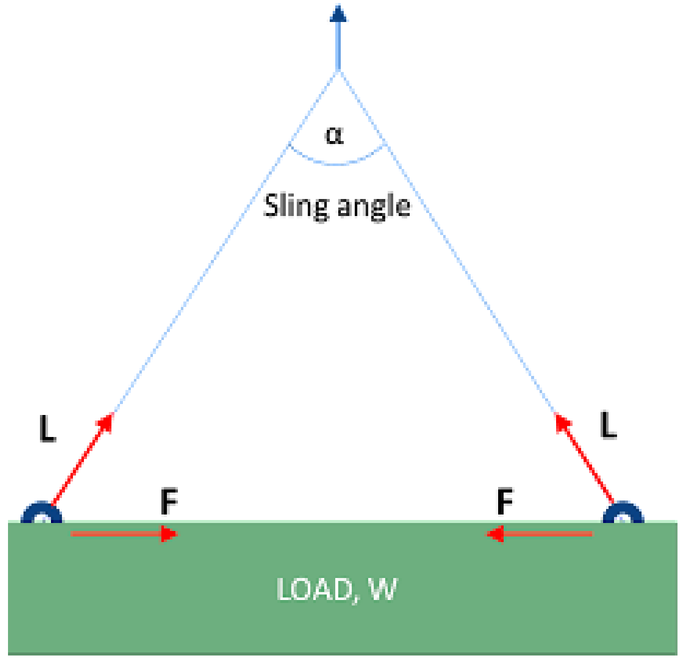


Figure 6: Restraint force requirement from National Transport Commission.

Regulation on transportation safety
Besides the constraints in size and weight, load restraint is also an important factor for the design of a prefabricated module. Load restraint does not limit the transport capacity. In fact, it ensures the safety during transportation. The National Transport Commission Australia published a load restraint guide to specify the restraint requirement for load carrying vehicles to ensure safety during transportation.[12]

In terms of design consideration for transportation, the load restraint guide provides useful information on the transportation loads acting on the prefabricated structure. Specifically, the prefab module must be designed to withstand the load up to 0.8g acceleration along the length of the module, 0.5g acceleration across the length of the module and 0.2g acceleration load in uplift direction (see Figure 6).



Sling angle (α)	Sling force (L)	Compressive force (F)
0^0	W	0
30^0	0.52 W	0.13 W
45^0	0.54 W	0.21 W
60^0	0.58 W	0.29 W
90^0	0.71 W	0.5 W
120^0	1 W	0.87 W

Figure 7: Sling angle and sling force

Table 8: Transportation forces in terms of accelerations in different directions and stacking methods.

Stacking method	Loading direction	Acceleration
Stacking direction specified	Forward direction	0.8 g
	Rearward direction	0.5 g
	Lateral direction	0.5 g
	Vertical direction	0.2 g
Stacking direction unspecified	In-plane (forward, rearward, and lateral direction)	0.8 g
	Out of plane (vertical direction)	0.2 g

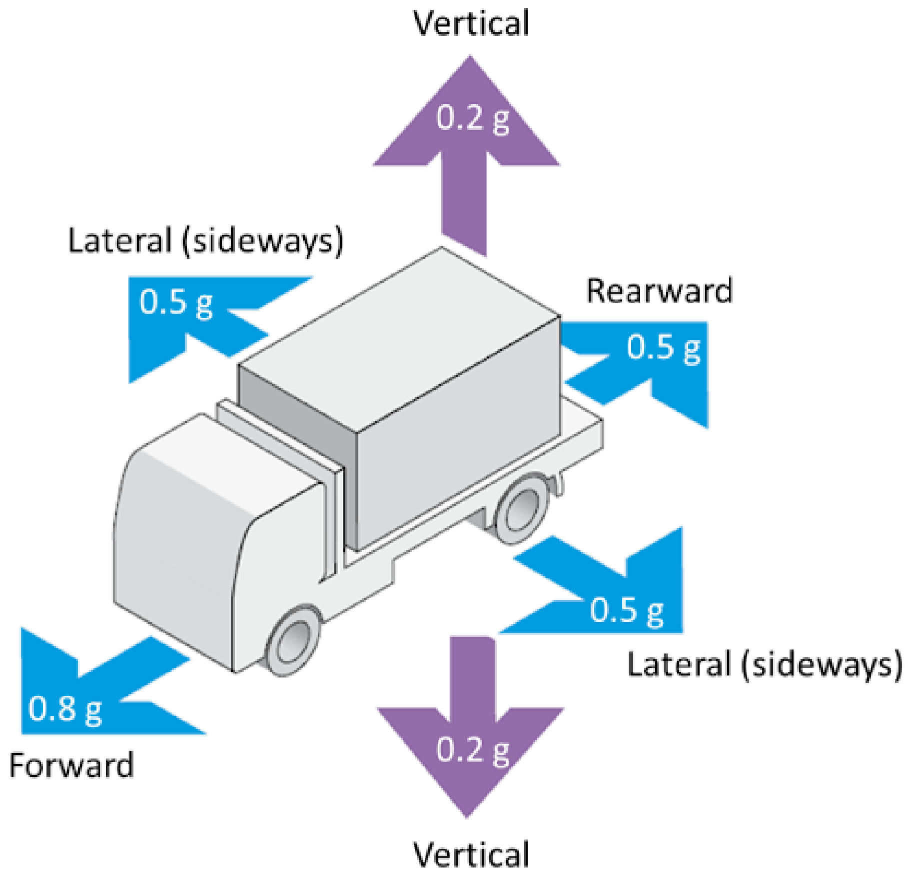


Figure 8: Transportation loading directions.

Engineering consideration for the transport, logistic and assembly

Lifting design and requirements.

A lifting design should be performed to ensure the safety and quality control during the manufacturing and assembly phases. There are several lifting phases to be considered namely lifting in the factory during manufacturing, loading onto road transport and unloading at a project site, lifting for assembly, and demolition. In each phase, the design for lifting should specify all intended lifting activities, lifting procedures, and required mechanised plant (cranes or forklifts). Also, all lifting activities must follow the safety requirements of operating cranes and forklifts. Further guidance about design for lifting can be adopted from AS 3850.2.[13]

Engineering consideration for lifting should include the dynamic effect of crane lifting, the effect of sling angle on both lifting capacity and the structure of a module. A dynamic load factor of at least 1.2 should be added to account for the crane winch speed and braking, and also for some minor impacts during lifting.

The effect of the sling angle on both the lifted module and the lifting point needs to be considered. As presented in Figure 7, increasing the sling angle will introduce more compressive force to the lifted element. It also increases the total force acting on the lifting point. As a result, the ability of a module to withstand these loads need to be checked.

Figure 9: Victoria OSOM road network and restrictions (adopted from [9])

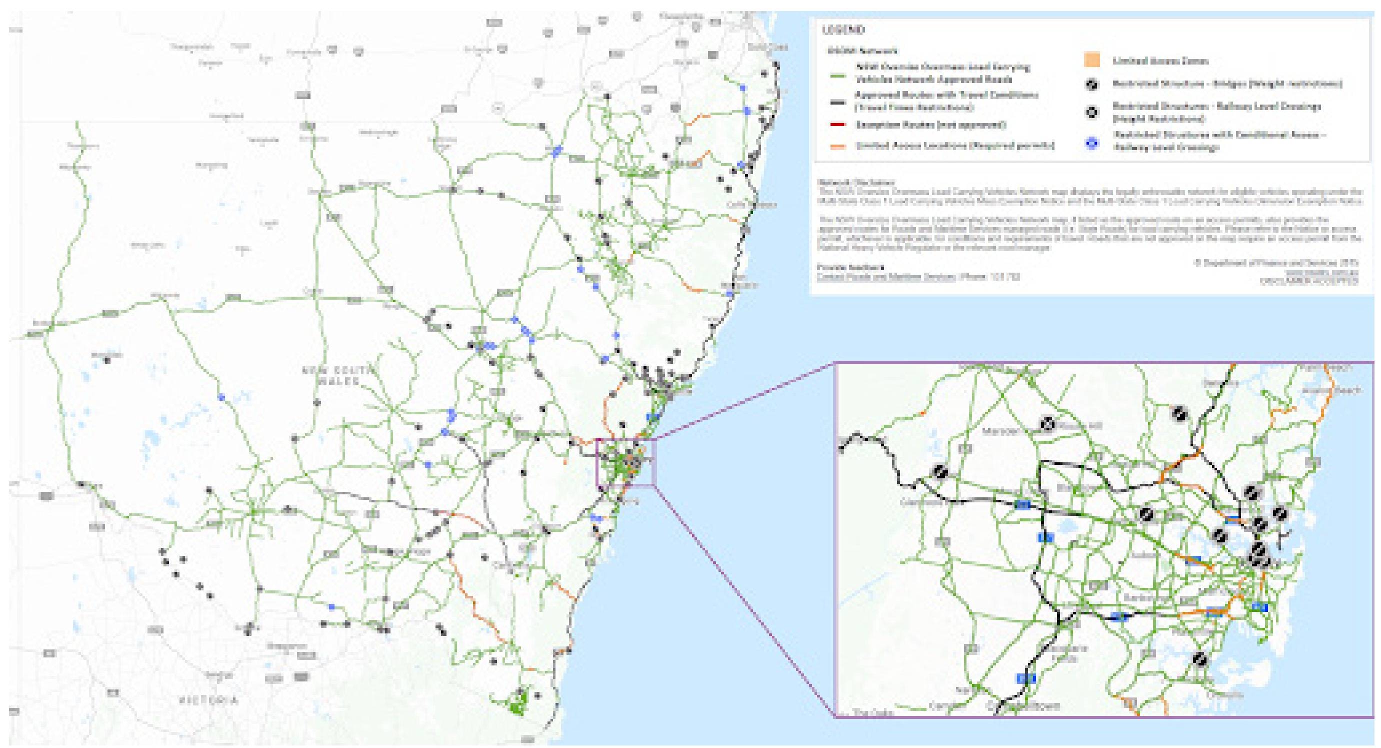


Figure 10: New South Wales OSOM road network and restrictions (adopted from [7])

Design for transportation

As aforementioned, the design of prefab housing needs to account for the transportation action. Based on the restraint force requirement by the National Transport Commission,[12] the recommendation design forces during transportation are presented in Figure 8 and Table 8. If the stacking direction is specified during manufacturing and transportation phases, there are different applied accelerations as regards the direction of the prefab unit (see Figure 8). When a stacking direction is not specified for the transportation, a maximum acceleration of 0.8 g in-plane and 0.2 g out of plane should be taken (see Table 8).

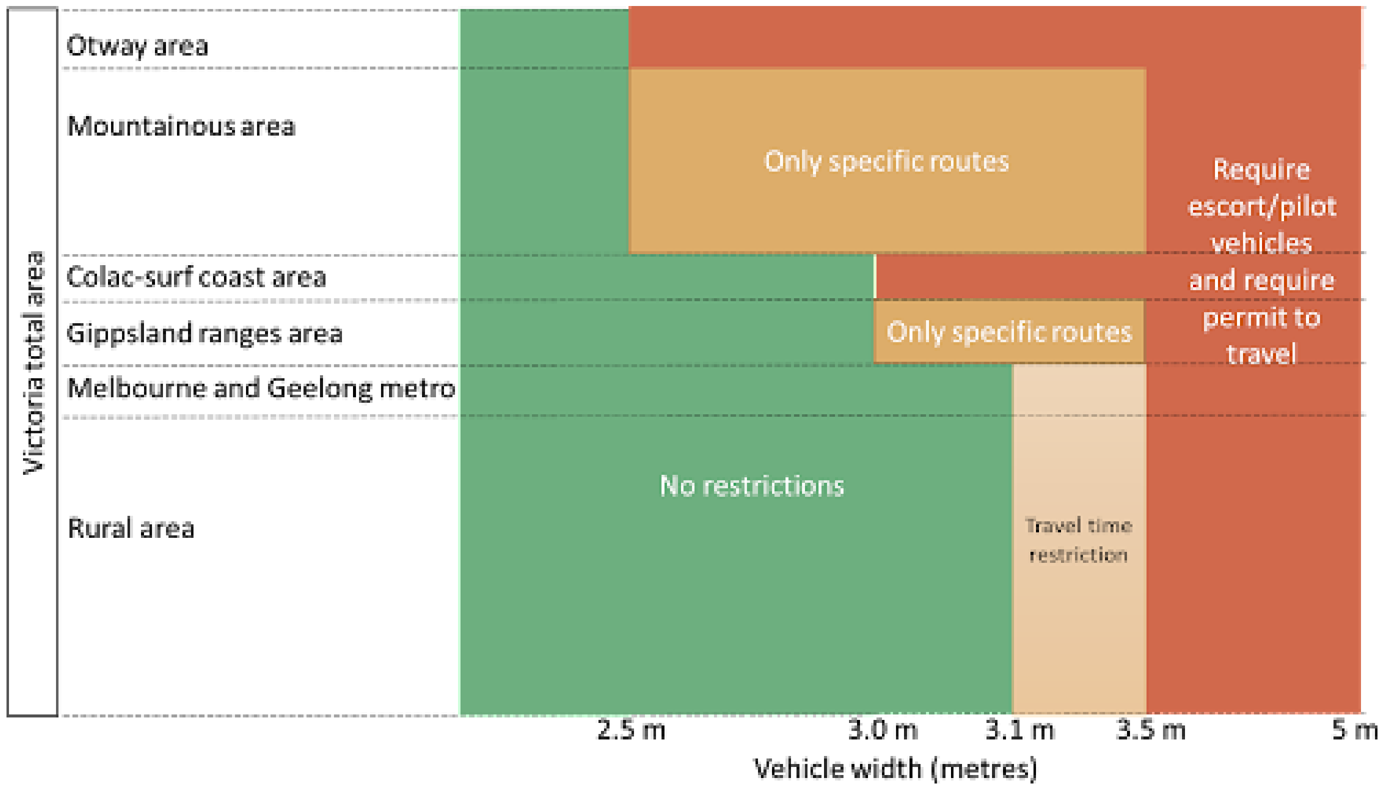


Figure 11: Travel restriction of vehicle in Victoria areas with different width.

Outcomes and Deliverables

Deliverable 01: A map/list outlining the regulatory framework of transportation restriction and limit

Deliverable 02: A guideline on transport, logistics and assembly.

The guideline has been presented in the previous sections. In brief, the allowed width of a vehicle plays a key role in deciding module size. A module width of not larger than 2.5 meters will maximise its accessibility to all regions while a module width larger than 3.5 metres is not recommended as it will require a permit and escort vehicle for the transportation. A module width larger than 2.5 metres but less than 3.5 metres will not require a permit and escort vehicle to be transported on the majority of the road network.

However, some restrictions such as travel times, sizes, and weight are applied to specific locations as presented in Sections 3.2 and 4.1. As it is the dominant factor to the transportation, a vehicle width and its associated possible travel area is illustrated in Figure 11 by using information from Section 3.2 and Figure 9. In this figure, the height of each row represent its relative area.

The limits of height and length of a prefab module are decided based on the width of the module. Basically, the maximum height ranges from 2.8 metres to 3.6 metres while the maximum length is in the range from 11 metres to 20 metres as presented in Table 7. Finally, the suggested maximum weight of a module is 28 tonnes. The weight of a module should be minimised to ensure the sufficient capacity of a crane for assembly.

In terms of manufacturing and assembly, there are several methods that can be applied in the design of a prefab module for bushfire relief. A hybrid method which is a combination of volumetric module and flatpack is preferable since only general access vehicles can travel to some bushfire prone areas. Finally, the design of a module, mainly structural design, must account for the external forces from lifting and transportation outlined in Section 3.3.

Table 9: Site locations for the analysis of the transport, logistic and assembly approaches.

Site address	Category
59 Karingal Drive, Wye River VIC 3234	Coastal
11 Dale Place, Rosedale NSW 2536	Coastal
2969 Healesville-Kinglake Rd, Kinglake VIC 3763	Mountain
33 Bundarra Street, Blackheath NSW 2785	Mountain
1472 Genoa-Mallacoota Road, Mallacoota VIC 3892	Rural
43 Moss Lane, Cobargo NSW 2550	Rural
8 Bruce Street, Mallacoota VIC 3892	Rural

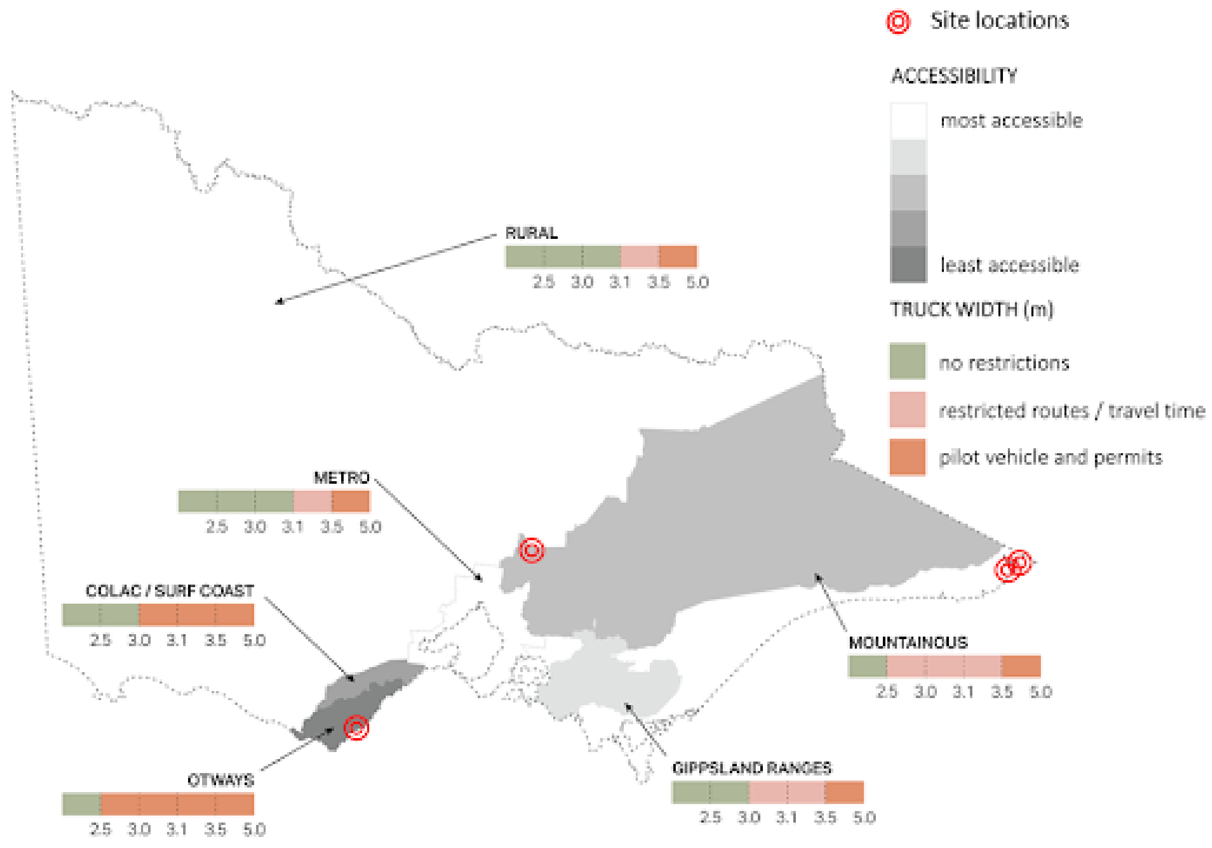


Figure 12: Site locations in Victoria.

Coastal sites		Mountain sites		Rural sites		
59 Karingal Drive, Wye River VIC 3234	*11 Dale Place, Rosedale NSW 2536*	*2969 Healesville-Kinglake Rd, Kinglake VIC 3763*	*33 Bundarra Street, Blackheath NSW 2785*	*1472 Genoa-Mallacoota Road, Mallacoota VIC 3892*	*43 Moss Lane, Cobargo NSW 2550*	*8 Bruce Street, Mallacoota VIC 3892*
Site overview						
 *photo taken from Google Maps	 *photo taken from Google Maps	 *photo taken from Google Maps	 *photo taken from Google Maps	 *photo taken from Google Maps	 *photo taken from Google Maps	 *photo taken from Google Maps
Transportation limits to the suburb						
Height: 4.3 m Width: 2.5 m Length: 19 m Weight: 42.5 T (6 axles semi-trailer) • Width and length limits are due to geometric features. • Weight limit is due to a bridge mass limit.	Height: 4.5 m Width: 3.5 m Length: 25 m Weight: 42.5 T (6 axles semi-trailer) • Height limit is due to a bridge height. • Travel time restrictions apply to vehicles that exceed 2.5m wide and 19m long.	Height: 4.6 m Width: 3.5 m Length: 25 m Weight: 49.5 T (6 axles semi-trailer) • Travel time restrictions apply for vehicles that exceed 3.1 m wide.	Height: 4.6 m Width: 3.5 m Length: 25 m Weight: 42.5 T (6 axles semi-trailer) • Travel time restrictions apply to vehicles that exceed 2.5m wide and/ or 22m long. 2 escort vehicles are required for vehicles that exceed 2.5m wide on a part of the routes.	Height: 4.6 m Width: 3.5 m Length: 26 m Weight: 49.5 T (6 axles semi-trailer) • Travel time restrictions apply for vehicles that exceed 3.1 m wide.	Height: 4.6 m Width: 3.0 m Length: 25 m Weight: 49.5 T (6 axles semi-trailer) • Contact the police for vehicles that exceed 3.0 m wide or/and 25 m long. • Travel time restrictions apply for vehicles that exceed 2.5 m wide and/ or 22 m long.	Height: 4.6 m Width: 3.5 m Length: 26 m Weight: 49.5 T (6 axles semi-trailer)
Site condition						
This site has unpaved roads, several trees and steep slopes.	No-through road, unsuitable for large vehicle The site comprises some trees and overhead electrical cables.	The site is clear, even surface with a few trees.	Overhead electrical cables on the boundary.	This site includes unpaved roads, several trees and steep slopes.	Approaching this site includes unpaved roads and several trees with steep slopes.	The site is clear and flat. Overhead electrical cable on at the front.
Suitable construction and assembly method						
Suitable for small modules or a flat-pack option	Suitable for small to medium modules or a flat-pack option.	Suitable for all types of prefab construction.	Suitable for small to medium modules and a flat-pack option.	Suitable for small modules or a flat-pack option.	Suitable for small to mid-size modules or a flat-pack option.	Suitable for all types of prefab construction.

Figure 13: Test site analysis

Deliverable 03: Site Analysis
In this section, 7 site locations in three categories namely coastal, mountain and rural will be analysed to illustrate the transport, logistic and assembly approaches outlined above. The site addresses and their categories are showed in Table 9. The site locations in Victoria are illustrated in Figure 12. In each site location, the transportation constraints to the suburbs will firstly be analysed to find out suitable transportation method from the factory to an assembly point near the construction site. Next, the site constraints are checked to determine suitable construction and assembly method for each specific site.

Recommendations

The development of a hybrid prefab module comprising of both flatpack and volumetric modular pod. The hybrid module should be transported using either a 2.5 metres or 3.5 metres wide truck to maximise accessibility. It is also recommended to use lightweight materials to minimise transportation and lifting costs.

In terms of listing some current factories for prefab housing products, there are a huge number of factories and companies manufacturing modular houses, sheds, granny flats in Victoria and New South Wales. Therefore, the work has not been completed as its scope should be narrowed down to some smaller categories.

Appendix

Victoria Oversize/overmass network:
https://nhvr.maps.arcgis.com/apps/webappviewer/index.html?id=3bc2b185071147eda470e86e02f7885b
https://vicroadsopendata-vicroadsmaps.opendata.arcgis.com/datasets/vicroadsmaps::hvr-oversize-overmass-osom/about

NSW oversize/overmass network:
https://roads-waterways.transport.nsw.gov.au/business-industry/heavy-vehicles/maps/nsw-load-carrying-network/map/index.html

Info sheet:
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CHAPTER 4

A Review of the Planning and Regulatory Frameworks

Introduction

Australia has been considered as one of the most bushfire-vulnerable regions in the world and this is expected to increase due to climate change. An increase in extreme fire weather days has been reported at several monitoring stations during past decades mainly due to the warmer and drier weather circumstances. During the 2009 Black Saturday bushfires, an area of more than 4500 km2 was burned [1] and more than 2000 houses were destroyed in Victoria.[2,3] Recently in 2019-2020, the Black Summer burnt an approximate area of 1.5m hectares with a total of 396 homes lost.[4]

As a response to the devastating fires, the Australian and state governments have implemented new policies and regulations in order to reduce the bushfire risk to populated areas. However, people are not necessarily able to keep up with these legislation changes, and often do not understand which process to follow once emergency strikes. Hence, it has been determined that one of the main problems that prevents speedy reconstruction in Australia are convoluted regulatory frameworks and the arduous processes to follow.[5] In 2004, the National Inquiry on Bushfire Mitigation and Management [6] reported that land-use planning was the single most important mitigation measure to prevent losses form bushfires. Furthermore, planning and development controls must be effective, to ensure that inappropriate developments do not occur. However, to date there is no consistency between states and territories in regards to the process which a person needs to follow when faced with the need to rebuild after a bushfire catastrophe.

Methodology

The aim of this work package is to review the regulatory framework related to design and construction of a house in a bushfire area. This section will focus on understanding the government's requirements in regards to the state's planning process, bushfire regulations and building codes that need to be considered when designing a prefabricated house as a solution for bushfire and disaster relief. This report focuses on the regulatory framework in the states of New South Wales (NSW) and Victoria.

Additionally, this work package aims to gather the available information in the form of a map, to provide a clear understanding of the current requirements relating to:

- Bushfire zones, and their evolution in recent years
- Burnt areas and their evolution in recent years
- Vegetation and forest maps and their evolution in recent years
- Land use as per government planning and their evolution in recent years.

To achieve this objective, a varied consultation on reviews papers was conducted as well as the examination of the database and online services of the Australian, NSW and Victorian governments. Papers related to Australian Bushfire background, regulations and planning were also analysed.

Analysis and Content

An assessment of the existing conditions and regulatory framework
Currently, Australian bushfire management policy and regulation focus on five main areas:

- prevention and bushfire mitigation
- preparedness
- response and suppression
- recovery
- monitoring. [7-9]

Bushfire regulatory framework
The National Construction Code (NCC) [10] is a standard that sets out the requirements for the design and construction of a building in Australia. This Code aligns the minimum required level for the safety, health, amenity, accessibility and sustainability of buildings. In respect to bushfires, the NCC requires buildings that are located in a bushfire prone area (BPA), to be designed and constructed to reduce the risk of ignition from a bushfire. The BPAs are regulated by each state or territory authority.

While each state may have different approaches to define their BPAs, the process usually involves an assessment of the land and mapping according to its topography (slope), vegetation (fuel type and load) and weather, among other factors. As required by the NCC, a landowner who wants to build a structure in a bushfire prone area must demonstrate compliance to the Australian Standard AS 3959 "Construction of buildings in bushfire-prone areas".[11] This standard classifies the bushfire prone areas in 6 levels of Bushfire Attack Level (BAL), which are determined by the severity of the building's potential exposure to ember attack, radiant heat and direct flame contact, as follows:

- BAL-LOW – very low risk
- BAL-12.5 – low risk
- BAL-19 – moderate risk
- BAL-29 – high risk
- BAL-40 – very high risk
- BAL-FZ – extreme risk (Flame Zone).

Figure 1 presents a description of what each of the BAL level consider. The identified level of BAL determines the type of construction and materials required to obtain a building permit. Factors such as the property's fire danger index, vegetation type, distance of the site from the classified vegetation type and effective slope under the classified vegetation type are some of the factors that must be assessed.

AS 3959 provides material specifications, elements of construction and systems for each of the six BALs. Alternatively, it allows for the use of materials, elements of construction and systems that comply with the fire testing provisions of Australian Standard AS 1530.8.1.[12]

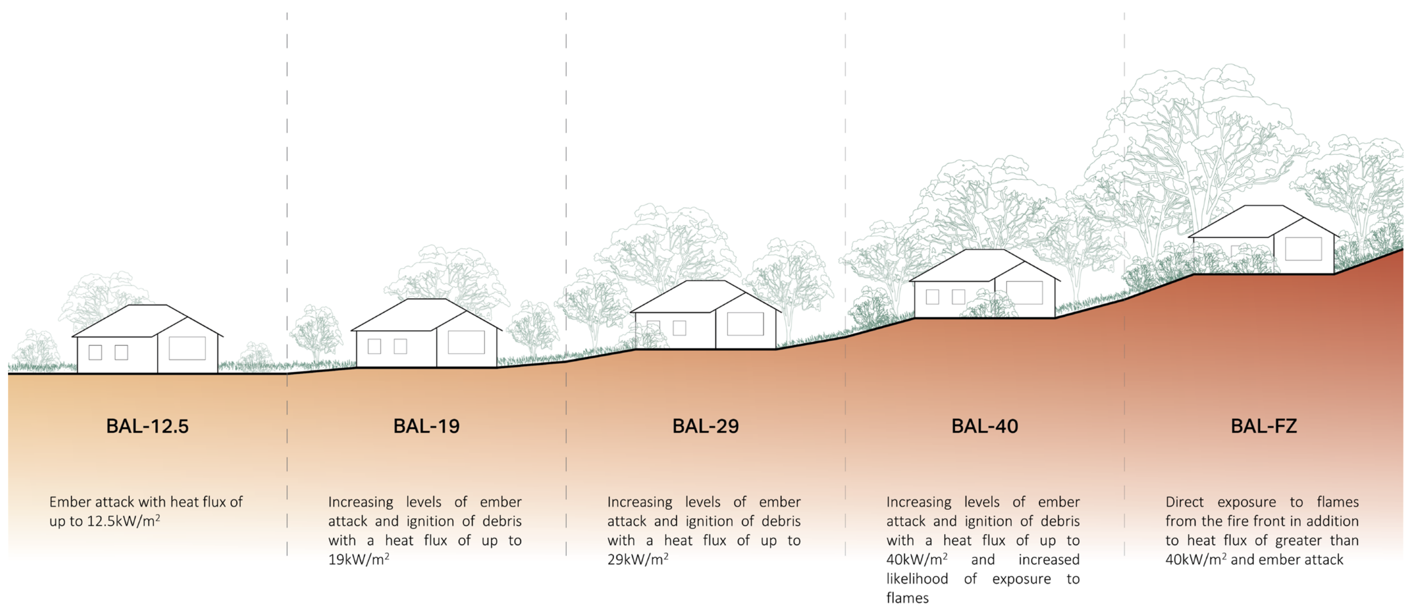

Figure 1: Bushfire Attack Levels description[4,11]

To allow designers and approval authorities make informed decisions on the best way of mitigating life safety risk during a bushfire, the private bushfire shelters (Class 10c) are regulated by the performance standard Private Bushfire Shelters [13], and the Design and Construction of Community Bushfire Refuges Handbook (a non-mandatory document).[14]

The NCC defines these private shelters as “a structure associated with, but not attached to, or part of a Class 1a dwelling that may, as a last resort, provide shelter for occupants from immediate life threatening effects of a bushfire”.[10] Although these documents provide guidance on how and where to construct these shelters, they are not mandatory and are not accepted as an alternative to full building compliance with AS 3959.[15] Additionally, the BCA emphasises that they are not a stand-alone solution to mitigate life safety risk and advise that reliance on a bushfire bunker can be life threatening.

New South Wales regulatory framework
When designing and constructing in bushfire prone land (BFPL- similar term as BPAs but particular to NSW terminology), the regulatory framework in New South Wales is based in the following main Regulations:

1. Planning for Bushfire Protection 2019 (PBP)
2. Australian Standard AS 3959 Construction of buildings in bushfire-prone areas
3. National Association of Steel Framed Housing NASH Standard (Steel Framed Construction in Bushfire Areas).

To identify if an allotment is within a BFPL the NSW government created an online mapping tool, which can be accessed on their website.[1] Through the NSW Rural Fire Service, the state of New South Wales created the document Planning for Bushfire Protection 2019,[17] which provides the state with standards for designing and building in a BFPL. The general objective of PBP is “to provide for the protection of human life and minimise impacts on property from the threat of bushfire, while having due regard to development potential, site characteristics and protection of the environment”.[17] The PBP framework is based on the fact that a bushfire protection measure (BPM) shall be included at the beginning of the project. The BPMs should be tailored to each condition depending on the geographic location, site circumstances and the nature of the proposed land use. Some examples can be seen in Figure 2. The PBP regulation assigns specific objectives that each land developer needs to meet in order to complete a successful project.

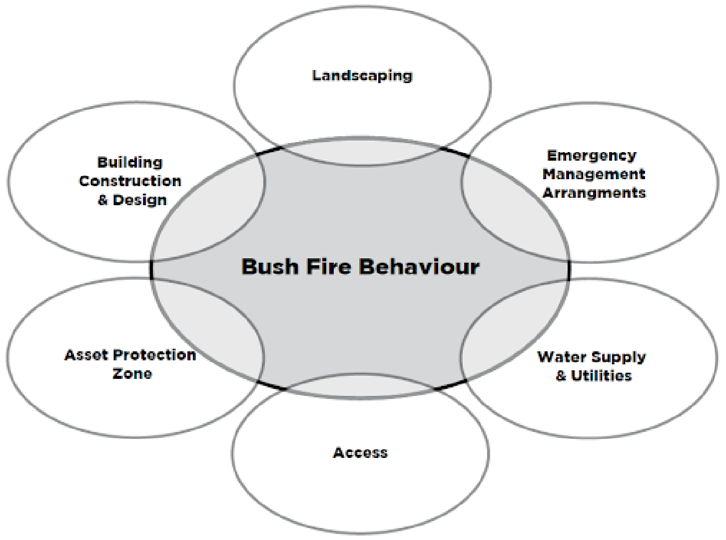

Figure 2: NSW Bushfire protection measures[17]

The PBP regulation is clear in that all the design and construction of the building needs to comply with the requirements of the NCC. Furthermore, it highlights how a suitable design and a compliant construction process improves the building’s ability to protect its occupants during a bushfire. Construction measures should not be applied as a stand-alone mitigation solution, but should form part of a suite of BPMs, which are consistent and complement each other. The adequate planning, design and construction sequence needs to be applied in the buffer zones as well. Buffer zones, also known as asset protection zones (APZ), are the areas located between the occupied land and the bushfire hazards. APZs must be provided with appropriate access, water supply and landscaping.[17]

Victoria’s regulatory framework
Together, Victoria’s planning and building systems form the bushfire regulatory framework to control land use and proposed developments to manage the bushfire risk and hazard in the safest way possible. Figure 3 illustrates the interaction between the planning and building regulation framework. The main components of Victoria’s regulatory framework are described below.

Bushfire hazard mapping, planning zones and overlays:
At a state-wide macro scale, a mapping of the bushfire hazard was carried out in 2011 to identify Victoria’s high-bushfire-risk areas and divide them into two categories: bushfire prone areas (BPA), and Bushfire Management Overlays (BMO). Mapping is based on a detailed set of criteria, including location, vegetation, weather characteristics, size and slope.[18,19] To identify if a property is within a BPA or BMO, the Victorian government created an online mapping tool named VicPlan which is available on their website.[20] BPA’s are areas that are likely to be subject to bushfires, with a characterisation based on Bushfire Hazard Level. This is an indicator of how extreme a bushfire can be, based on landscape conditions. Bushfire Hazard Levels can be different across all areas, regardless of their proximity to each other.

BPAs were formally designated under the Building Act. As such, specific construction and planning requirements apply when planning to construct under a BPA. To update and review the BPA’s maps, the Department of Environment, Land Water and Planning (DELWP) works closely with the local councils, emergency services and other stakeholders in the area. The latest review was conducted in July 2021.[21] As shown in Figure 5, most of regional Victoria except for some urban areas are designated as BPAs.[22]

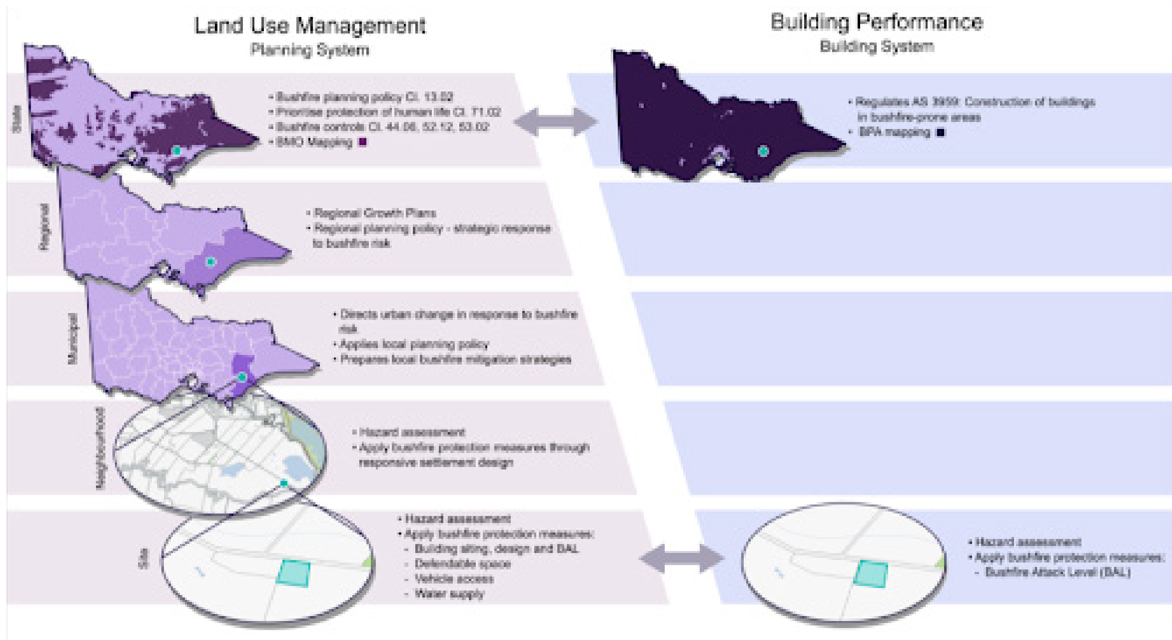

Figure 3: Planning and building regulatory framework for Bushfires in Victoria[5]

The BMO is a planning system to manage the development of land in areas designated as very high to extreme bushfire hazard. The BMO is enforced in areas where there is a potential for extreme bushfire behaviour, such as a crown fire and extreme ember attack and radiant heat.[4] Figure 6 depicts the areas that have been designated as BMOs.

DELWP developed its BPA and BMO hazard mapping criteria based on Australian Standard AS3959:2009, vegetation types, as well as stakeholder consultation and scientific reports. These criteria include a buffer to capture properties in proximity to areas of continuous vegetation that may be at risk from ember attack.[4]

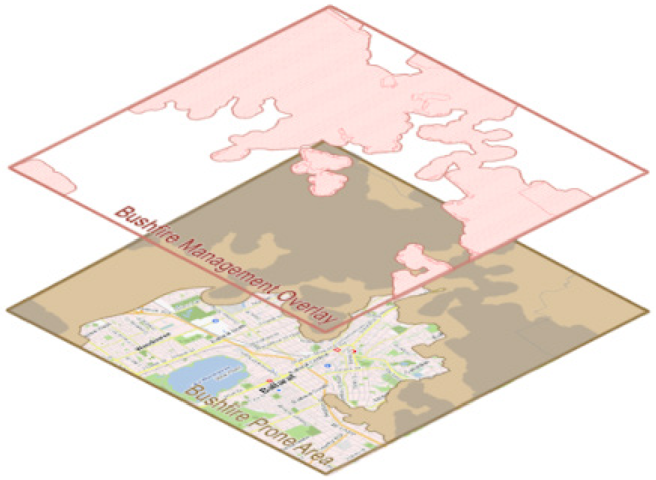

Figure 4: Bushfire hazard mapping[4]

Bushfire planning provisions:
In 2017, Victoria's planning provisions developed strategies for planners to better identify, assess and manage bushfire hazards. Therefore, additional to the existing building permit, a planning permit was introduced when constructing in areas with a BMO. These changes have resulted in a consistent state-wide approach to managing bushfire risk through the land-use planning system. With the inclusion of this provision, it is mandatory that every new development that falls inside a BMO shall include bushfire protection measures such as defendable space, water supply, access and ongoing vegetation management procedures.

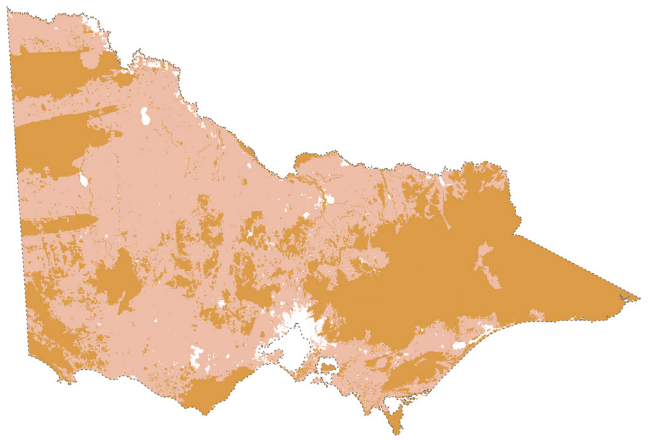

Figure 5: Bushfire prone areas in Victoria

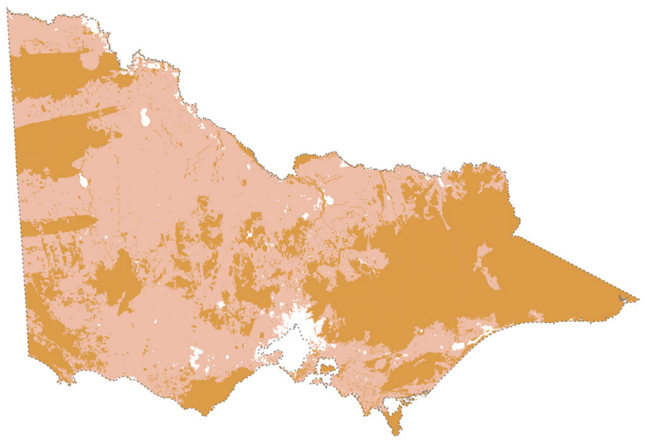

Figure 6: Bushfire Management Overlays in Victoria

As a result, when constructing inside a BMO the landowner must consider:

- the bushfire hazard around its property and potential impacts of its development
- the siting of a building, its design and ability to withstand bushfire attack (BAL)
- on-site water supply
- emergency services vehicle access
- fuel loads and vegetation management.

In addition to a Building Permit, all new buildings and extensions in the BMO need to apply for a planning permit. Landowners must include three components in their planning permit application:

- a bushfire site assessment
- a bushfire hazard landscape assessment and
- a bushfire management statement.

Building controls and regulations:
All new buildings designed and constructed in a BPA must comply with the Australian Standard: AS 3959:2018 "Construction of buildings in bushfire-prone areas". They must also comply with the Victorian regulations which, as stated previously, require issuing a: planning permit, building permit and occupancy permit.

To obtain a planning permit, the landowner must submit a bushfire assessment, a bushfire hazard landscape assessment, and a bushfire management statement to the relevant authorities. More than one planning permit may be required if, for example, additional to the residential dwelling the landowner needs to build an outbuilding such a shed, water tanks, etc.

Once the planning permit is granted, the landowner will need to apply for a building permit. To obtain this, the landowner is required to engage a private building surveyor who will process and issue the permit while guaranteeing that the property is code-compliant. Most importantly, design must fulfil all requirements of AS 3959:2018, where the property is granted an appropriate BAL level according to the different aspects described in section 3.1.2. Additionally, the property needs to achieve a 6-star energy efficiency rating to obtain the building permit.

Finally, when the building is constructed, an occupancy permit must be issued before the landowner can move into their house.

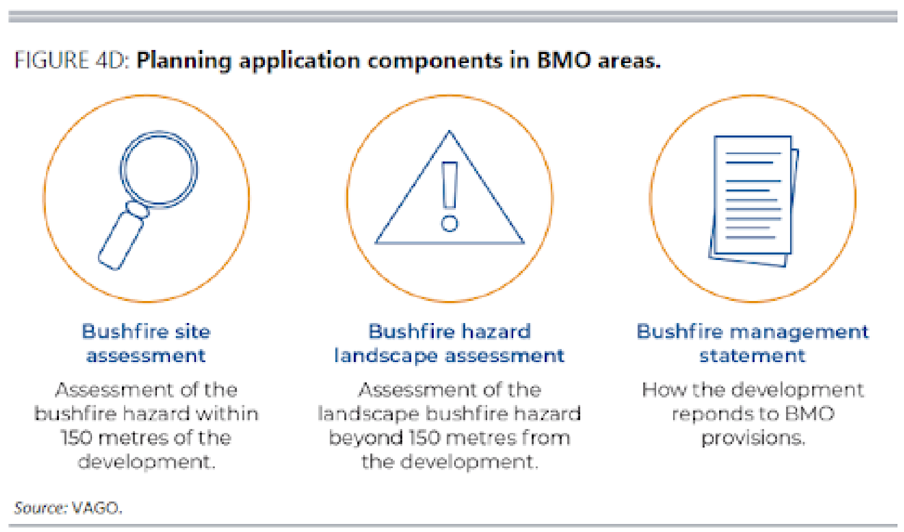

Figure 7: Planning application components in BMO areas[4]

Historical data and regulatory framework maps
This section provides an overview of historical data and regulatory information in the form of maps showing specific areas of Australia, New South Wales and Victoria. While a large number of resources are available online for each jurisdiction, a selection of maps is included in Appendix A, which enable an understanding of the planning conditions and overall the progression of fire risk areas by location. The following maps are provided in Appendix A for reference purposes:

- Figure 8: Australia's state of the Forest reported in 2018 [32]
- Figure 9 Australia's state of the forest burnt (2011-2012; 2015-2016) [32]
- Figure 10 Australian planning land use 2020 [33]
- Figure 11 Australian planning land use 2011 [33]
- Figure 12 Satellite view of areas burnt in Australia in the past 2 years [34]
- Figure 13 Impacts of the 2019–20 bushfires in the Rainforests of NSW north coast and tablelands (left) and Blue Mountains (right) [35]
- Figure 14 Collection of Bushfire Data in NSW over the past 100 years [36]
- Figure 15 Victoria's major bushfires 2000-2017 [37]
- Figure 16 Victoria's major bushfires 2001-02; 2005-06 [38]
- Figure 17 Victorian Forest Cover 2018 [39]
- Figure 18 Extent and frequency of wildfires across the state of Victoria with the outlines of the wildfires that burned during 2019 and 2020. [40]

Recommendations

This work package presents a summary of the planning and regulatory framework required for landowners to build or rebuild dwellings according to the regulations in NSW and Victoria.

After recent years of catastrophic fires, both Australian states have recently restructured their regulatory processes to provide an improved bushfire management system focusing in ways to increase the community's prevention, preparation, response and recovery for bushfires. The recent implementation of the Australian Standard: AS 3959:2018 "Construction of buildings in bushfire-prone areas" in NSW and Victoria regulates the type of construction materials and introduces important changes that need to be addressed by the landowner during design, construction and occupancy phases. However, these additional mandates have not been clearly transmitted to the communities, thus creating frustration and anxiety for the landowners who have already experienced distress for their loss. Additionally, such requirements add extra costs and time to already onerous design and construction processes. Even though the regulations are important for the safety of the occupants and their community, the increased bureaucracy slows down the process of obtaining a planning and building permit and delays the community's recovery after a bushfire catastrophe.

The main changes imposed by AS 3959: 2018 are the updated classification of the BPAs to 6 levels of bushfire attack level (BAL), adding many restrictions in terms of construction materials and design provisions to areas classified as having a very high or extreme risk, such as BAL 40 or BAL-FZ. The BAL classification system is a function of variables which are particular to each property, and the states or local councils do not provide a mapping or pre-classification of each lot. Hence, each landowner is required to engage a professional that will make this assessment on a case-by-case basis. This imposes a further cost that, together with the additional time for completion of the necessary documentation, generates confusion upon the interested party. Additionally, as the variables that define the BAL are subject to change over time, so does the BAL classification itself. This means that it is possible for a property to be classified as BAL 29 when the permit is acquired but some years later, that property could potentially transition to a BAL 40 due to the changes in their surroundings, which are out of the landowner's control.

After the devastating fires in 2019-2020, it has become evident that bushfires are increasing in their spread and magnitude. Likewise, planning into the future with the fast and changing conditions in mind (i.e. preparing for warmer weathers and more and intense bushfire seasons) should incorporate a potential increase of a land's current BAL ratings. An allotment that today may be classified as BAL 19 or 20, soon could be classified as BAL 40 or ZF.

As a response to this adverse condition, a structured automated BAL assessment is recommended to be implemented where this classification is done. However, this should not be done by each landowner, but by the local council or state using digital technologies, special mapping software and the like that can provide a BAL classification per zone or property location. Enabling a suitable designation will avoid a long and costly process for landowners, while speeding the planning and building permit and design process. In a similar manner, this system could provide accurate information to the insurance companies allowing them to understand the risks and support estimates on rebuilding costs.

One step toward this could be for the government to build on current and existing programs. For example, the National Computational Infrastructure Australia (NCI) together with the Australian National University are working on developing a plan to incorporate satellite imagery in as part of a strategy for the bushfire prevention.[23] In partnership with various state, environmental and land agencies they aim to understand the fire risk situation at a local level while providing landowners information to plan prescribed burnings as part of their fire mitigation. With satellite image resolution of up to 500 metres nationwide, they are able to map the vegetation conditions. Hence, this system could also be used for local council to study and rate areas according to their BAL classification.

Another example is the collaboration between the Department of Planning, Industry and Environment (DPIE), CSIRO [24] and the National Landcare Programme [25] who have been researching in remote sensing of vegetation to track changes in the rangelands. Recent developments are providing additional details of the vegetation conditions such as the length of the tree crown lengths, woody and non-woody vegetation, hillslope erosion, etc. They have prepared maps that track the risk levels for wind erosion in Australia's agricultural areas. These satellite tools could be used to build on or create an automated system where local councils can pre-define the BAL rating for areas, aiming to simplify the process that each landowner needs to engage.

Currently, when a landowner needs to rebuild in a BPA the planning, building and occupation permit process is not straightforward. Each process requires a medium to high level of skill to first understand the sequence of events and their many stages, while figuring out the different reports that each landowner has to prepare and submit (i.e bushfire site assessment, bushfire hazard landscape assessment, bushfire management statement, etc.). The arduous and long procedure is not practical nor cost-effective when trying to quickly rebuild and provide relief to a community after a disaster. Eventually, and after obtaining the necessary permits, when construction of their home starts, the landowners are likely to be faced with shortage of skilled tradespeople and materials [26-28], which is a predominant condition in rural areas, regardless of a bushfire taking place or not. Further to the extended rebuilding costs in rural areas, little to no temporary housing is generally available for the tradespeople, construction managers and others who are involved in the reconstruction effort. This situation raises an additional logistical complexity and cost, which will ultimately be assumed by the landowner.

Rebuilding after a bushfire is difficult, not only because families are devastated and emotionally drained but because the recovery processes established by institutions has proven to be slow, complex and inefficient.[26] Governmental agencies are inclined to respond to the shortage of materials and labour during the reconstruction 'boom'. But as families take time (sometimes years) navigating into the permit process, they miss the market opportunity hence face the lack of materials and labour and increase in costs when they start their reconstruction process.

Examples show that when post-disaster reconstruction is slow, frustrated home owners take their own action building without the proper compliance, supervision and quality. As a result, most rebuilt residences end up with construction defects and failures associated with poor building workmanship.[29] Frustration on the slow process was also experienced by Victorians in the aftermath of the 2009 bushfires, where new regulatory policies, shortage in materials, lack of skilled labour and increasing costs was part of the burden families had to face during the recovery season.[26] An example of the regulatory complexity during this rebuilding period was evidenced when the newly developed BAL rating systems had an impact specially for those constructing in the BAL-40/FZ zones as the specialised materials where difficult to acquire led to an increase of time and cost for landowners to rebuild.[26,27]

Providing prefabricated homes as a solution can help solve some of these issues.[28] As prefab housing would be constructed in an offsite area, these houses could be ready to transport immediately once the bushfire has finished, with minimal labour needed. Prefabricated houses can be designed and constructed in a controlled environment to comply with BAL 40, the second to last highest level of risk. Indeed, their use can be viable in many critical bushfire scenarios, including areas conservatively rated lower than BAL 40 and where the BAL can be expected to rise.

A house having this kind of design, with high-level manufacture and assembly techniques, can provide enhanced and safer conditions during construction, deliver a better performance during occupation, and potentially be a more cost-effective solution than a dwelling built on site. Building surveyors could pre-approve these options on the manufacturing site and reduce the onsite inspections/approval process currently undertaking, further reducing time and cost for the landowner.The reduction in time and cost during the permit, design and construction processes is expected to facilitate a fast-tracking permit system by the local government which can be in line with their regulation process.

The prefab house could even serve as a quick temporary dwelling to bring relief to the community after the disaster, enabling a transformation into a permanent dwelling while coordinating all the permit and regulation process. Furthermore, a modular design of the dwelling may be applied to allow for expansions of the home as needed by the occupant or when more financial resources become available. However, this alternative needs to be explored further as moving from a temporary to permanent requires a design framework that plans and designs considering its prospective durability and opportunity to grow into the future.[30] Additionally, issues of regulation, building permits, taxes and compliance need to be explored.[31]

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Appendix

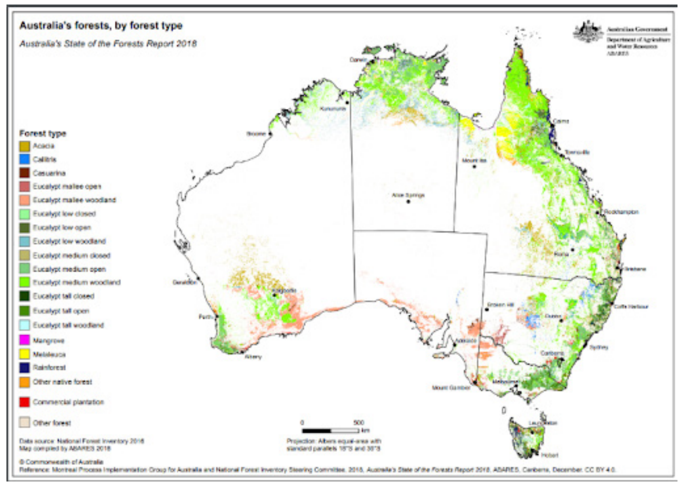


Figure 8: Australia's state of the Forest reported in 2018 [32]

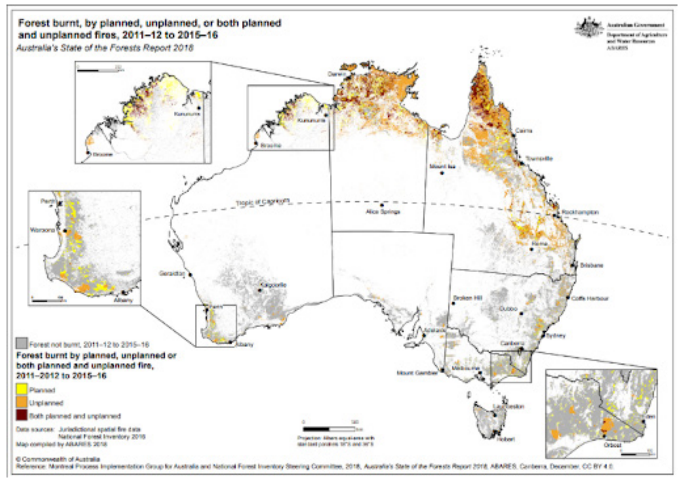


Figure 9: Australia's state of the forest burnt (2011-2012; 2015-2016) [32]

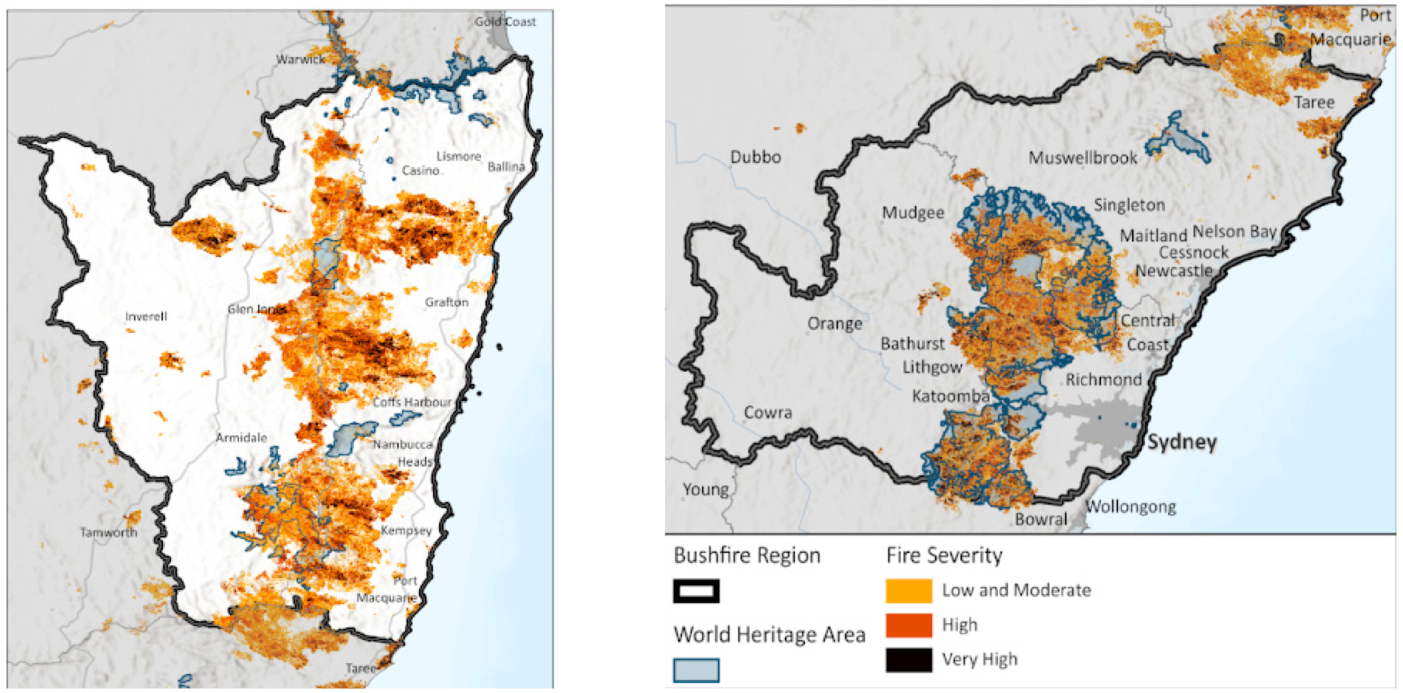


Figure 13: Impacts of the 2019–20 bushfires in the Rainforests of NSW north coast and tablelands (left) and blue Mountains (right) of the 2019–20 bushfires [35]

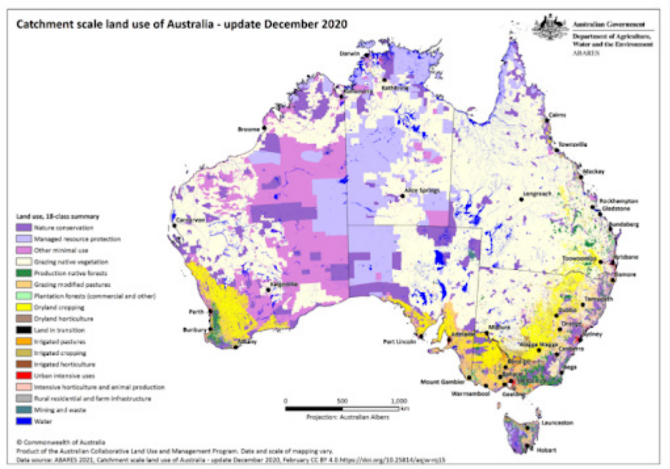


Figure 10: Australian planning land Use 2020 [33]

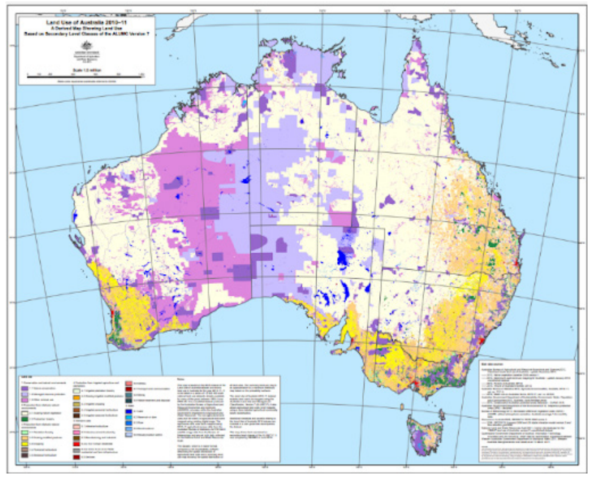


Figure 11: Australian planning land Use Australia 2011 [33]

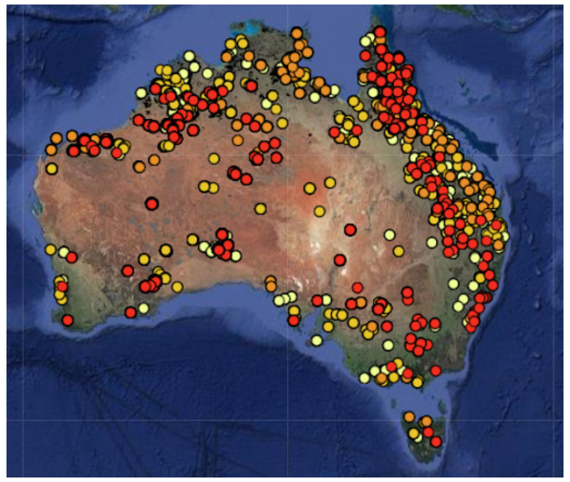


Figure 12: Satellite view of areas burnt in Australia in the past 2 years [34]

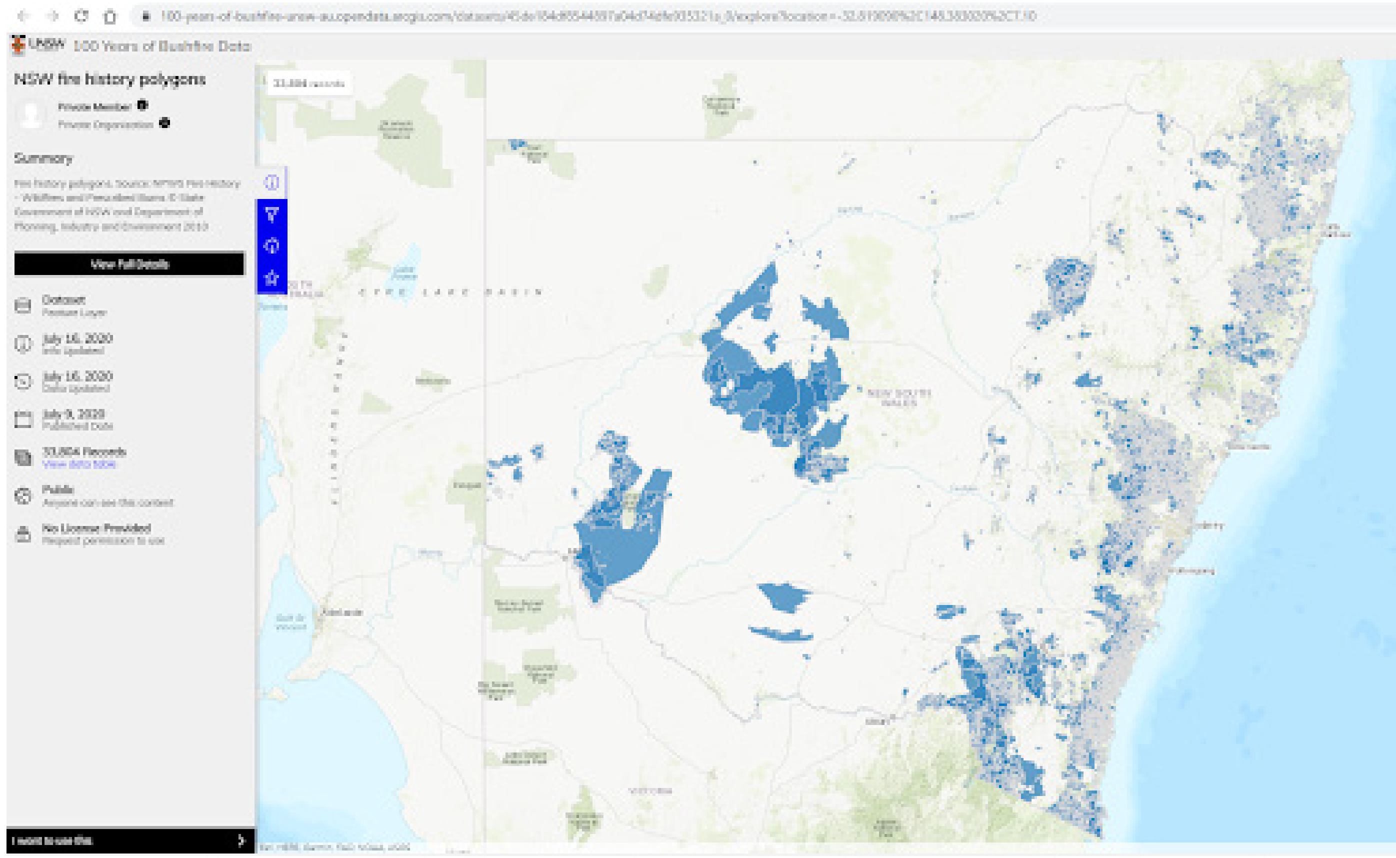


Figure 14: Collection of Bushfire Data in NSW over the past 100 years [36]

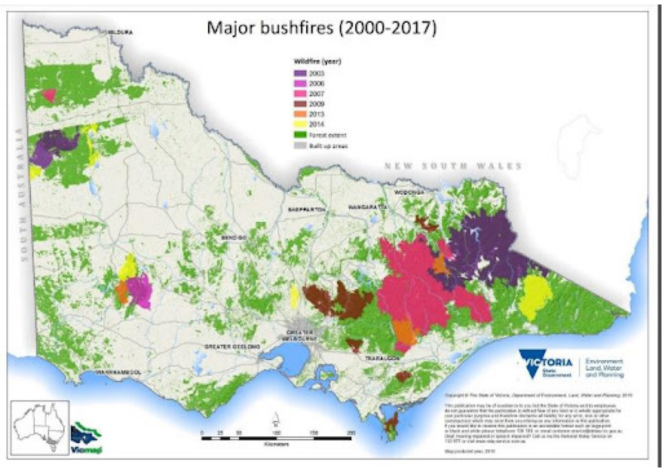


Figure 15: Victoria's major bushfires 2000-2017 [37]

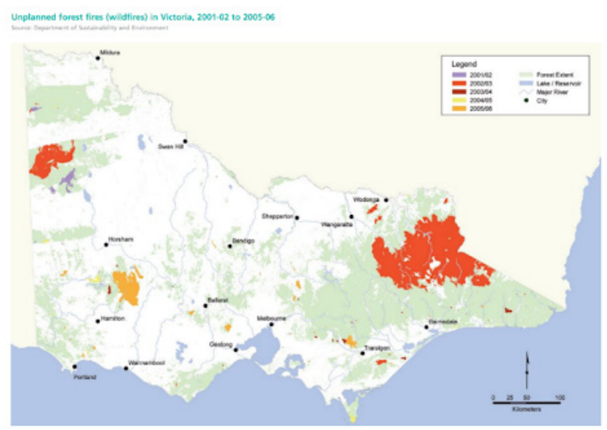


Figure 16: Victoria's major bushfires 2001-02; 2005-06 [38]

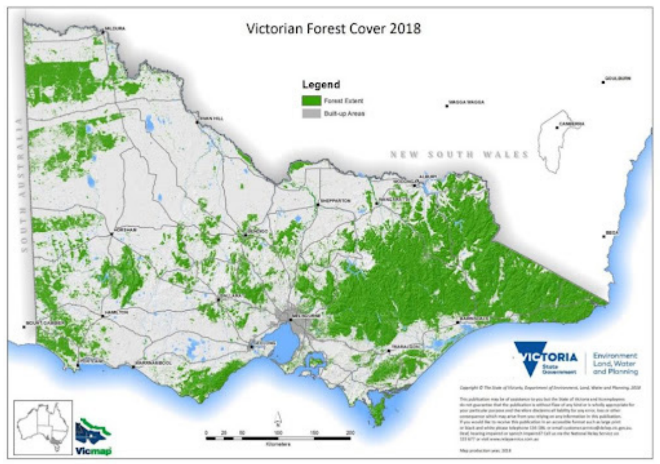


Figure 17: Victorian Forest Cover 2018 [39]

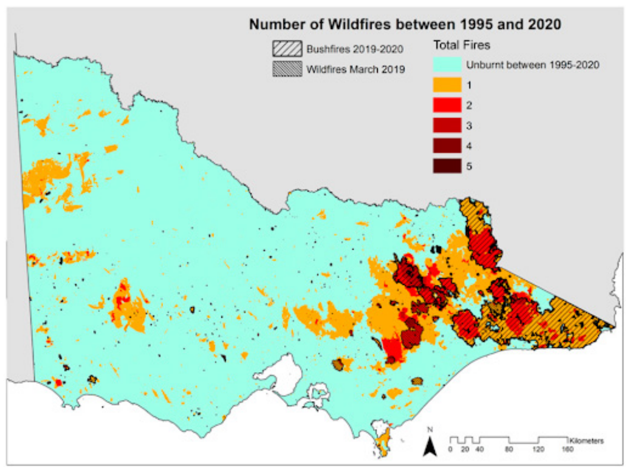


Figure 18: Extent and frequency of wildfires across the state of Victoria with the outlines of the wildfires that burned during 2019 and 2020 [40]

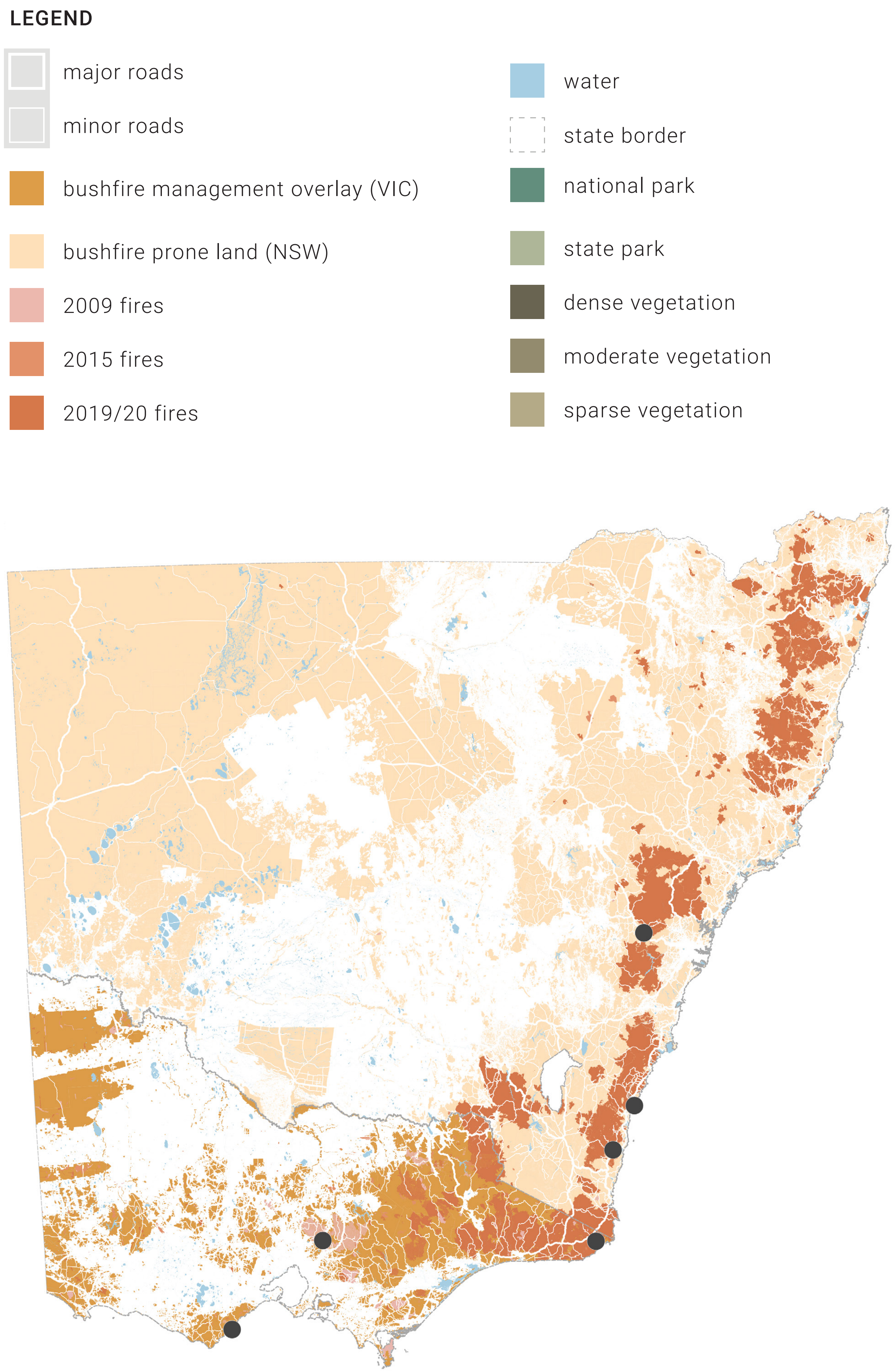
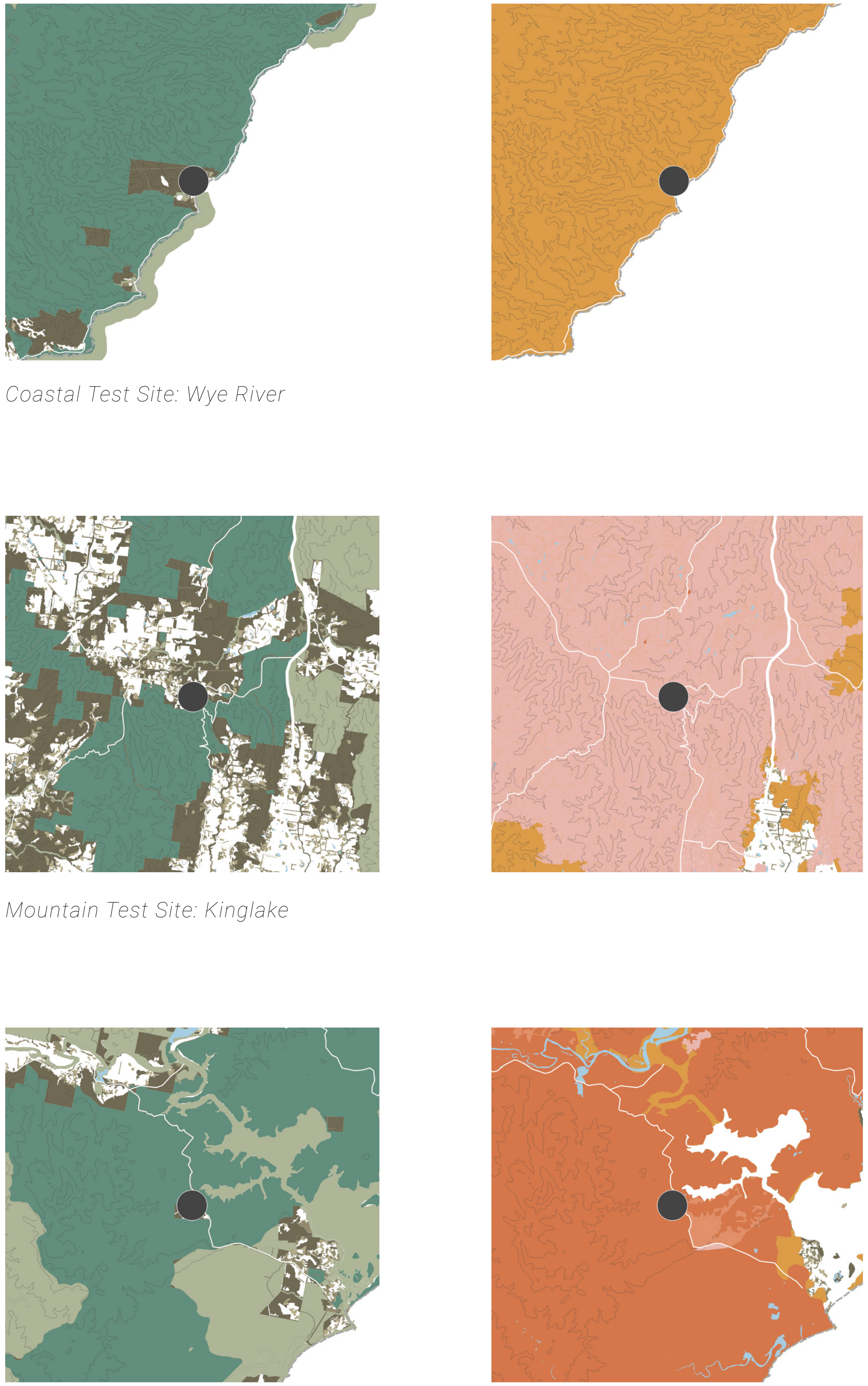


Figure 19: Fire in NSW and VIC

VEGETATION

FIRE



Coastal Test Site: Wye River

Mountain Test Site: Kinglake

Rural Test Site: Mallacoota

Figure 20: Victorian test sites, 1:250,000

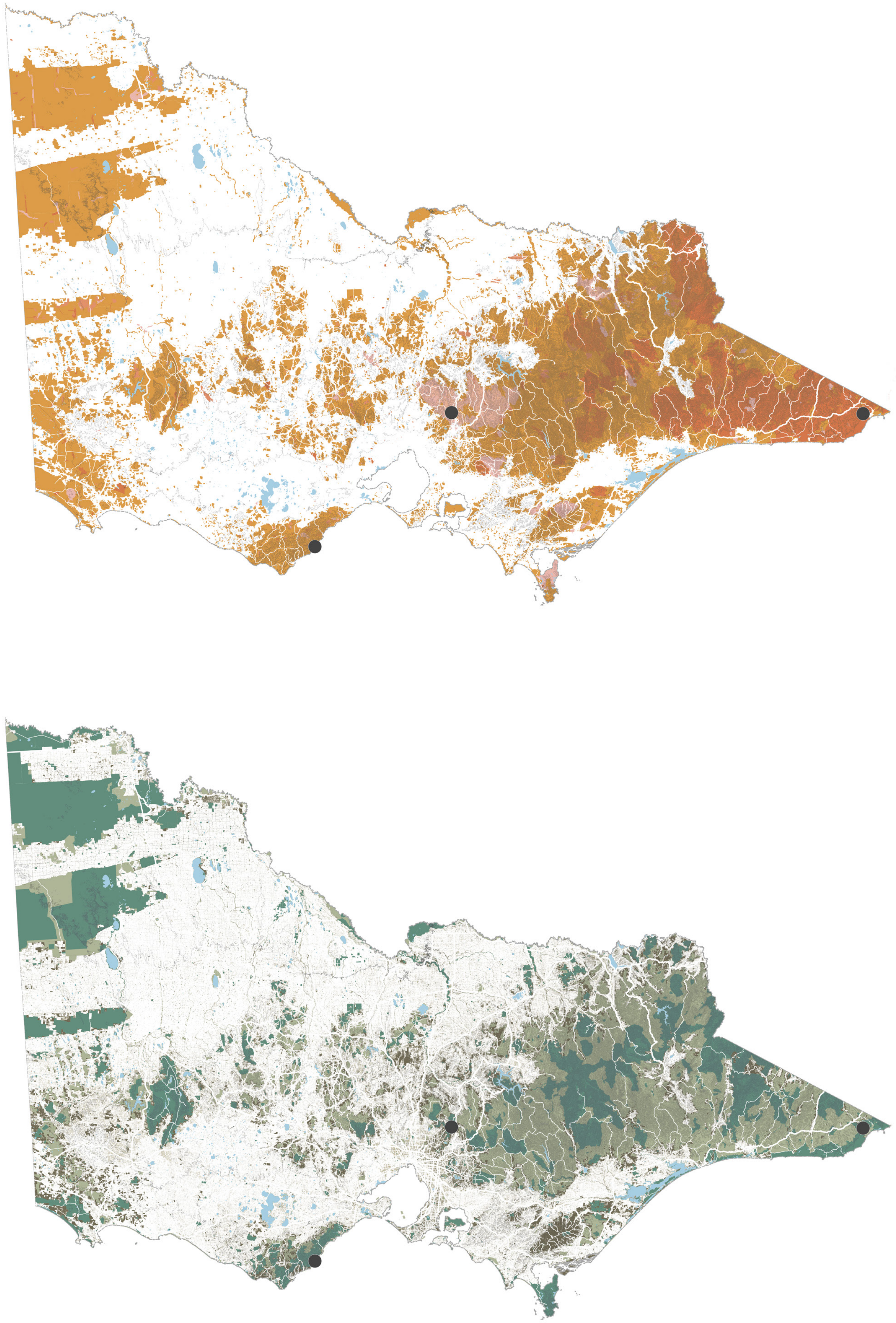


Figure 21: Victorian fire and vegetation

CHAPTER 5

Human Experiences of Prefab Housing for Bushfire Relief; Complexities, Barriers and Opportunities

Introduction

Research has shown that disaster-affected populations have been found to have, years after the event, 'a high prevalence rates of mental health problems, including acute stress disorder, post-traumatic stress disorder, depression, anxiety, separation anxiety, incident–specific fears, phobias, somatization, traumatic grief, and sleep disturbances.'[1] In response, scholars have identified five elements they consider to be essential preventative interventions, the first of which is a sense of safety.[2] For bushfire affected communities, this sense of safety is intrinsically linked to shelter and housing. As one survivor simply puts it: 'I didn't want to go anywhere else, I wanted to go home.'[3] Another, struggling to get their home rebuilt, explained, 'to people who have lost everything…mental health is getting out of a caravan.'[4] This argument is also supported by a longitudinal study conducted by Australian scholars about the recovery process after the Black Saturday bushfires, who found the number one stressor for survivors was managing the practical rebuilding or reestablishment of homes, farms and businesses.[5]

> *Many studies show that long-term poor mental health outcomes for disaster-affected people are predicted by post disaster stressors. Despite this finding, existing recovery frameworks vary in how these stressors are conceptualised. […] Participants identified the biggest problems as managing rebuilding processes, managing their own mental health, memories of the Black Saturday fires, and concerns for their own family.*[6]

The human experience of obtaining and living in temporary accommodation and rebuilding homes is a factor that is often undervalued or overlooked in the development of housing solutions for bushfire affected communities. Given the extended time that it takes for permanent homes to be approved and rebuilt, those affected by bushfire and other disasters are often living in temporary accommodation for a number of years. As a result, the design and amenity of temporary housing options have the potential to have a significant impact on their daily lives (and recovery) for an extended period of time.

Figure 1: Bushfire effected residents reported feeling lost and disempowered in the aftermath of the fires. Image credit: The Guardian

Common experiences and priorities of those affected by bushfires include:

- *Feeling Lost*: Many want to get back to their properties/land asap. There's often not anywhere else to stay because everything has been burnt.
- *Decision fatigue and mental fog*: Need clear options and simple processes or they get overwhelmed.
- *Feeling Powerless:* Often can't choose anything for yourself (clothes etc). A mentality of you get what you're given and shouldn't complain.
- *Anxiety about pets and animals:* People want to return to their animals/livestock, especially if they've been injured. They also highlighted the need for sheds/fences/chicken coops/etc.
- *Need for a hot shower*: A very popular feature for people who have returned to live in caravans and sheds on their properties.
- *Feeling Stalled:* Everything about your life gets put on hold while you are trying to rebuild/recover. It's hard to accumulate new possessions if you have nowhere to store them.
- *Small steps:* Many people took to gardening/planting trees on their properties as a therapeutic way of re-grounding and a way of making any kind of positive progress.

Methodology

For the purposes of this chapter, the Black Saturday Bushfires of 2009 and the Black Summer Bushfires of 2019/2020 offer the most recent and impactful experiences to draw from. A literature review was therefore conducted of journal articles, media articles, interviews, and documentaries about the bushfire recovery experiences and processes for both events, with a focus on housing in particular. Ethics approval was also obtained for an interview that was also conducted with a Mallacoota resident who lost her property in the Black Summer bushfires.

Figure 2: Many residents are still living in sheds and caravans as rebuilding progresses at a glacial pace. Image credit: New Yrok Times

Analysis and Content

While residents were reluctant to criticise specific temporary accommodation offerings, the review indicates several key areas relating to housing could be better addressed. These experiences include:

- *Confusing*: Unclear processes in immediate aftermath of bushfire
- *Disempowering*: Limited choice of temporary accommodation options available
- *Slow:* Lengthy timeframes for site clean-up and delivery of temporary accommodation
- *Distraction:* Temporary accommodation as a financial diversion
- *Vulnerable:* Length of stay in temporary accommodation often cycles through several fire seasons
- *Impersonal:* Very little opportunity to customise accommodation
- *Exasperating:* The transition from temporary to permanent accommodation strangled by red tape.

Confusing: Unclear processes in immediate aftermath of bushfire
Many of the first-hand accounts regarding bushfire recovery processes are dominated by frustrations about how confusing they were and how people had been left to fend for themselves in the immediate aftermath of the fire. It is important to acknowledge that the procurement of temporary accommodation and reestablishment of homes occurs within a context of trauma. Many of those affected referred to having decision-fatigue and 'brain fog' during the postdisaster recovery process, which severely affected their capacity to navigate complex negotiations.

As one survivor explained: 'You've got fire brain, you're traumatised, you're running on adrenaline, you're filling out a bunch of paperwork, you're running after this grant and that grant, you're sitting in queues…One day this charity is offering $500, then another is offering $1000. And that took a toll. It seemed like for months we were chasing grant leads.'[7] The study of the recovery process of the Black Saturday bushfires also emphasised this experience, highlighting;

> *the importance of understanding the real and complex secondary stressors in a postdisaster environment, where the rebuilding of lives involves not only the reestablishment of the built environments in which people live and work, but the complex psychosocial demands that arise in these contexts of extreme change, loss and trauma.*[8]

This suggests a need for clear and concise processes, that are well-coordinated and resourced. This was reiterated by a local politician who stated 'the paperwork and red tape can be difficult to understand at the best of times but it's even more difficult for people experiencing trauma and dealing with the mental, emotional and physical stress of rebuilding after the fires.'[9] Another bushfire survivor also argued that 'putting the onus on bushfire survivors to navigate a confusing recovery system has disadvantaged older and less computer literate people, resulting in many missing out on grants they were entitled to.'[10] Another respondent to the study of the recovery process of the Black Saturday bushfires described the negotiation of payouts, funding applications and policies as a major frustration, stating:

> *There're so many all at once. It's hard to specify just one. Insurance, dealing with the insurance side, settling the claim. Dealing with VBRRA [Victorian Bushfire Reconstruction and Recovery Authority], telling us to apply for grants and then knocking us back. The grant application process. The building, initiating the building process. Trying to find a builder who would build up here.*[11]

This experience was reinforced by another respondent, who also reinforced the need to minimise reliance on multiple tradespeople to provide temporary accommodation, stating,

> *The biggest stress was trying to get workers, contractors, things like that. To get the fences and the roof replaced and other things like electricians and plumbers—people like that.*[12]

Figure 3: Temporary Accommodation pods ready to be deployed outside Cobargo.
Image credit: New York Times

Disempowering: Limited choice of temporary accommodation options available
The Mallacoota resident pointed out that the experience of not knowing exactly what type of temporary accommodation they were going to get until it arrived was disempowering. Similar to other first-hand accounts, she was at pains to acknowledge her gratefulness for the accommodation, whilst also reflecting on the fact that it was frustrating not being able to have a choice in the matter. This sense of powerlessness is exacerbated when residents then find themselves living in temporary accommodation for years beyond their original expectations.

Slow: Lengthy timeframes for site clean-up and delivery of temporary accommodation
During our research it also became clear that people greatly underestimated how long it would take before they could start rebuilding. While the Black Summer bushfires in particular were hampered by the COVID19 pandemic and subsequent material shortages, others cite excessive bureaucracy, planning delays and a lack of government support as key factors contributing to the delay.[13] This argument is supported by the analysis of the Black Saturday bushfire response (which occurred prior to the pandemic and subsequent supply chain crisis) which found the biggest issue to be

Figure 4: Site clean up is often slow and hazardous, with the assumption of asbestos contamination. Image credit: The Guardian

frustrations with planning delays and rebuilding.[14]

These delays also include the clearing and clean-up of properties, in order for rebuilding to commence. This is particularly important because most insurance policies stipulate that the rebuild has to start within 12 months or the policy is voided.[15] Referring specifically to clean-up delays, one survivor explained,

> *I go out there and I look through the rubble of what's left and it's just a constant reminder. We just couldn't stand always looking at our house flattened, all our belongings destroyed. We just want to move on, we just want to build a new home and go home and the longer it drags on, the harder it is*.[16]

Many councils have recently been forced to extend the two-year exemption period that permits residents to live on their properties in temporary accommodation while they rebuild because of these delays.[17] As one Victorian resident explained, 'even at the planning stage with local council, we had to wait several months just to get the planning permit on a place that already had a house on it before the fires came through.'[18] No official government estimates exist regarding how many homes have been rebuilt across NSW and Victoria to date.

Pete Williams (a Disaster Recovery Expert with Deloitte) estimates only 15% of homes have been rebuilt in Victoria in the three years since the fires and out of the 380 places destroyed in East Gippsland and Mallacoota VIC only 44 have been rebuilt.[19] At November 2021, in two of NSW's worst affected areas – Bega Valley and Eurobodalla – less 8% of survivors have finished rebuilding.

Williams also suggested another contributing factor in the delay is the fact that a lot of the affected properties in Victoria are very remote (towns affected by Black Saturday were less remote).[20] This increases the difficulty in getting supplies and workers to the remote locations. After the immediate impact of the pandemic subsided somewhat, a shortage hit in construction materials and labour. This was brought about by delays in shipping materials from China during the pandemic and various government stimulus packages that created a construction boom such as the $25K HomeBuilder Scheme.

The increased demand took workers and materials away from bushfire rebuilding projects, especially those in remote areas. Another factor was that many of the bushfire victims also signed contracts right before the pandemic struck, before the price of materials increased, and builders were less likely to action projects that were now under-priced and therefore harder to deliver in ways that didn't leave them out of pocket.[21]

Distraction: Temporary accommodation as a financial diversion

In a 2022 Guardian podcast entitled Survivors of Australia's bushfires still waiting for homes, one interviewee stated that they got no immediate help from local authorities or agencies after they lost their property and they had to figure out how to get water and food themselves.[22] They organised their own clean-up of their property about a month after the fire. It took two months for a company to come in and start assisting them with the clean-up and three months for the BRV (Bushfire Recovery Victoria) to provide them with a caravan for them live them.

About a year after the fires, they were able to sign an agreement for a government funded temporary accommodation pod with BRV, though they were in two minds about whether it was worth it. By then they had put together a makeshift accommodation solution themselves and considered the temporary accommodation to be 'a distraction' from the main objective, which was to rebuild their permanent home.[23] While the state government has funded the construction of the temporary homes (coming in at about $150K each), survivors then have to lease them, paying the equivalent of social housing rent. BRV Modular Homes cost up to $205 a week depending on the number of rooms (though it is worth noting that the rent can't exceed 25% of a household's total income.) Many bushfire affected residents feel that these rental payments take funds away from the main goal; constructing a permanent home.[24]

Another interviewee on the podcast pointed out that when you include the cost of transporting the modules, the project management of the installation and removal of the structures, the overall cost starts to approach the equivalent of building a permanent house.[25] While acknowledging the need for immediate housing relief, the interviewees felt that the government is investing in very

Figure 4: A bathroom pod being installed in a shed as a work-around for a disabled resident in a temporary accommodation pod, so they can shower while they wait for the rebuild. Image credit: The Guardian

expensive temporary solutions where they would rather have seen that money go towards the faster reconstruction of permanent solutions.

Vulnerable: Length of stay in temporary accommodation often cycles through several fire seasons
Many of the bushfire affected residents also flagged the insecurity of their situations as they wait for rebuilding to commence as a key issue. As one bushfire affected resident put it,

> *'We desperately need to feel stable and we don't.'*[26]

Navigating insurance deadlines, coupled with impending deadlines of rental terms and permits for temporary accommodation increases anxiety and stress. Many first-hand accounts refer to the uncertainty of life in temporary accommodation as being a significant barrier to mental recovery.[27] In other instances, bushfire victims have unwittingly made their situation more precarious by selling their burnt-out properties and buying land in town to rebuild in safer locations. Because they have moved, they are no longer considered to be 'bushfire affected' and are therefore ineligible for planning prioritization by local governments. One resident, who lost their house and is now living in a temporary shed on the new block waiting to build, described the assessment of no longer being bushfire affected as 'Orwellian.'[28]

Other bushfire affected residents also point out that the delays mean that they are spending years living in non-compliant temporary accommodation on the very sites where fires took everything they owned. The Mallacoota resident suggested that this makes people feel very vulnerable and acts as a trigger for feelings of insecurity and anxiety, especially if the length of their stay in temporary accommodation cycles through several fire seasons.[29]

Impersonal: Very little opportunity to customise accommodation
There is very little opportunity to customise temporary accommodation, especially as the temporary structures are typically rented and need to be returned in the condition in which they were delivered (after which they are deployed to other disaster affected areas). This means residents can't make simple modifications like adding hooks for pictures or washing lines. On a more significant scale, it also means residents can't make modifications for disability access and suitability. One media article described the challenges faced by the Jees family in Cobargo,

> *Life in their tiny temporary accommodation has been hard, even before an unseasonably wet year that now has them fighting mold. Because the Jees' third son, Mason, 16, has muscular dystrophy, he cannot use the cramped, camp-style shower in the pod. Before the new bathroom was installed in a newly constructed shed [two years after the fires], every time he wanted to shower, he had to go to his grandmother's house, a few miles away.*[30]

As a lot of the temporary accommodation options that were on offer after the Black Summer bushfires were prefabricated modules, there is very little opportunity for residents to have any input in the design or layout.

Exasperating: The transition from temp to permanent accommodation strangled by red tape
Many of the first-hand accounts regarding bushfire recovery processes cite excessive bureaucracy and complex planning processes as being a major stressor, with one resident describing their experience as 'bureaucracy-induced trauma.'[31] Another respondent to the study of the recovery process of the Black Saturday bushfires described a similar experience, citing their main issue as:

> *Bureaucracy. Lack of communication both internal and external within departments, between agencies. So having to repeat the same things, fill out forms and having to continuously repeat and having to answer the same questions when all this data was being collected but not centralised. That I found extremely difficult, from the practical side of the time it takes in having to apply for things and also from the psychological side—it retraumatises people.*[32]

The Guardian has recently reported that many of the support services are being withdrawn (the deployment of case managers from state government agencies has ended and mental health programs are finishing) leading to local advocates hitting out at what they see as the abandonment of bushfire survivors, particularly in light of the fact that only 7.5% of survivors have finished rebuilding.[33] An article in the New York Times seconds this, reporting earlier this year that barely one in ten families in the affected regions have finished rebuilding, accurately predicting that local anger about this issue would influence the outcome of the election.[34]

Residents have also struggled with inflexible planning policies and requirements. For one family in Cobargo, obtaining a planning permit involved a wall of planning paperwork; 'legacy planning issues with their previous home, changes to the development law, meant that at one stage it looked as if they might never be permitted to rebuild.'[35] This experience is not uncommon, and like many, they described the application process as a nightmare.

Bushfire affected residents also reported a similar experience with Country Fire Authorities (CFA) officials, who are typically required to endorse the siting and location of buildings in rural areas.[36] Bushfire affected residents also pointed out that many of the fire officers were still traumatised themselves from fighting the recent fires, and were therefore possibly not the best placed to be making these assessments.

First-hand accounts of the bushfire recovery experience also indicate that many residents have ended up outsourcing the planning application to reduce their stress levels.[37] The Mallacoota resident indicated that she did the same, despite the fact that she is a trained architect with professional experience in compiling lodging complex planning applications.[38]

Recommendations

Deloitte Disaster Recovery Expert, Pete Williams, believes that while there are temporary accommodation options available there is an absence of strategic long-term accommodation options and solutions.[39] This is evidenced by the fact that the management of the rebuilding process is a primary stressor for bushfire affected residents.

Factors that need to be taken into consideration include:

- Clearly explained and accessible processes in immediate aftermath of bushfire
- Temporary acoomodation designs to minimise reliance on multiple trades
- Capacity for choice of temporary accommodation options available
- Strategic approach for site clean-up and delivery of temporary accommodation
- Design capacity for temporary solutions to develop into permanent housing
- Design ability to fire proof temporary accommodation as fire seasons approach
- Design to support the opportunity to customise & personalise accommodation
- Less overlapping bureaucratic paperwork and red tape.

The human experience of bushfire recovery needs to better taken into account in the way immediate housing solutions are designed and procured. Better governance of the rebuilding process is also required to avoid additional stress for trauma affected survivors, as well as lengthy and unnecessary delays. As one resident explained, in relation to temporary accommodation offerings,

> *We're very, very thankful but it's not like being at home, and the longer it drags out, it just starts to destroy your soul…we just want to go home.*[40]

Endnotes

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15 ABC News. Gippsland bushfire victims urge Grocon to hasten clean-up so they can return and rebuild. Kellie Lazzaro. 20/04/2020
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22 The Guardian Full Story Podcast: 'Survivors of Australia's bushfires still waiting for homes.' Laura Murphy Oates and Natasha May 3/05/2022
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CHAPTER 6

Principles and Approaches to the Design of New Prefabricated Housing Solutions

Introduction

The review of policy and regulatory frameworks relating to existing prefab housing provision, transport and assembly, and the human experiences of bushfire recovery and prefab housing has established that complex settings are at play when providing housing in these contexts.

There is already an established range of prefabricated products offering solutions in this domain in Australia. These products range from the provision of reasonably effective and simple short-term solutions in the immediate aftermath of disaster, to longer-term options via permanent housing products that deliver high quality fire and sustainability performance criteria.

However, the evaluation of precedent prefab housing projects illustrates that although many examples perform well on the more obvious aspects like design quality, fire resistance and prefabricated construction methods, they are performing less well on a range of other issues like affordability, flexibility and types of procurement aligned to bushfire and disaster recovery. Many examples of prefab housing offer standardised rather than customised solutions, and do not allow people to participate in either the design or construction process despite this being desirable for trauma affected communities. Although there are case study products offering short-term emergency accommodation, as well as permanent replacement home products, there are no examples which offer a solution for both the short term and long-term – i.e. there is no 'kit of parts' approach that allows rebuilding incrementally over time from the emergency aftermath of a disaster right through to longer-term solutions.

Based on the review of transport, logistics, and regulatory frameworks it is also clear that the locational distribution of bushfire and flood affected areas is mainly in remote and regional areas. For transport and assembly logistics these locations carry additional challenges because of restrictions in haulage and heavy vehicle regulation for roads which then affects on-site delivery capability and limits the types of construction assembly that use mechanised plant. These aspects limit the scale, volumetric scope, and mass of modular or volumetric products, as well as affecting assembly options. The building regulatory and planning frameworks for bushfire affected areas also create complex and demanding bureaucratic frameworks in relation to building and planning permits, because of construction codes and bushfire management overlays. These regulatory requirements - and their permission protocols - affect the affordability and practical timelines for rebuilding, especially when using building procurement systems or products that are not traditional as with prefabrication. All of these aspects provide potential barriers to prefabricated solutions.

In conclusion it is clear that housing solutions for bushfire and disaster affected areas are complicated by a wide range of specific settings, scenarios and conditions that mean the advantages of prefabrication in terms of design and technical performance are not the only values that need consideration.

Understanding that "industrialized housing is not merely a technological system but a total system" the initial review stage of this research has established that the components of this system for bushfire and disaster housing are extremely diverse and wide-ranging.[1]
They range from:

- the differential requirements, from the short-term needs of post-disaster emergency shelter to the long-term desire for the reconstruction of permanent homes
- the challenges of geography, topography and site location leading to difficulties of logistics, supply chain and transportation to remote and mountainous areas
- the challenges of technical, material and service specifications for fire-resistant or resilient forms of construction in relation to the regulatory constraints of bushfire affected zones, and the process of permissions required
- the economic and financial toll of recovery for individual householders including extended timelines for emergency and longer-term rebuilding
- the specific needs and preferences for housing form and functionality, and the desire for agency and participation in the rebuild process by those affected as a part of the recovery process.

In the second stage of this research, we have drawn on the findings of the review stage and acknowledged the wider systemic components at play, utilising a methodological framework to generate a design template for a prefabricated housing solution.

The methodology draws on scholarship and research in the field, including a problem-solving approach laid out by Aitchison et al, which addresses how to consider the multiple and complex parameters embedded in housing solutions for bushfire and disaster affected areas.[2] The process is structured as follows:

- Identify, through the review, all the parts of the system that come to bear on housing needs for bushfire and disaster affected regions.
- Determine the various 'settings' or 'objectives' or 'ends' for each of these parts – to satisfy the needs identified.
- Develop or design possible solutions for the parts of the system, integrating these with the goal of creating a 'scenario' approach.

In this Chapter, we will consider the first two steps, which will effectively establish the objectives for a design solution. We will also explain how an approach to 'timeline' via the use of the story board 'scenario' has framed how we approached the design proposals. In Chapter 7 we will explain in detail the prefabricated housing solution design that has been developed, including mapping it out in relation to a series of tested design scenarios.

Identifying the Parts of the System

It has been demonstrated in previous research that developing successful prefabricated housing solutions holds particular challenges, because "unlike other product manufacturing sectors, and because of myriad differences between every project and its site, industrialised housing is an exercise in diversity not similarity."[3]

In other words, the systemic interactions between housing and its broader interactions with building regulation, finance and land create complexity in relation to context. These interactions have often prevented the development of successful 'one size fits all' models for housing. Quite the opposite, prefabricated housing solutions have had to consider customisation, and the development of solutions for highly specific regional markets and locations. So, it is arguable that housing solutions for bushfire and disaster raises the level of complexity and need for customisation even further.

In relation to developing an understanding of the broader system, Arthur Bernhardt's 'multi-factorial' diagram provides a good foundation.[4] Developed as part of a study analysing the interactions involved in the mobile home industry, his diagram attempts to visualize and identify both the mobile home industry itself (via its production system, its distribution system, and its 'park' or site systems) as well as the broader system surrounding it which he entitles the 'supporting environment'. This is clearly shown in the diagram (Figure 1) as two encircling domains, the inner system of the mobile home industry and wider system of what we might call related infrastructure - including building code regulation, highway regulation, finance, land use, taxation, transportation, and supply chains.

Using the conceptual logic of Bernhardt's approach, we can consider the diversity of elements

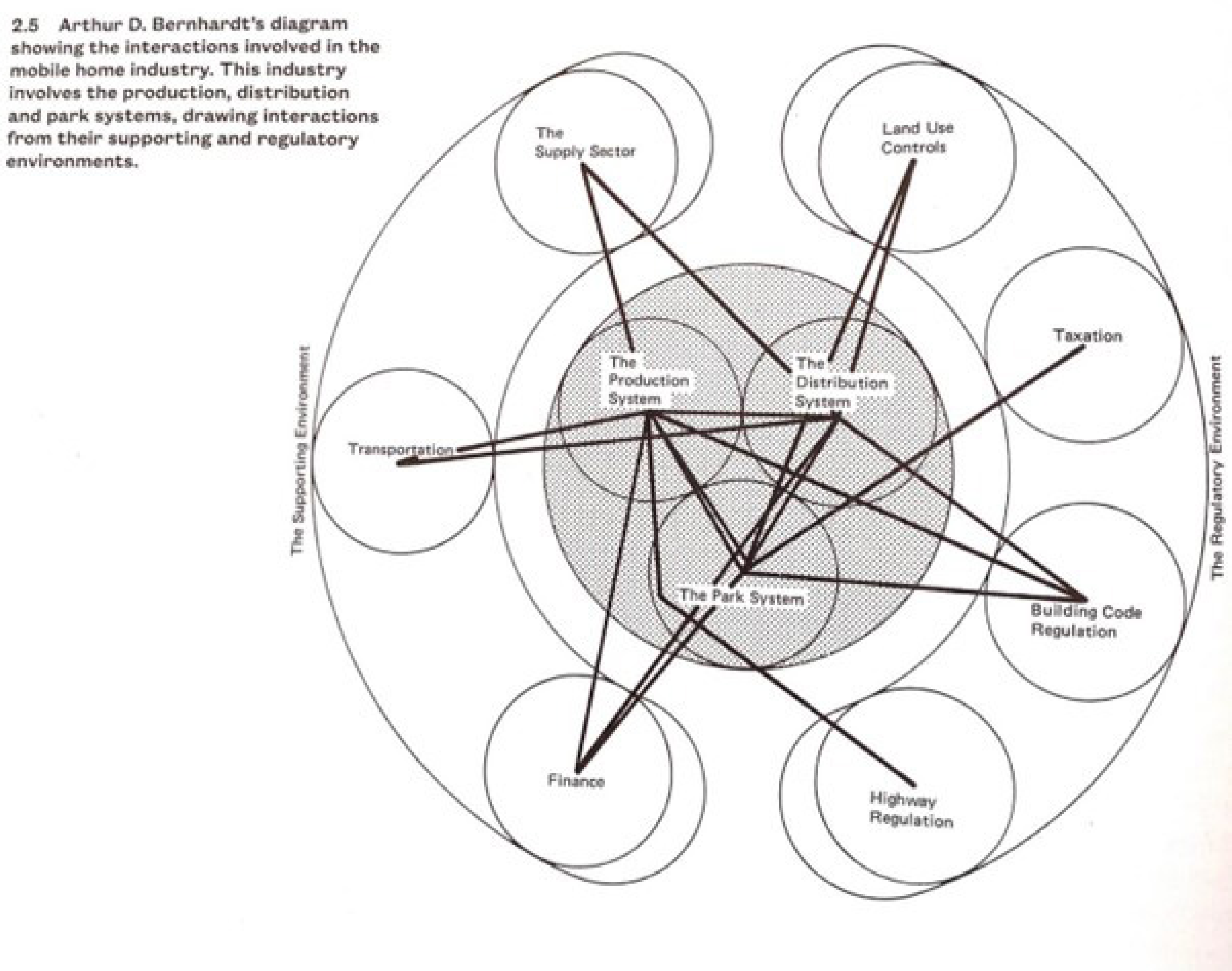


Figure 1: *Arthur Bernhardt's 'multi-factorial' diagram*

or 'parts of the system' in the bushfire and disaster housing context, through the lens of first, those parts connected to the prefabricated industrialized housing system, and second, those parts connected to broader environments and contexts.

This is best illustrated as a Diagram (Refer Figure 2) - Objectives for a Prefabricated Housing Solution for Bushfire and Disaster.

The Diagram has broadly used the four categories of evaluation criteria generated in Chapter 2 for the review of existing prefabricated housing case studies for bushfire and disaster contexts, since these provide a relevant set of usable 'settings' which are relevant to the prefabricated housing system. These categories are effectively the 'parts' of the prefabricated industrialized housing system that typically need to be considered when designing a new product or prefab solution for housing, as follows:

- Construction System
- Program and Performance
- Context
- Site Implementation.
-

In addition, however, there are also 'whole system' parts identified. These sit outside the prefabricated industrialized housing system and represent the broader environments and contexts at play. They have much in common with Bernhardt's 'supporting environment' domains in his multi-factorial diagram for the mobile home industry, and include:

- Finance
- Building Regulation
- Land-use Controls
- Transport Regulation
- Supply Sector.

Two new additions considered especially relevant to the prefabricated housing for bushfire and disaster context:

- Time
- Community.

Having established these relevant 'parts' of two domains or 'systems' via the explanatory diagram its then useful to undertake a second step which is to determine the various 'settings' or 'objectives' or 'ends' for each of these parts – to satisfy the needs identified. These are labelled in the diagram but also briefly explained below, including in relation to how these objectives are drawn and influenced by the identified parts of a wider system.

Identifying the Parts of the System

Construction System

Central to any prefabricated housing solution, the construction system can be defined as: the combined approach to construction methods for the core structure, walls and floor; a strategy for the manufacturing and assembly methods in terms of a volumetric, flatpack or hybrid approach; and a decision regarding material selection and finishes.

The specific objectives that have emerged from the review stage have highlighted the how these design decisions need to accommodate the remote and regional locations of bushfire and disaster affected communities. Broader systems of transport and highway regulation limit the scale, volume and mass of prefabricated elements and imply a hybrid approach with prefabricated pods and prefabricated panels to facilitate ease of transportation.

The topography, and geographic terrain of bushfire management overlay areas, suggests the use of discrete footings for ground works and a platform approach to the elements. In addition, broader supply systems are critical to consider in the selection of both materials and assembly approaches to this type of housing solution because of supply chain issues in remote and regional areas, and the paucity of labour on site. They imply a balance in the design of the panelised or hybrid elements toward easily available standardised sheet and material sizes, and the capacity for the hybrid use of traditional and semi-skilled building labour on sites. In fact, on-site assembly and incremental additions to prefabricated pods could be facilitated by accommodating the use of owner-builder or community labour force, dry trades and non-mechanised processes for later and panelised stages.

In conclusion the objectives emerging from the relevant parts of both the prefabricated construction systems, and wider transport and supply systems issues imply a 'kit of parts' or product platform approach using a combination of 'core' prefabricated volumetric serviced pods of suitable transportable dimensions, with a wide range of additional optional parts that could range from prefab panelised wall elements to include traditional constructed aspects.

Whole System

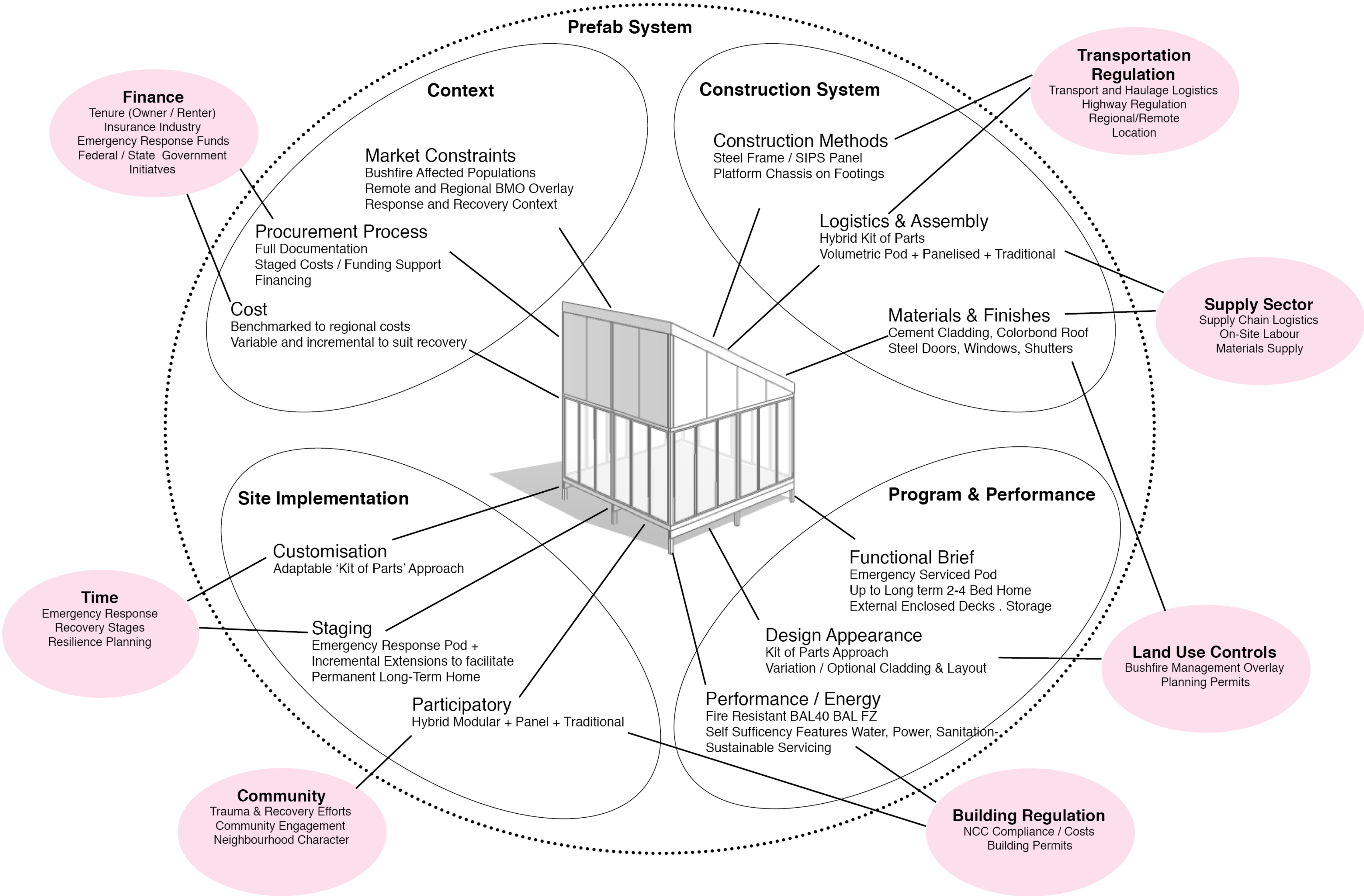


Figure 2

Program and Performance
Core to any prefabricated housing solution is how the spatial aspects of its design 'perform' across a range of functional, spatial, aesthetic, and regulatory domains. This includes aspects of the functional brief in relation to number of bedrooms, bathrooms and living spaces as well as external spaces; the design appearance of any solution in terms of how it works with neighbourhood character and in alignment with individual and community desires; as well as its practical performance in relation to energy, ventilation, heating, and light.

The specific objectives that have emerged from the review stage have highlighted how these design decisions need to accommodate and nest within the broader regulatory context of land use control and building regulations in the context of bushfire-vulnerable regions. The review of planning and regulatory frameworks has established the increasingly onerous government requirements for planning approval and building control in bushfire management overlay zones, as well as the levels of time, funding and skill required to navigate these domains in order to rebuild. These parts of the broader system are becoming increasingly dominant and unwieldy, affecting the level to which housing rebuilding even happens.

It is outside the scope of this study to consider how government regulatory systems can be adapted to facilitate rebuilding in bushfire and disaster affected regions, and particularly how some of the barriers to introducing prefabricated solutions could be addressed at the scale of industry and government partnership. But it does imply that further collaboration is needed from government and industry to address the serious extra time and cost delays that this part of the system can be responsible for.

It is, however, possible to see how prefabricated housing can address some of these issues. For example, high levels of bushfire performance (BAL40 and BAL FZ) can be achieved in factory-controlled environments. It is also clear that, in relation to the immediate requirements of emergency housing, the bushfire and disaster context can benefit from housing solutions that have built in high levels of self-sufficient infrastructure (solar power, water collection, waste solutions) to address disaster contexts.

The specific objectives that have emerged from the review stage have highlighted how the design decisions for this part of the system can utilise the industrialised production processes to deliver high quality design solutions with excellent regulatory and service performance, to provide durable and highly functional housing solutions.

Context
The broad context of any prefabricated housing solution relates to the level to which it is addressing a housing supply need, and consists of: the market constraints, meaning the specific needs, location and size of any projected market; the types of procurement processes for the housing that are suitable including approaches to obtaining finance via traditional or other means; and finally the cost of the final housing solution - which should be appropriate, and benchmarked to the market but which will affect other determinants including construction systems, program and performance.

The specific objectives which have emerged from the review stage are in part clear and obvious in relation to design decisions. Any prefab housing solution for this context should consider the specific needs of bushfire and disaster affected communities and individuals and be tuned to the specific conditions of use, meaning the need to accommodate a solution around an emergency response, at least as a primary first objective.

The broader system of finance and procurement is a particularly relevant player in this case given that the context of the procurement and deployment of emergency solutions will be set, at least in part, by federal and state government response and recovery protocols and processes. In addition, individuals will be struggling with a myriad of issues ranging from emotional trauma, to financial complexities, including the insurance dimensions inherent in the destruction of their original home and the need for rebuilding.

It is outside the scope of this study to suggest in detail how a prefab solution for bushfires could develop its procurement strategy hand in hand with government. However, case study projects like the BRV Emergency Shelter do suggest a precedent in which housing solutions are deployed as a collaboration between government and industry stakeholders as an emergency response setting. This might imply the need to consider how to 'stockpile', or otherwise consider storage and manufacture of emergency units, or their ability to be quickly manufactured in the event of a disaster.

In considering longer-term solutions to permanent rebuilding, our research has already established the problems associated with two distinctly different solutions to procurement – meaning short-term emergency response housing versus a longer-term permanent reconstruction of the home. As demonstrated in the review of precedents, individual experiences of short-term prefabricated accommodation (eg the BRV Shelter) becoming long-term is very problematic because of the negative effect living in temporary accommodation has on individual and community recovery.

In considering the broader procurement and finance systems for prefabricated housing solutions for bushfire, a clear objective is therefore to consider a 'combined' solution which can span from all the way from short-term emergency need through to long-term permanent home replacement. This implys a hybrid solution with an incremental process using a 'kit of parts' or product platform approach, where an initial prefabricated pod can provide the short-term accommodation, but where this pod is then incrementally extended over a period of time, to create a permanent home. Such a procurement approach could also address objectives around cost and finance.

Site Implementation
This category in the prefabricated housing system provides one of the core challenges to success. This is because of the myriad differences between every project and its site, meaning that industrialised housing must be adaptive and flexible in providing a diversity of customisable solutions. This has always been an inherent challenge to industrialized housing because of its need to adopt high levels of standardisation to remain competitive.

This part of the prefab system therefore typically addresses levels of customisation, meaning the capacity for the system to be flexible and adaptable. In addition, it can include the level to which the solution is able to be constructed incrementally, in stages, over time or extended and added to – and for these decisions to be made in part or whole by the user, or individual householder on demand (rather than just by the manufacturer for construction purposes).

The parts of the system related to site implementation have emerged as critical to this study, in part because they were the parts most poorly scored in the precedent case studies. This demonstrates that flexibility in implementation or 'short-term to long-term' based features in the case study housing are rare. In turn, this reinforces the message that flexibility and an incremental approach is a gap in the current prefab housing market provision. Therefore, this aspect has emerged as a clear objective which might address the very specific needs of this market.

In considering this aspect, we have also included two parts into the broader system, both of which create clear objectives for any design proposal.

The first is a consideration of 'time'. Housing for bushfire and disaster affected areas is a specific problem which is aligned to an 'event' – a disaster. The temporal aspect of a disaster and its aftermath are absolutely integral parts of the broader system impacting the design response to housing. This is because the response is very different based on time – from one week after an event, to six months, to two years – and so on. Therefore, considering the fourth dimension of time is key in solutions for bushfire housing.

Second, we have added 'community' as a part of the wider system which needs to be accommodated and considered. Just as a disaster is an 'event' so an event happens to a 'community', which generates both individual and community effects – from trauma, to financial loss, to neighbourhood transformation. Any housing solution needs to consider how it is responding to the community dimensions. Thus might range from the capacity of a prefab housing solution to be participatory or collective in its implementation process, to the way in which deployment of the housing solution affects or strengthens neighbourhood character in the long-term.

In conclusion, the objectives emerging from the relevant parts of both the site implementation parts of an industrialised housing system as well as the broader parts of the system related to disaster 'events', provides a clear path toward an incremental approach to prefab housing implementation which can be flexible across the immediate response and recovery stages of a disaster.

Endnotes

1 Herbert, Gilbert. *The Dream of the Factory-Made House: Walter Gropius and Konrad Wachsmann* MIT Press, 1984. p321

2 Aitchison, M, et al. *Prefab Housing and the Future of Building: Product to Process*, London, Lund Humphies 2018, pp56, pp103-104

3 Aitchison, M, et al. *Prefab Housing and the Future of Building: Product to Process*, London, Lund Humphies 2018, p78

4 Bernhardt Diagram reproduced by Aitchison et al. Bernhardt, Arthur D. *Building Tomorrow: The Mobile/ Manufactured Housing Industry,* Cambridge Mass 1980. p321

CHAPTER 7

A Developed Design Template for New Prefabricated Housing Solutions

Introduction

This chapter outlines the design template that has been developed for new prefabricated housing solutions. The housing solution responds to the four categories established in the Evaluation Criteria in Chapter 1 that were used to assess and analyse existing prefabricated and disaster relief projects. These categories also form the four key settings from which this chapter is structured. They are:

- Construction System
- Program and Performance
- Context
- Site Implementation.

Additionally, the design responds to the settings of time and community with a proposal that can be deployed across a number of stages; for the needs of initial recovery (post bushfire and other disasters), the progression after this initial recovery and the expansion into a fully permitted house for ongoing life.

Setting 1: Construction System

Construction Methods
The construction system has been established around a consistent grid set out of 1.2m x 1.2m (Figure 1) which can support various design outcomes and has a number of benefits (Figure 2). A 0.9m x 0.9m grid is a useful human scale for doors and windows but 1.2m works well for sheet size and larger wall panels. This design allows for combinations of both dimensions and has established a variety of room sizes and types within the set out that can provide for the various requirements. These room sizes are defined through the following dimensions (Figure 2):

- 1.2m (Extra Small / Utility Room)
- 2.4m (Small Room)
- 3.6m (Medium Room)
- 4.8m (Large Room).

The structural system has been designed to accommodate the variety of room sizes and is based on a consistent framework with footings and bearers set out at 2.4m intervals. The floor structure has been tested with a standard Spantec steel frame system. However, an alternative perimeter steel frame has also been designed that works within the grid set out, supports the structural columns (also at 2.4m / 4.8m intervals) while also supporting the floor or decking panels. This frame is repeated at loft level which then allows for infill wall panels to be assembled between these two frames. With further development it is envisaged that this single system could meet all the structural requirements at both ground and loft level.

A skillion roof is proposed for its simplicity in design, construction, transportation and assembly. Like the footing system, the roof is set out on a 2.4m x 4.8m grid and sections of roof (2.4m wide) can be a prefabricated and delivered to site fully constructed. Alternatively, the roof can be site built with either prefabricated panels or even traditional construction methods. There is the option for trusses to be included every 2.4m to add structural integrity and flexibility for spatial arrangements – particularly to divide and add privacy for areas of loft sleeping. Where the truss in located in an internal room it can be split into 2 x 45mm trusses to be butted up each time. Where the truss is located on an external wall, it can be a typical 90mm structure. Roof sheets allow for lap joins during expansion.

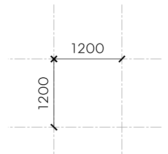


Figure 1

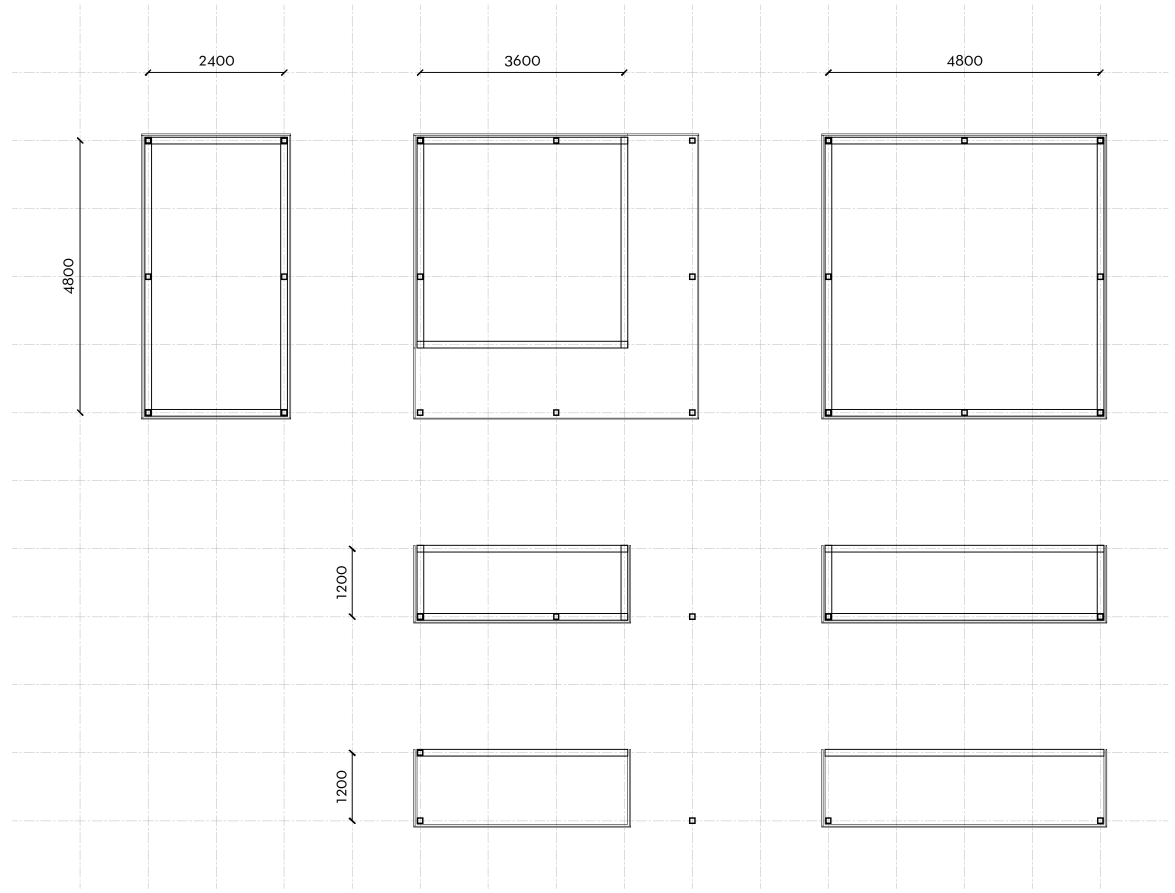


Figure 2

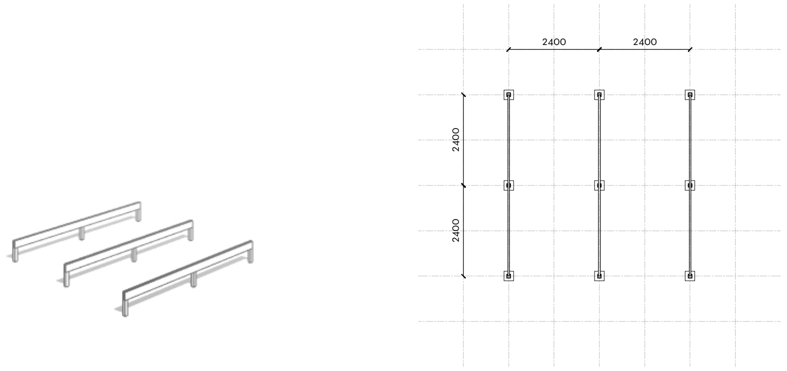
The structural system is outline as follows (Figure 3):

- Footings and bearers set out at 2.4m intervals. (figure 3a)
- Spantec steel frame system. (figure 3b)
- Alternative perimeter steel frame supporting floor or decking panels. (figure 3c)
- Loft level steel frame supported by steel columns, also at 2.4m / 4.8m intervals. (figure 3d)
- Loft level floor panels (optional) (figure 3e)
- Truss system for roof structure (figure 3f)
- Skillion Roof and loft level wall panels (figure 3g)
- Wall / door / screen panels infilled between structural frame. (figure 3h)

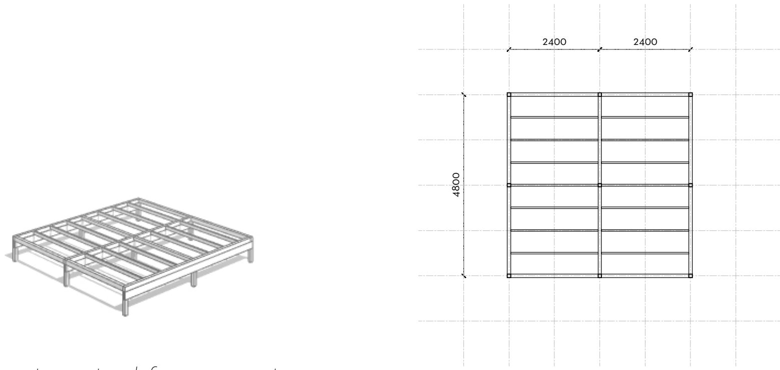
For construction with prefabricated panels, the design proposes three different (potentially four) construction systems:

- Structural Insulated Panels (SIPS) that combine a lightweight polystyrene core with plywood internal and external skins.
- Panels constructed with standard treated pine framing timber, with wool insulation batts and plywood internal and external skins.
- Panels constructed with standard light gauge steel framing, with wool insulation batts and plywood internal and external skins.
- A fourth system using Cross laminated timber (CLT) has also been considered within this proposal but more research into its viability (weight, material availability, bushfire resistance) would need to be undertaken.

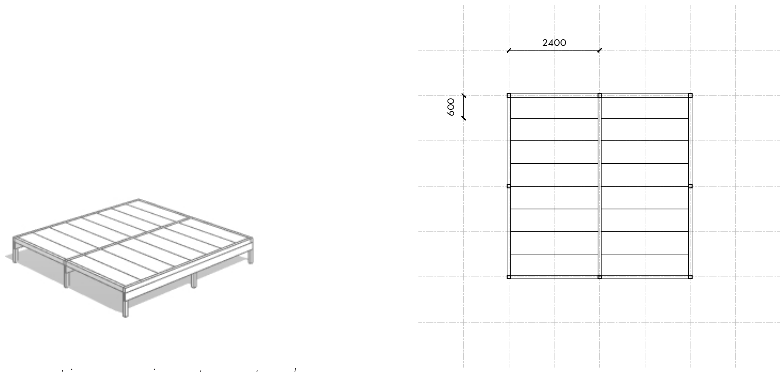
For standard onsite construction (or a combination of prefabricated and onsite construction) the



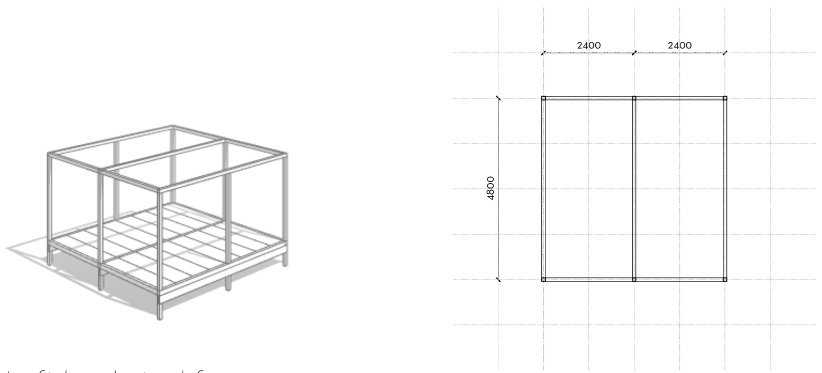
3a: Footings and bearers set out at 2.4m intervals



3b: Spantec steel frame system

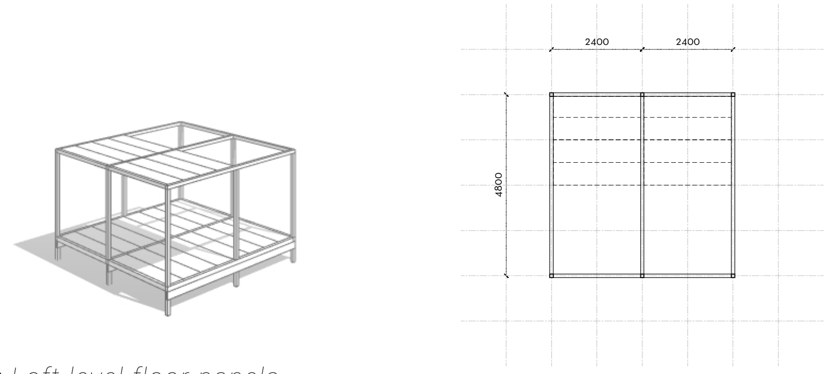


3c: Alternative perimeter steel frame supporting floor or decking panels

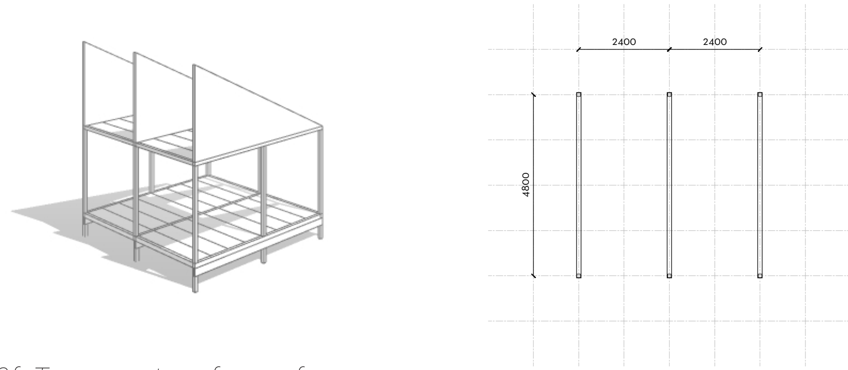


3d: Loft level steel frame supported by steel columns

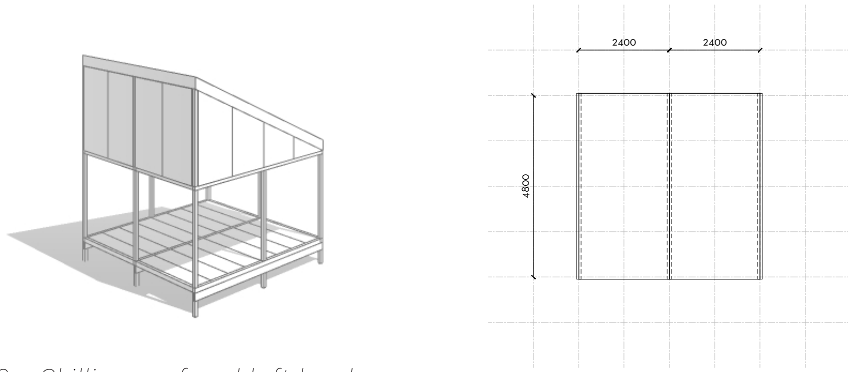
Figure 3



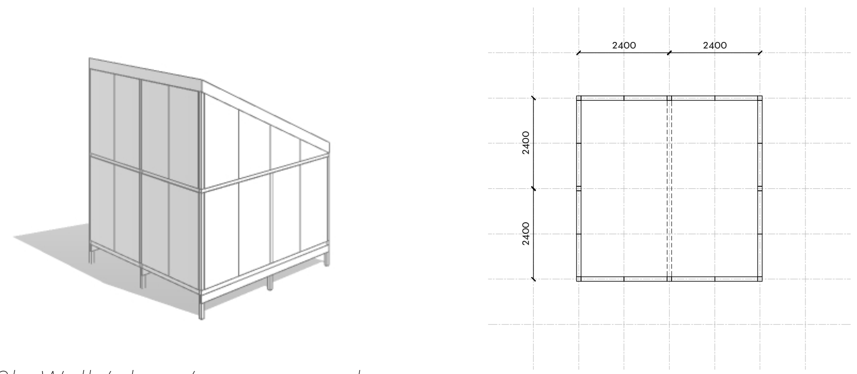
3e: Loft level floor panels (optional)



3f: Truss system for roof structure (optional)



3g: Skillion roof and loft level wall panels



3h: Wall / door / screen panels infilled between structural frame timber framed and light gauge steel options can be site built.

Logistics & Assembly
The construction methods for the proposal vary according to the different room sizes and the desire of the client:

- Prefabricated volumes constructed off site and transported to site for installation are available in room sizes 1.2m, 2.4m or 4.8m (2 x 2.4m).
- Prefabricated panels delivered to site for assembly are available for 1.2m, 2.4m, 3.6m, 4.8m room sizes.
- On site construction using a combination of prefabricated panels and traditional on-site construction methods can be achieved for all room sizes.

This hybrid kit of parts approach is designed for maximum flexibility in logistics and assembly with volumetric, panelised and traditional construction all possible. Exposed screw or bolted fixings are standard throughout the design which allows for easy disassembly, adjustment and removal.

Transportation and Delivery
The design responds to transportation and delivery requirements as per the recommendations in Chapter 3 which show that a delivery vehicle of 2.5m width or less is required for transportation to remote areas as well as locations with difficult access. As shown above, the 1.2m, 2.4m and 4.8m (2x2.4m) room sizes can all be constructed as a prefabricated volume and delivered to site within these transportation restrictions. These prefabricated volumes are designed with a temporary 'fourth wall' for bracing and structural stability during transportation. Alternatively, all design options can be delivered in prefabricated panels and components ready for assembly and construction on-site. Chapter 3 also shows how the weight for each volume (based on the three proposed structural systems) has been tested and proven viable within our system. The fourth possible structural system (CLT) has additional weight requirements which is why it has been included as a possibility only at this stage.

Setting 2: Program and Performance

Functional Brief (Program and Flexibility)
The design template for new prefabricated housing solutions uses a 1.2m x 1.2m grid which can support a variety of flexible program options. A 2.4m wide prefabricated core that can be used for internal spaces as well as utility spaces such as kitchens and bathrooms is designed as a prebuilt emergency relief housing module that can be delivered to site in the immediate aftermath of disasters (Figure 4). There is also the option for a series of 1.2m wide prefabricated utility spaces as shown in Figure 5. This base requirement can be delivered to site with off-grid services or ready for connection to mains services. From there various combinations and sizes or rooms can be added as required. The key room sizes are outlined below with suggested functions:

- 1.2m (kitchen, bathroom, wc, storage, study, bunks, hallway)
- 2.4m (kitchen, bathroom, study, small bedroom, undercover deck)
- 3.6m (bedroom, living room, dining room, playroom, office, undercover deck)
- 4.8m (living room, dining room, large bedroom, rumpus room, undercover deck)
- The skillion roof allows for loft sleeping and storage or a generous double height space in all room sizes.

In addition to the internal rooms are a series of undercover decks that provide highly functional outdoor spaces. These decked areas are always roofed and screened for both bushfire and insect protection. In many designs these outdoor spaces form undercover hallways that allow for greater separation and privacy under a single roof. Bathrooms and other utility spaces can also be accessed

Figure 4

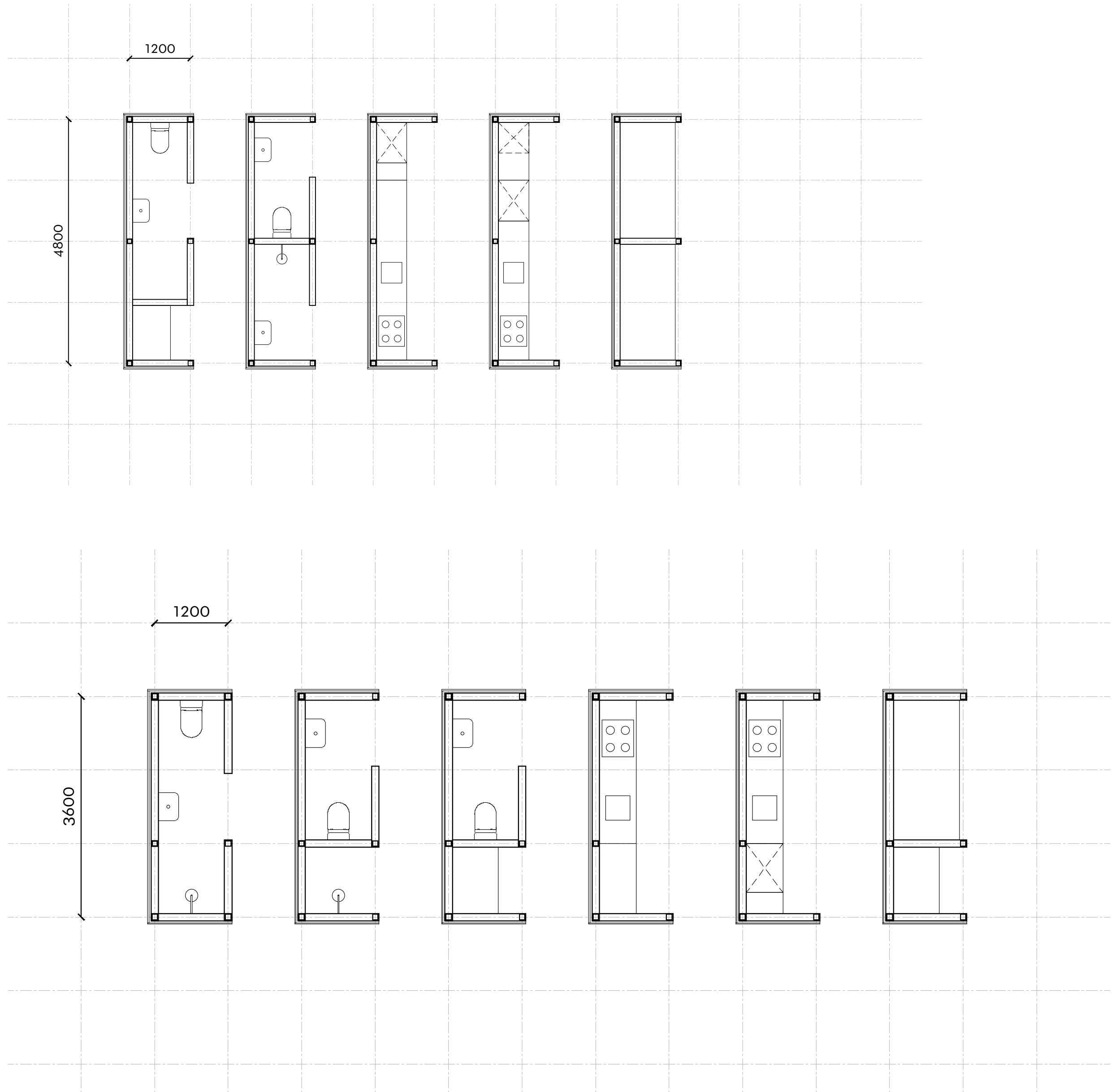


Figure 5

L shaped courtyard or extension

Square or rectangular expansion

Linear expansion

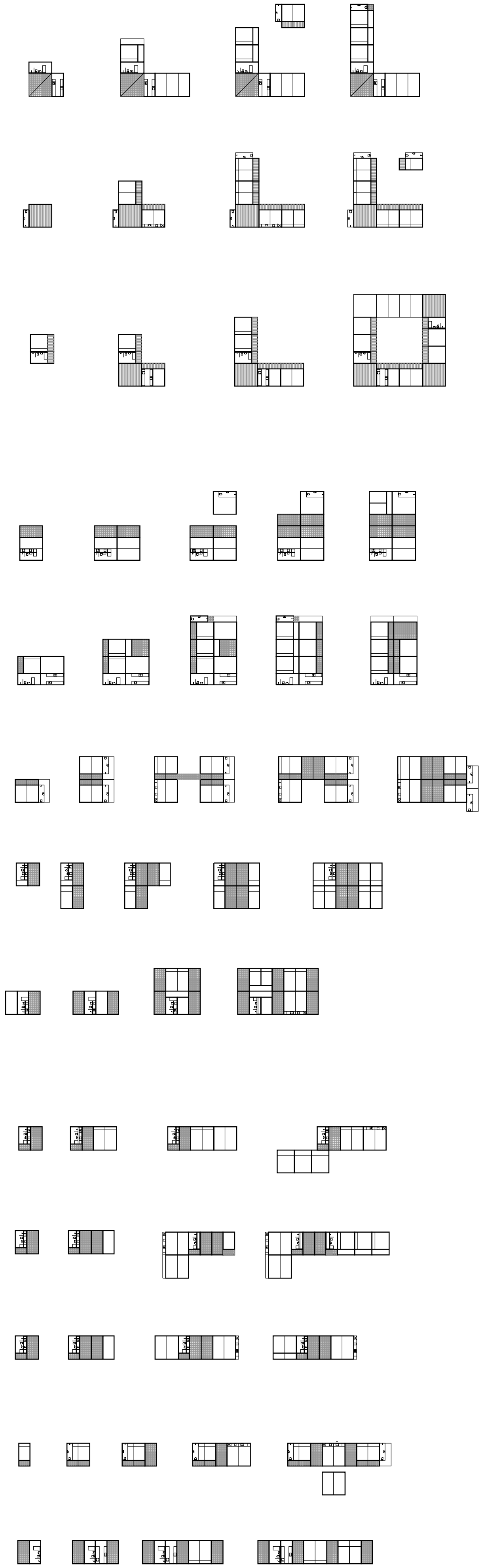


Figure 6

from these outside spaces which is highly functional in a small space. In many of the tested design options these 'outdoor' bathrooms are the first of two bathrooms in a permanent house.
A series of design options have been explored which show the potential of the system to expand in a number of different ways. While there are a seemingly open number of floorplan arrangements that could designed with the system we have found three common types (Figure 6). They are:

- Liner expansion (most commonly as a single width house with skillion roof)
- Square or rectangular expansion (most commonly as a double width house with gable roof)
- L shaped or courtyard expansion (most commonly as a single width house with skillion roof and open corners).

Design Appearance, Materials and Finishes
The design provides a base module that is formally simple with a square or rectangular floor plan. The single module contains a skillion roof that can be doubled up as a gable roof to provide a deeper floor plan. The design appearance is simple and recognisable with references to the existing forms found regional and agricultural locations. The design allows for a variety of door, window and screen configurations within the set system. (Figure 7).

The design also allows for a variety of material and finish options within the set system. The external materiality is proposed to meet bushfire ratings of BAL 40 as a minimum for reasons outlined in chapter 4. In instances where ratings of BAL 29 (or less) are sufficient, there would be a wider variety of material finishes available and these could be easily substituted without altering the systematic approach of the design.

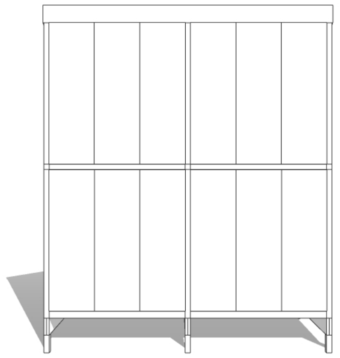
The internal materials were chosen to meet a number of requirements. They have to allow for a variety of colour finishes, be hard wearing and low maintenance finish and finally have structural or material integrity so they will not be damaged or broken during transportation and assembly (Figure 8).

The external materials and finishes are:

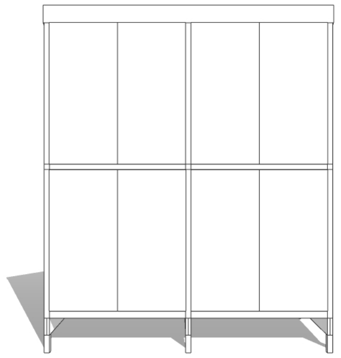
- Roof - Custom Orb metal sheeting with optional colour finish
- Wall 01 - Custom Orb metal sheeting with optional colour finish. In scenarios where a BAL FZ rating is required to be met we are proposing a double skin option with galvanised sheeting fixed to the external side of the structural wall and then a second skin of Custom Orb metal sheet fixed on battens with an air gap.
- Wall 02 - Cement Sheet with pre-sealed natural finish (Barestone).
- Decking - FRP grating which is both waterproof and fire resistant. The decking comes in panels that are interchangeable with the structural floor panels.
- Windows and Doors – Aluminium windows and doors.
- Screen 01 - Custom Orb perforated metal sheeting with optional colour finish, to be used as screening for windows for both thermal performance and bushfire protection.
- Screen 02 – Metal framed metal mesh screens for both insect and bushfire protection.
- External fixing details to be screwed or bolted for easy disassembly. Joins to be dealt with through lapped and strapped details depending on material choice.

The internal materials and finishes are:

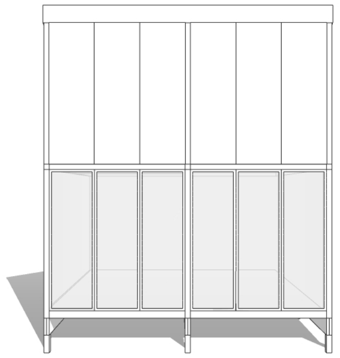
- Wall + Ceiling 01 – Plywood wall lining with optional paint / stain for custom finish.
- Wall + Ceiling 02 – Cement Sheet with pre-sealed natural finish or paint finish.
- Floor 01 - Cork Flooring. (3mm) allows for a consistent floor / deck level.
- Floor 02 (Bathrooms) – Vinyl to floor and walls with optional colour finish. This is a hard wearing, low maintenance finish which adds structural strength for transportation and assembly.



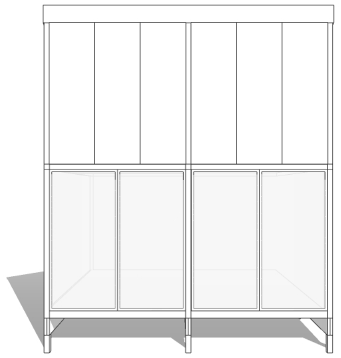
Wall panels (800)



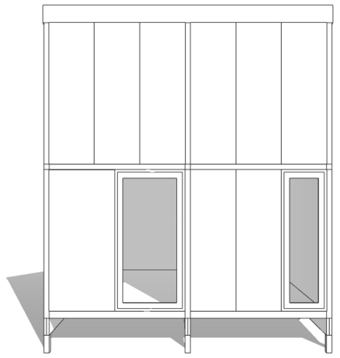
Wall panels (1200)



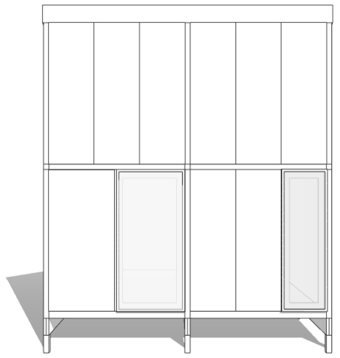
Metal mesh screens (800)



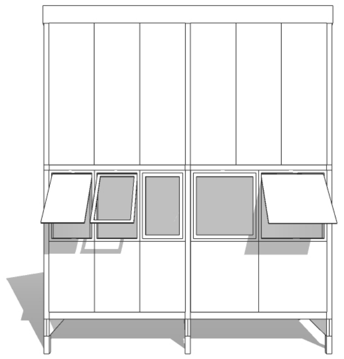
Metal mesh screens (1200)



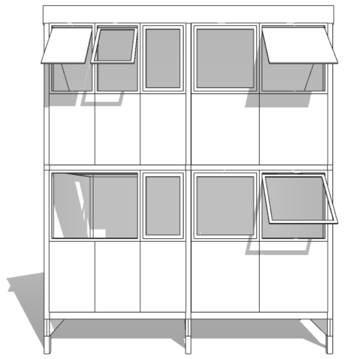
Doors (800 + 1200)



Doors with perforated screen (800 + 1200)



Windows + Hatches (800 + 1200)



Windows + Hatches (loft level)

Figure 7

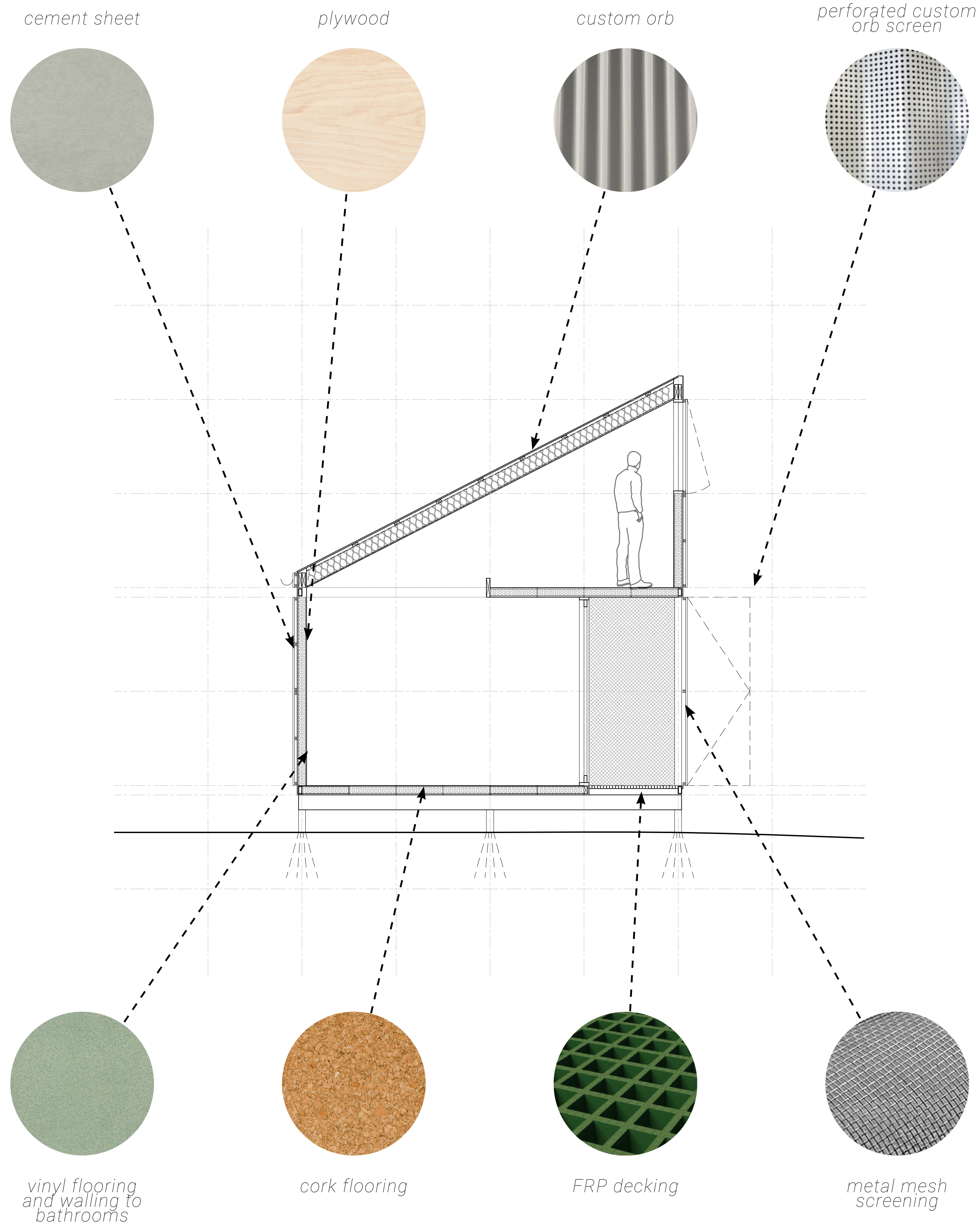


Figure 8

Performance and Energy
The design has allowed for all housing solutions to be off grid if required. There is provision for easy rain water capture and storage within water tanks as well as associated infrastructure such as pumps for reuse. Solar collection is proposed on roof solar panels (and battery storage) with the skillion roof pitch of 27 degrees allowing for excellent solar capture. When the roof is doubled up, this means that there is further flexibility with one side of the roof always able to maximise solar gain. Collected electricity can be used for hot showers, lights, heating and cooking. Additional (or alternative) heating is proposed through a wood burner and there is also the option for replaceable gas tanks where required.

Off grid service infrastructure is always located on the low roof wall side of the house as further (width) additions to the house can only happen from the high side of the skillion roof. Being located at an 'endpoint' of construction means services are always easily accessible. Off grid sewer treatment for these projects has been considered through a variety of methods including compost, septic and worm farm options but this would need to be further researched and developed in subsequent stages.

Setting 3: Context

Market Constraints
The design provides for a large number of built outcomes which can accommodate a variety of constraints for bushfire affected populations. The construction and delivery methods respond to remote and regional areas and provide for a variety of options (both on and off site).

Procurement Process
There are a range of procurement possibilities for the design template as it offers a suite of design options rather than a finished product. Clients could purchase one or many of the design options and the staged nature of construction also allows flexibility based on changing financial capacities. The simple, repeatable structural system allows for both traditional building contracts, fully prefabricated construction as well as owner builder and self-build options.

Costs
The project has been designed with standard construction techniques, materials, fixings and details. It can be built with readily available (often off the shelf) materials. This approach considers the needs of regional areas, particularly during periods of recovery post disaster.

Setting 4: Site Implementation

Groundworks / site strategy
A consistent approach to site implementation has be established for all design options. The Surefoot S250 footings system has been tested and proven for all material options and their associated weights. This means that unless there are particular ground conditions that render the Surefoot system unsuitable, the same approach with footings, posts and bearers every 2.4m will be implemented across all projects. Any site variances (such as slope or stepped levels) would be dealt with through flexible post sizes which allows the floor and deck levels across all designs to remain the same (Figures 9, 10, 11, 12).

Options for concrete slab on ground were considered within the design but excluded from this stage of design as the time and complexity involved in their construction meant they failed to meet the requirements for effective delivery of short-term accommodation. However, further stages may explore the viability of a concrete slab within the longer-term stages of construction of permanent housing.

Staging
The grid-based design allows for a staged development that can respond to a variety of different client needs over a period of time be they physical, site based, financial or personal and emotional. A 2.4m wide prebuilt emergency relief module(s) serves as the base requirement from which various combinations and sizes of rooms can be added as required. This development can happen over time in a number of stages with client involvement and flexibility in construction approach. The design options also allow for the joining of a series of rooms into a large single house or alternatively with the grouping of a series of separate designs across a site (Figures 13, 14).

Customisation and Participation
The design has considered and provided for customisation and local community participation at a number of levels. There is great flexibility with design for a variety of housing types. The XS, S, M and L room types can be configured to suit many different users including singles, couples, friends and families.

The design proposes prefabricated floor and deck panels which are supported within a structural frame. These panels can be easily interchanged allowing a transition from an outdoor space to an internal space (and back again) over time. These undercover outdoor spaces allow for of design configurations that offer separation (under a single roof) and are well suited to multi-generational groups as well as a variety of shared arrangements (Figures 9, 10, 11, 12).

The standardised grid set out allows for simple repeatable construction methods that can be completed by a large variety of local trades as well as owner builders. Furthermore, local community customisation is possible by substituting (900mm / 1200mm) windows, doors or panels for off the shelf versions from large suppliers such as Bunnings, local hardware stores or even second-hand suppliers. Further customisation is possible through alterations to the design such as new decks, pergolas or other built outcomes. This is facilitated through lashing points on the side of buildings, easily accessible structural frames to connect to as well as an internal wall finish (plywood) that has structural qualities for hanging pictures and shelves.

The design allows owners and occupiers to have a greater input in the design of their homes. The design proposes colour options for external wall cladding, internal bathroom walls and floors as well as paint finishes to the internal plywood lining. Material options within a set system give owners the ability to customise their homes and provide a sense of involvement and ownership which is beneficial to people disaster affected communities.

4.8m x 4.8m Emergency Examples

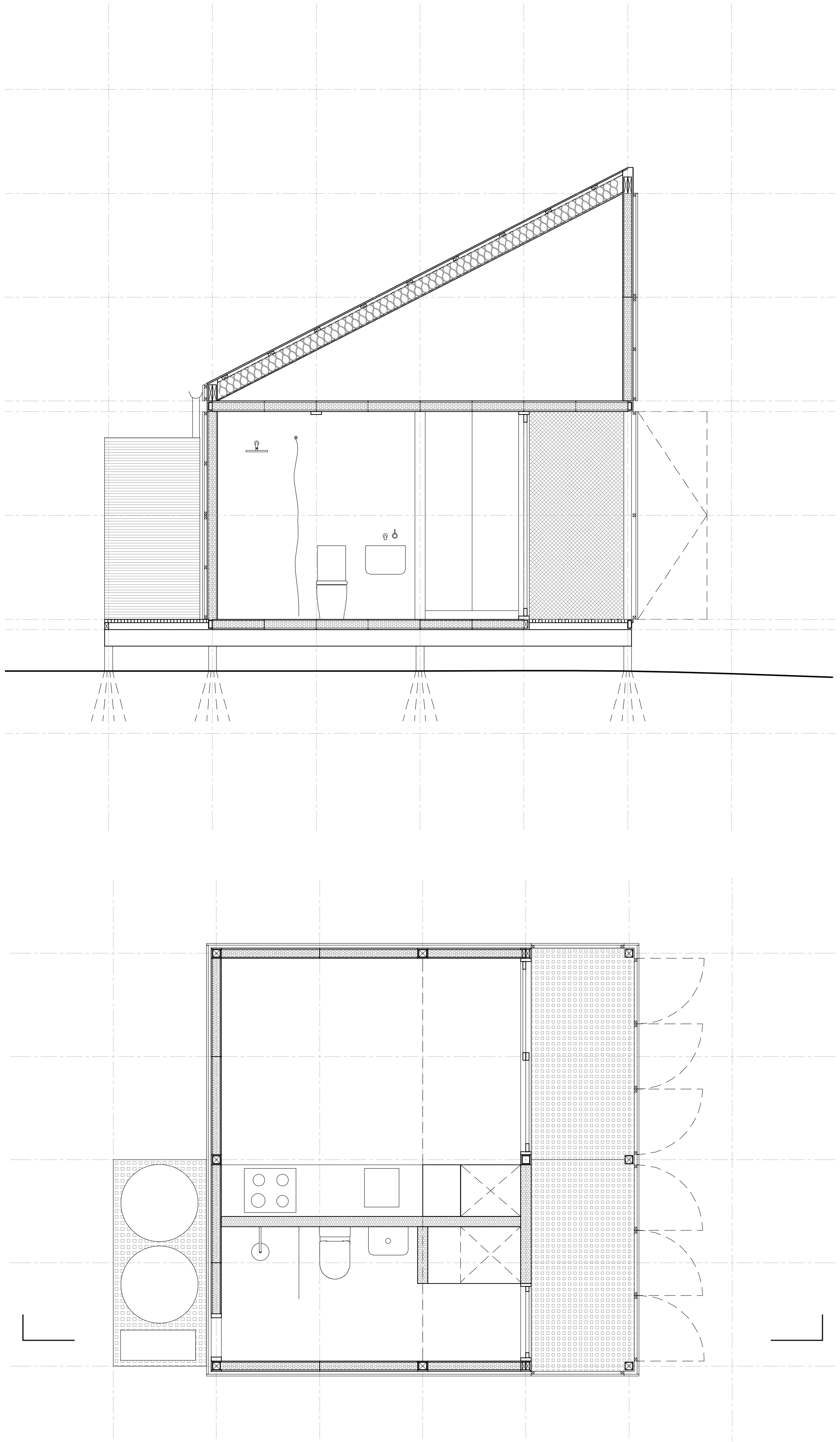


Figure 9: 4.8m x 3.6m Kitchen and bathroom (with services included) with loft storage above, Undercover outdoor circulation.

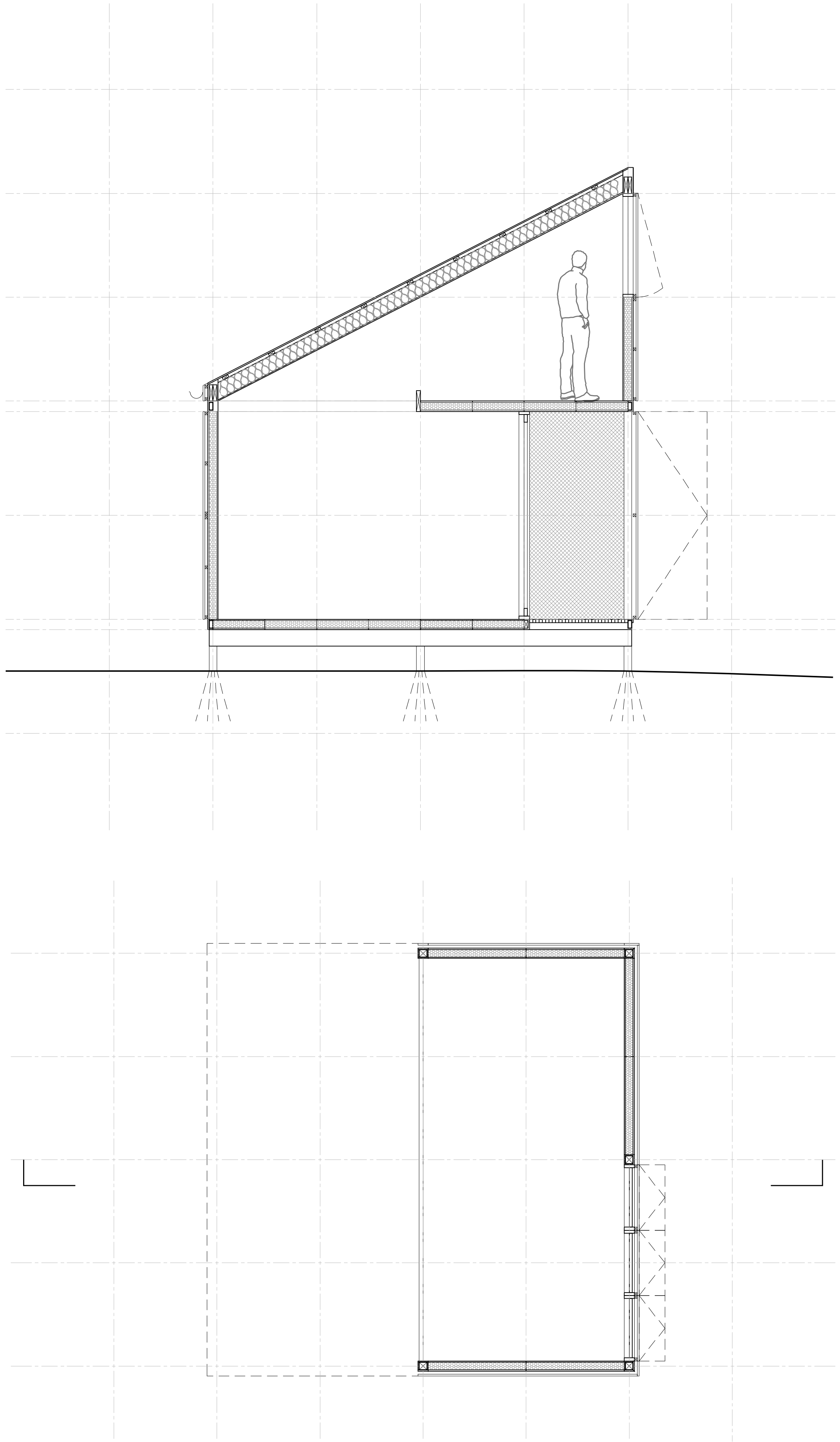


Figure 10: 4.8m x 3.6m bedroom showing loft study above, Undercover outdoor circulation.

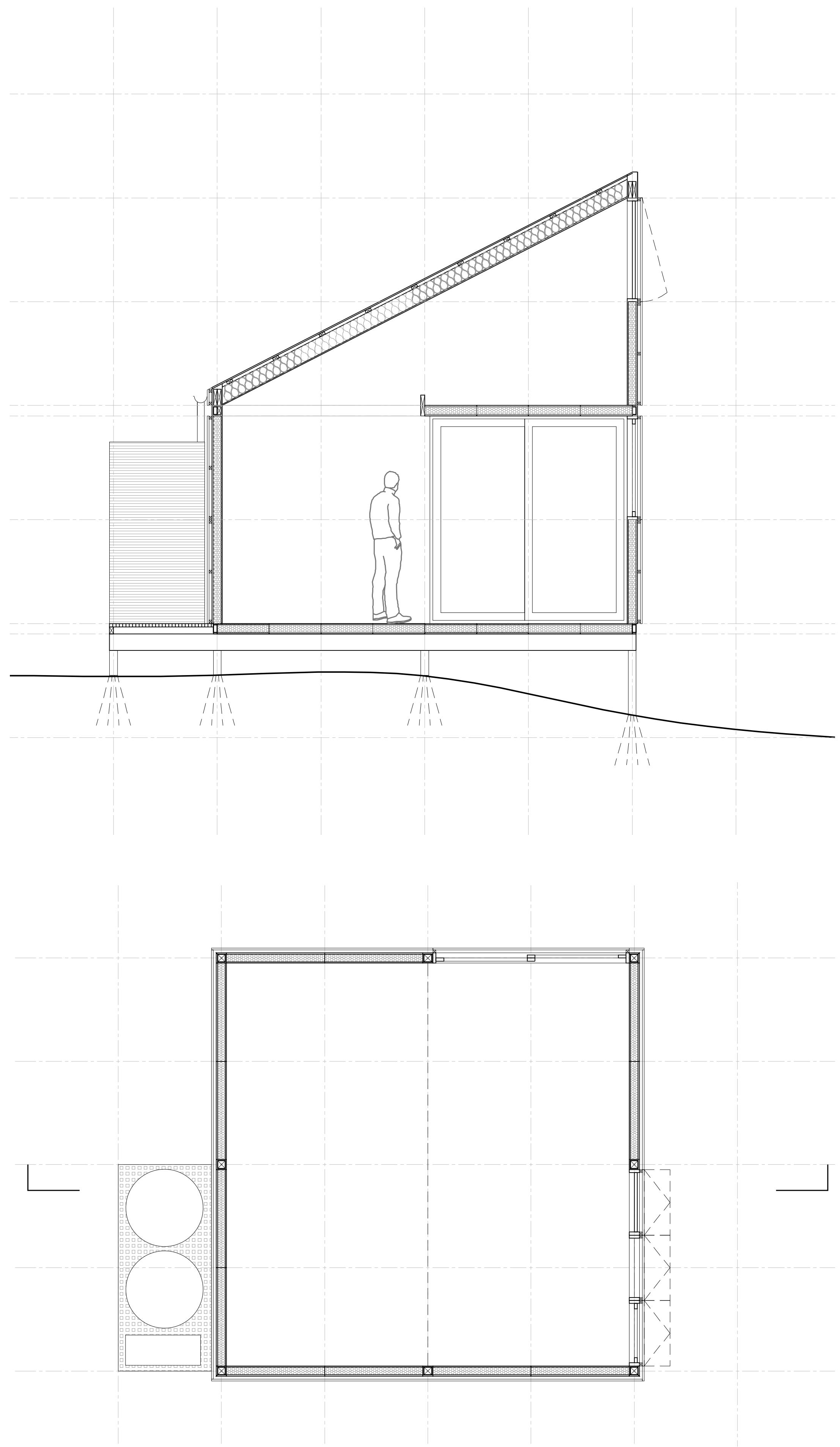


Figure 11: 4.8m x 4.8m Living with loft sleeping above. Additional services.

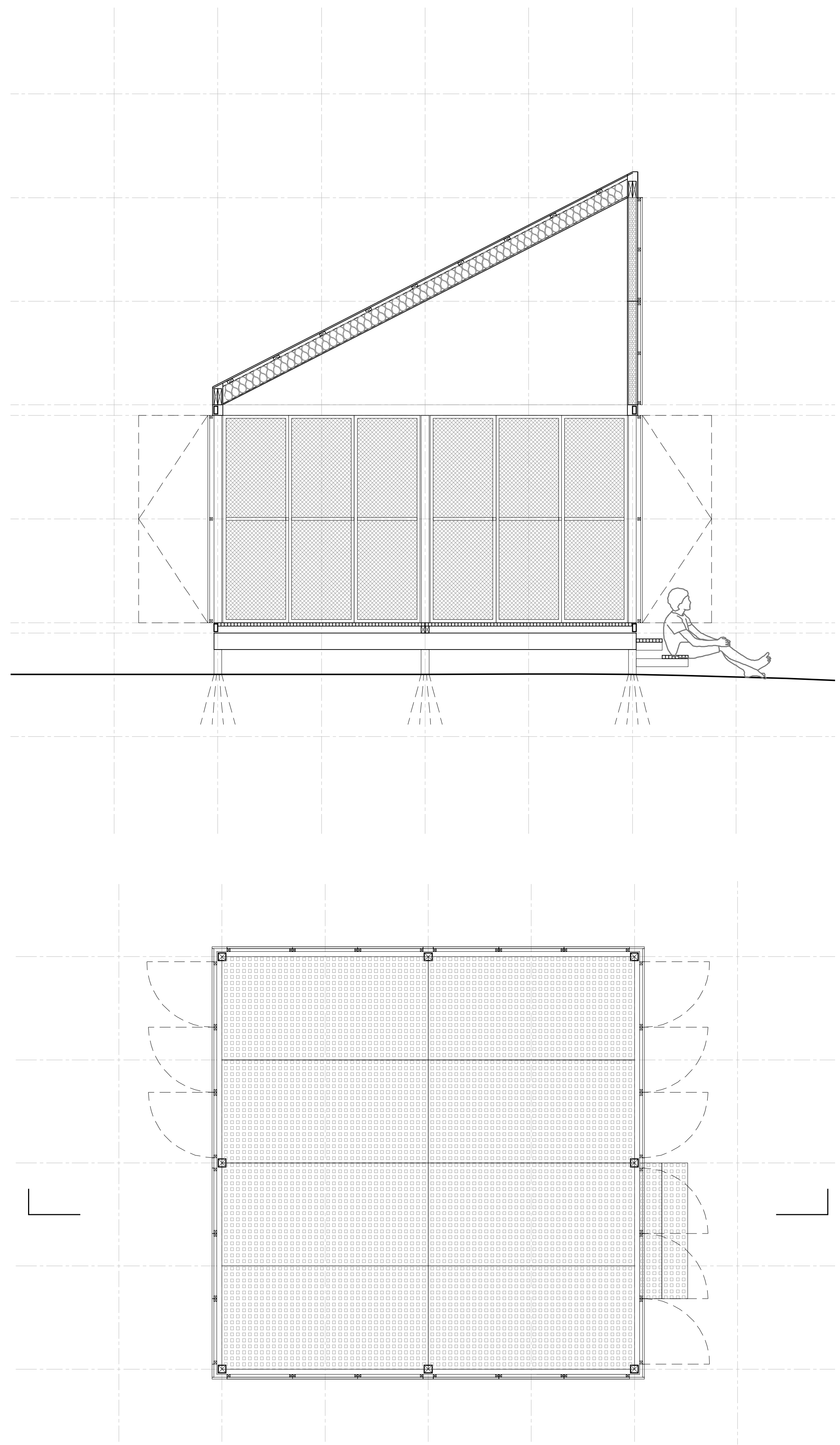
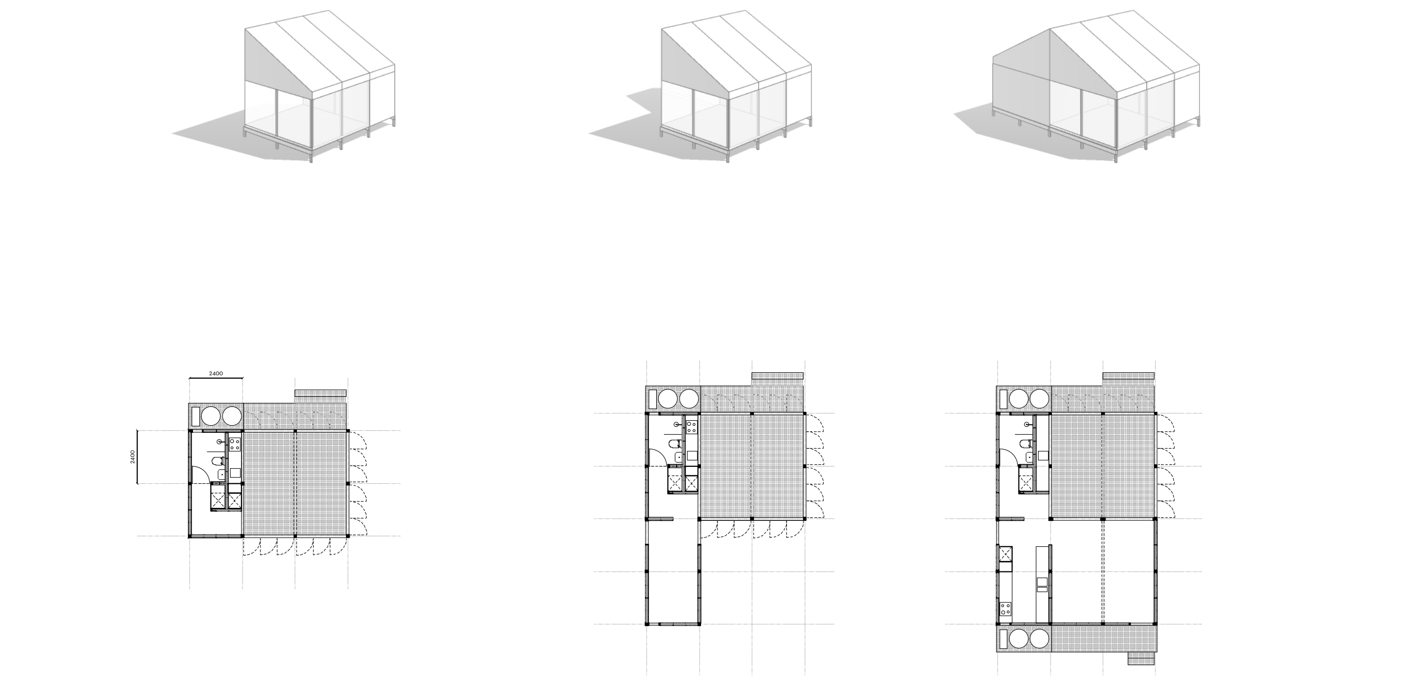


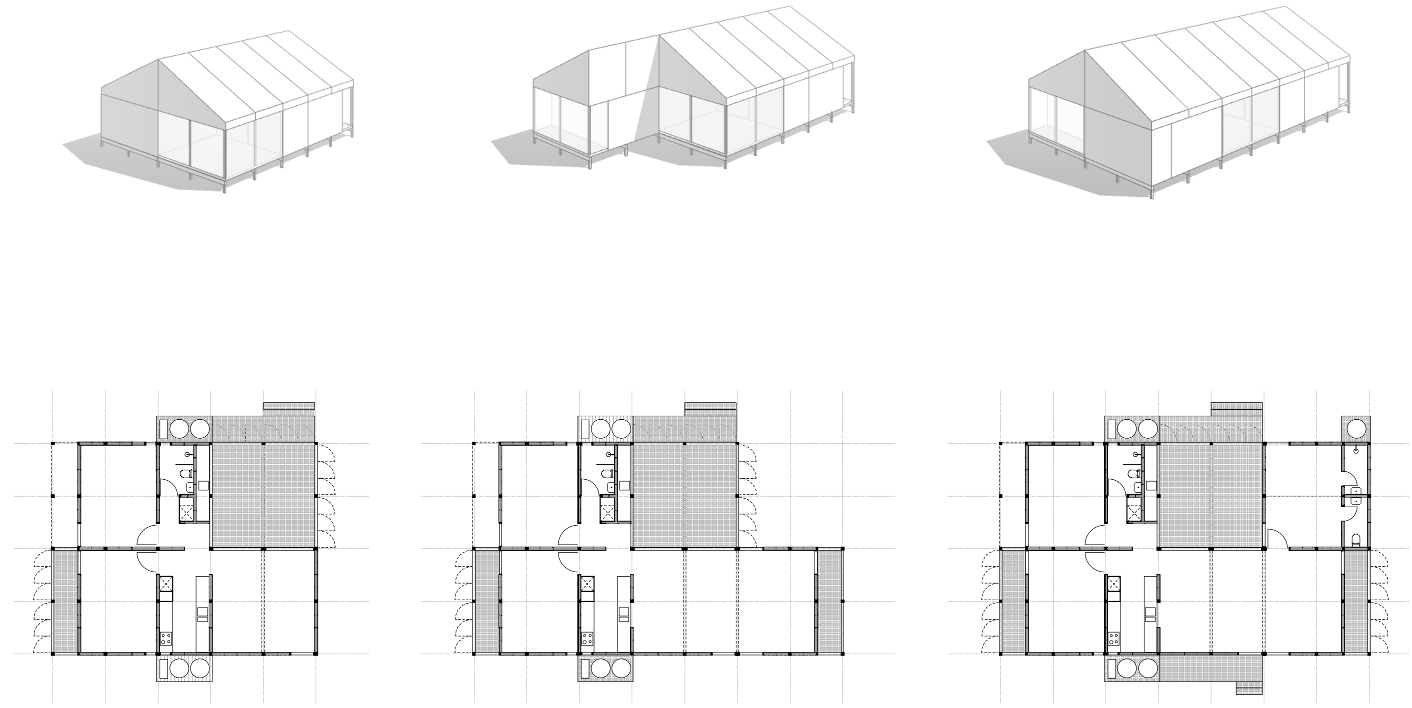
Figure 12: 4.8m x 4.8m Undercover outdoor space with operable screens to allow for customisation.



Stage One: Post-Disaster Accommodation

Stage One: Post-Disaster Accommodation

Stage Two: Progression Towards Recovery



Stage Two: Progression Towards Recovery

Stage Three: Ongoing Permanent Home

Stage Three: Ongoing Permanent Home

Figure 13

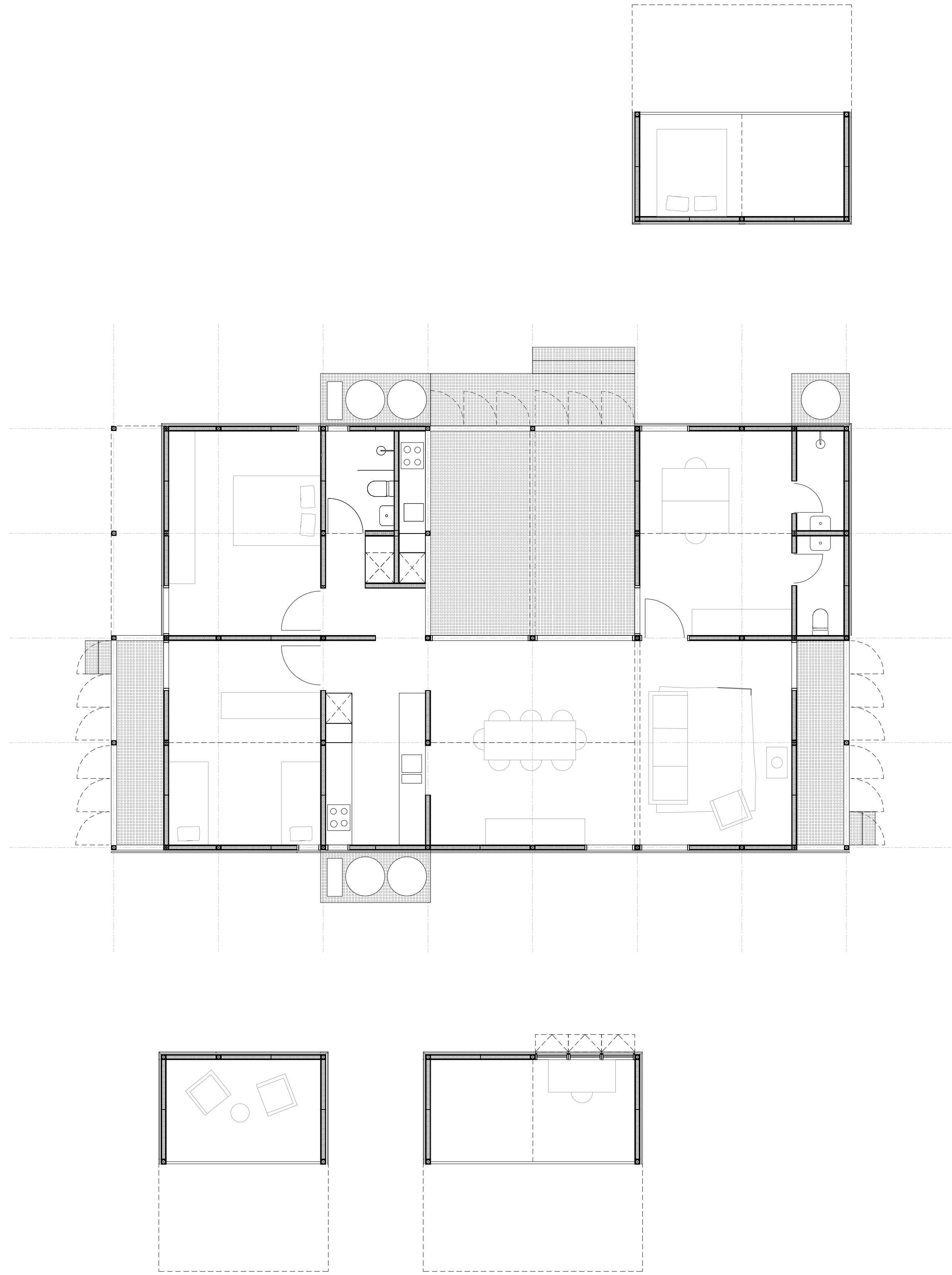
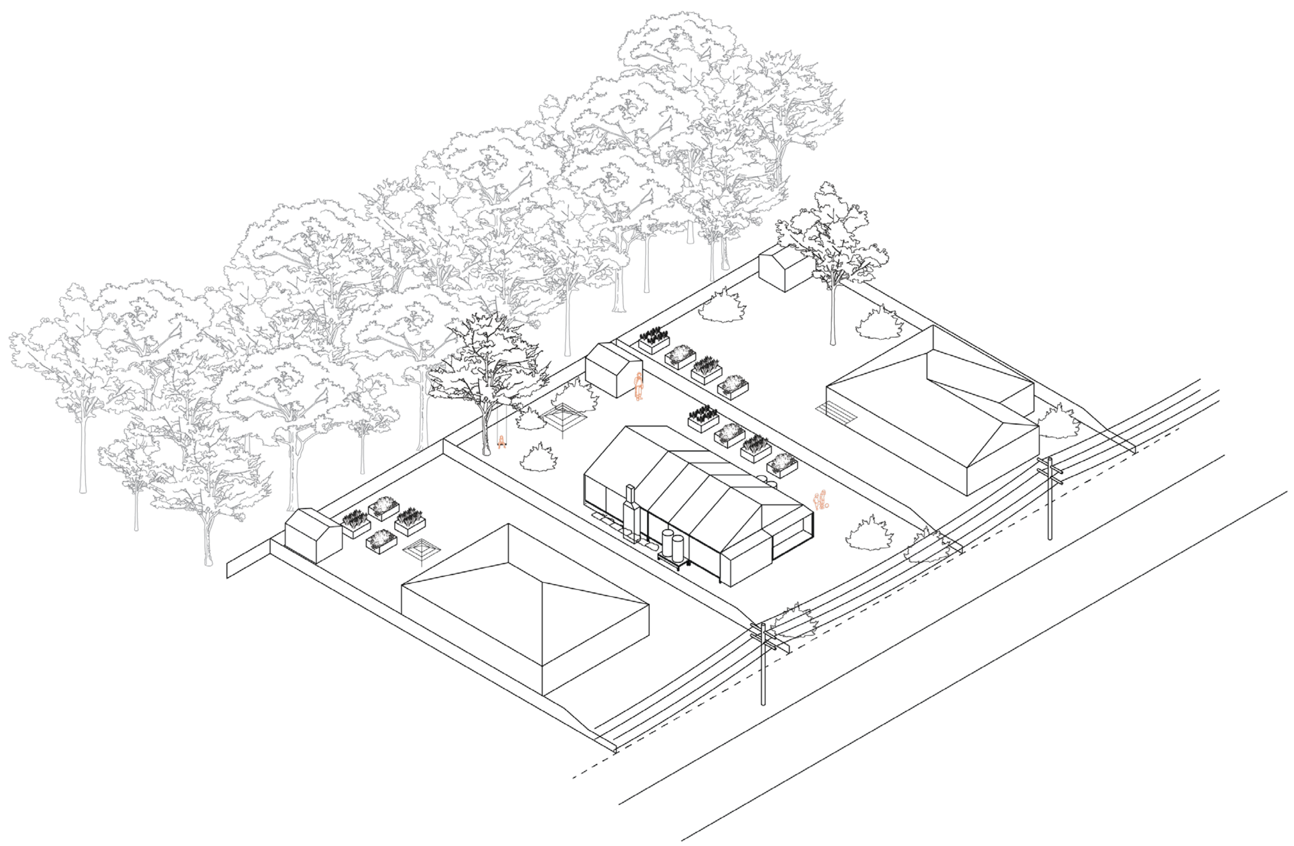


Figure 14: Ongoing Permamenet Home, showing optional loft plans.



A Scenario Approach for the Prefabricated Housing Solution

Following the methodology for problem solving laid out in the first part of the chapter, we have considered all the parts of the system that come to bear on housing needs for bushfire and disaster affected regions, and in turn determined the various 'objectives' for each of these parts – to satisfy the needs identified.

The next step has been to develop or design possible solutions for the parts of the system, integrating these into a consistent incremental approach. We have pursued this in the first instance using a 'scenario' based approach.

A 'scenario' can be defined as a sequence or development of events, or a setting. In this way, 'scenarios' are a way to consider design proposals beyond the static, but rather as part of a process over 'time'. This is an approach aligned to industrialised housing anyway, which assumes that rather than a house being a 'project' it is in fact a 'process'.

In addition, however, a scenario approach is very relevant to the specific objectives raised in the previous section - a need for an incremental approach to any prefab housing solution. Scenarios are a way to both develop an incremental design proposal, test how it works, as well as describe and explain its various stages over time. We have used a storyboard approach to visually describe a scenario by which an incremental approach to prefabricated housing might work well in the event of a bushfire disaster.
The scenarios we considered initially considered a combination of the following three settings:

Specific types of location
Specific locations are the sites that will allow testing of designs against real physical, regulatory and social scenarios. In developing our concepts for design solutions, we considered and tested ideas against a variety of locational types including:

- A heavily forested mountain region.
- A coastal region with access issues.
- Rural locations within, or close to a regional town.

Specific requirements in relation to time (short term, longer-term, permanent)
As explained, specific time periods are an inherent part of how a design response can respond to 'events' like disasters. In developing our concepts for design solutions, we considered and tested ideas against a variety of time phases including:

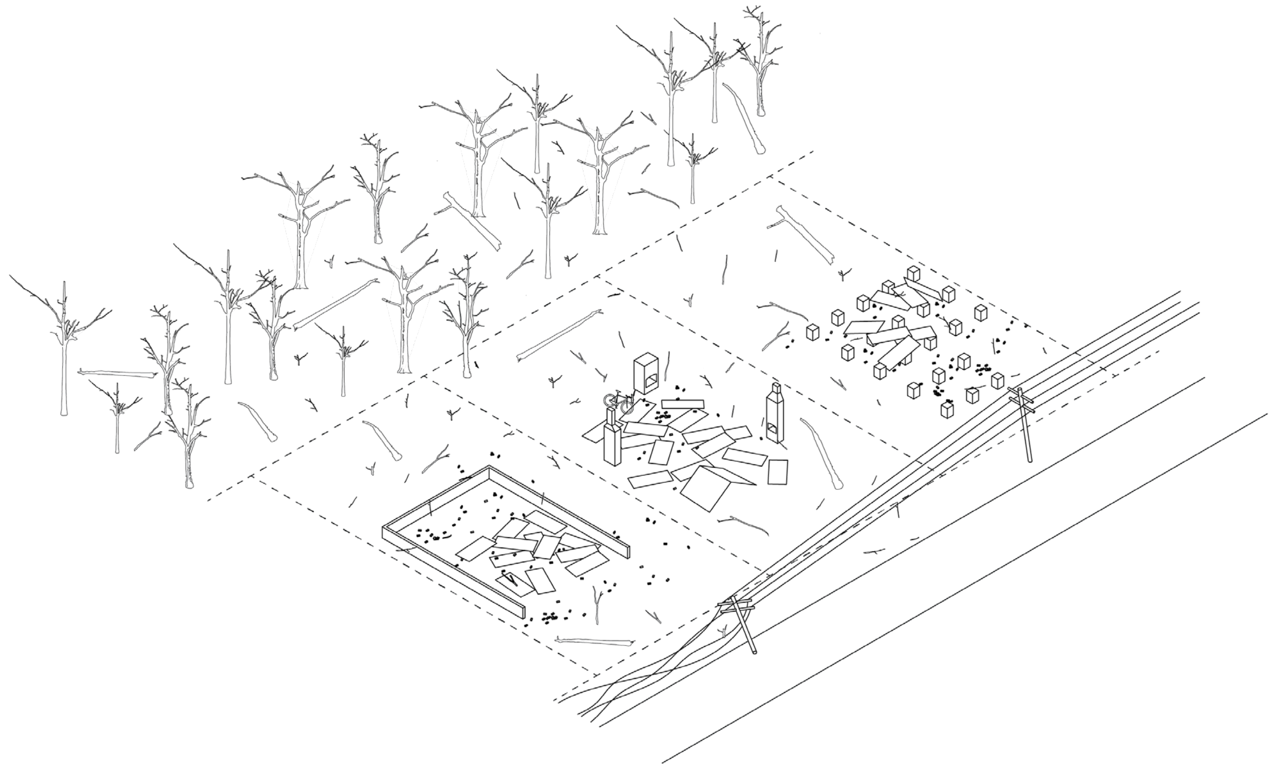
- Immediate Short-Term Shelter - involving the delivery of a temporary relief structure where no permits are required.
- Progression Toward Recovery as the stage where the relief structure is incorporated into a plan for an expanded house and the permits are obtained.
- Ongoing Permanent Home is where an expanded house is constructed through either prefabricated or other traditional building methods.

The needs of specific types of user
Based on the review stages we considered key user needs related to our case study research, to establish social, cultural and financial parameters for the design approach. This involved considering key personas or 'stories' to test important parameters and capacities for the design to respond to specific demographics. For example, understanding typical forms of employment, social and economic characteristics, age and mobility characteristics, and so forth can create types of users that provide further insights and ingredients for the design briefs.

The 'scenario' based approach in the design concept phase allowed an approach to typical design briefs and proposals that are able to be made bespoke and particular to certain settings, but which can be applied as replicable future models for a range of applications, conditions and needs over different locations and time periods. Through undertaking this concept design phase we generated a flexible 'kit of parts' approach as opposed to a 'one size fits all' housing solution or singular product to provide broader systemic solutions that respond to the needs of different audiences in different locations, over different stages of time.

Scenario Storyboard
The final 'scenario storyboard' for a prefabricated housing for bushfire and disaster, visualised on the following pages (Figure 3) provides a conclusion to this chapter, by presenting the requirements and objectives of the brief over time – as a representation of a timeline to the short-term to long-term dimensions of an incremental solution.

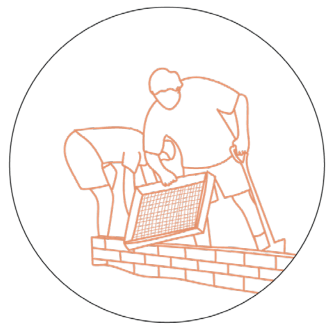
The following and final Chapter will provide a full description and explanation of the design proposal elements as a kit of parts, or product platform.



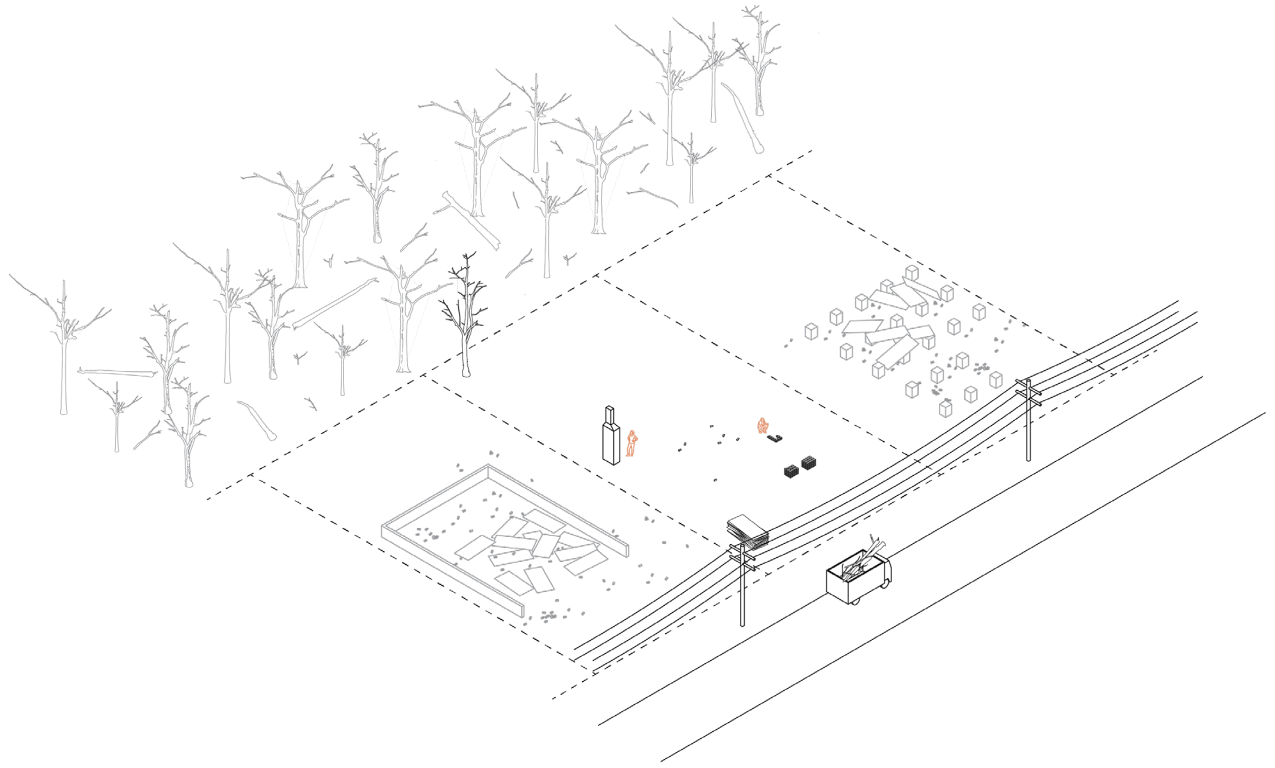
01 POST FIRE
immediately post disaster

disaster | 1 week | 1 month | 3 months | 6 months | 1 year | 2 years | 5 years | 10 years

site clearing



material collection

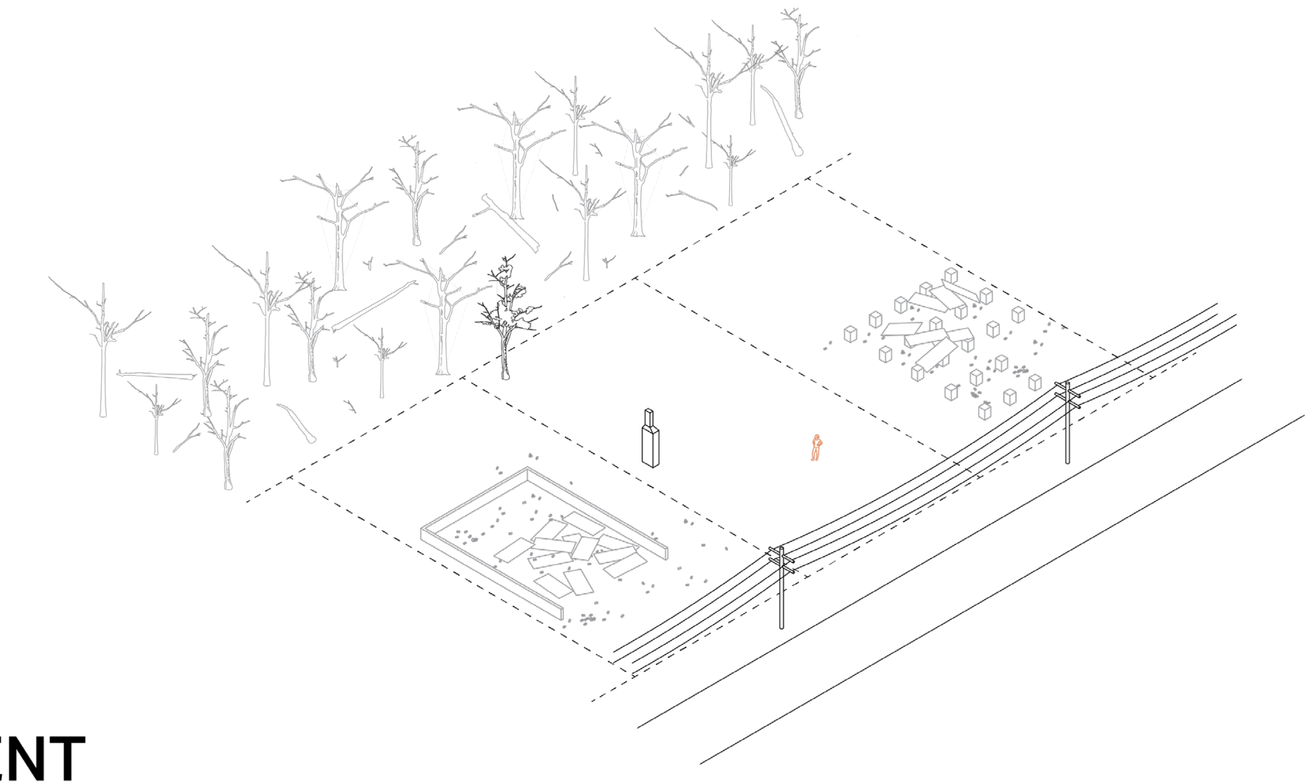


02 CLEAN UP
site made safe

disaster | 1 week | 1 month | 3 months | 6 months | 1 year | 2 years | 5 years | 10 years

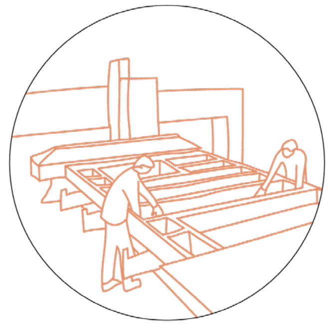
site assessment

client decisions

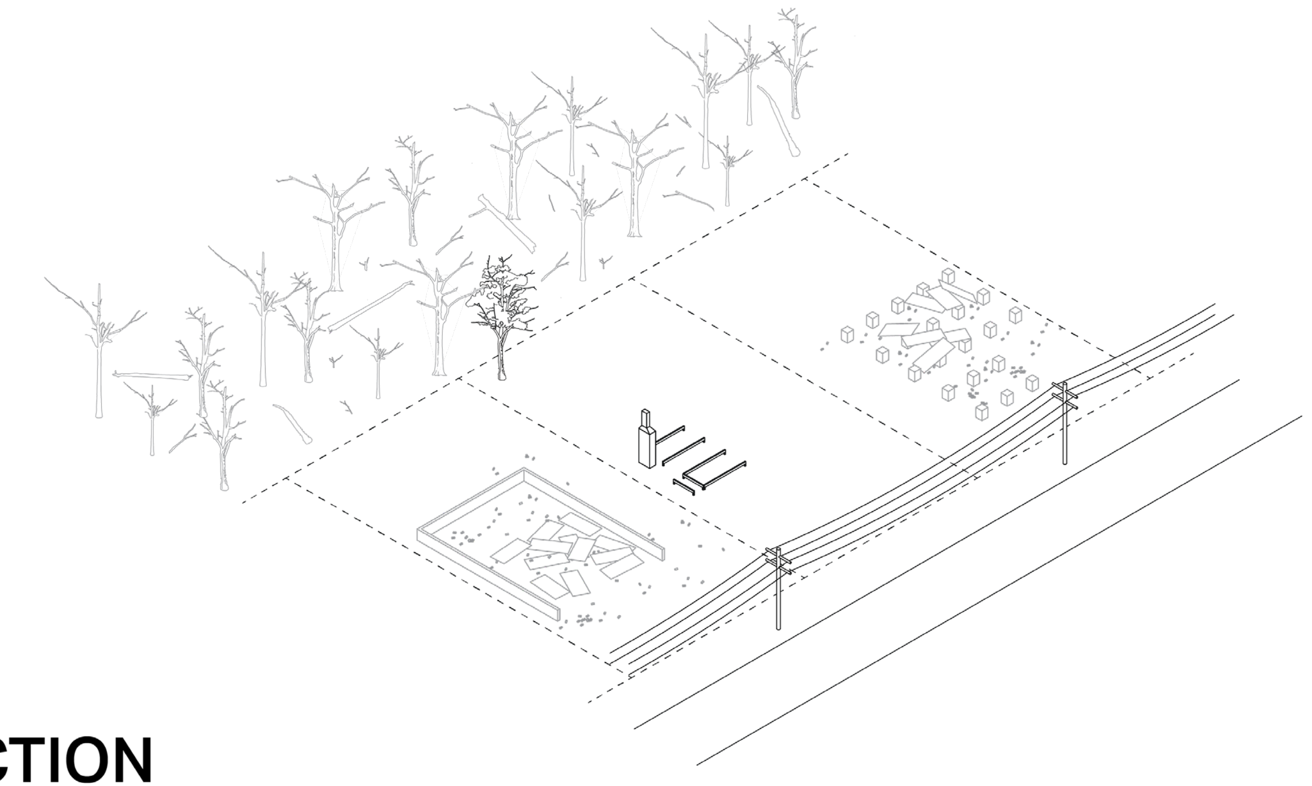


03 ASSESSMENT

siting decisions

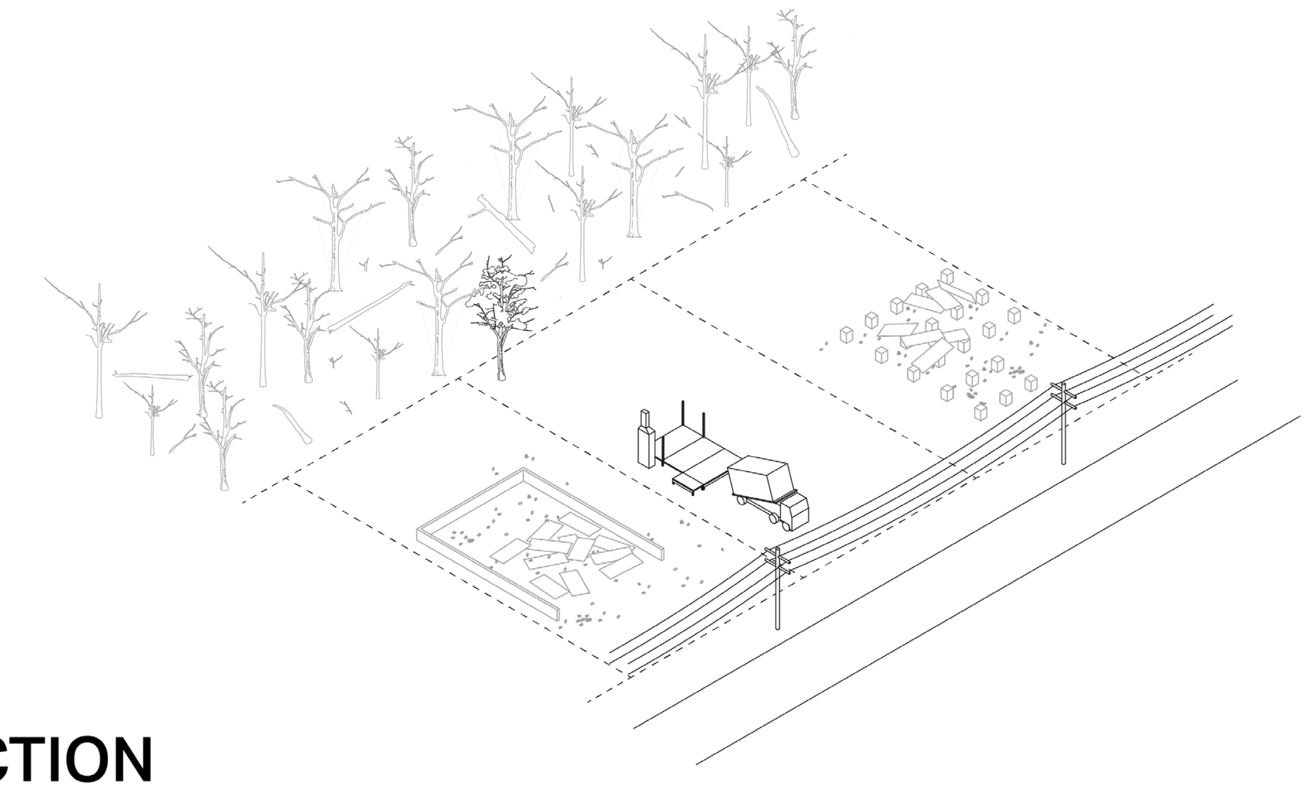


offsite prefabrication

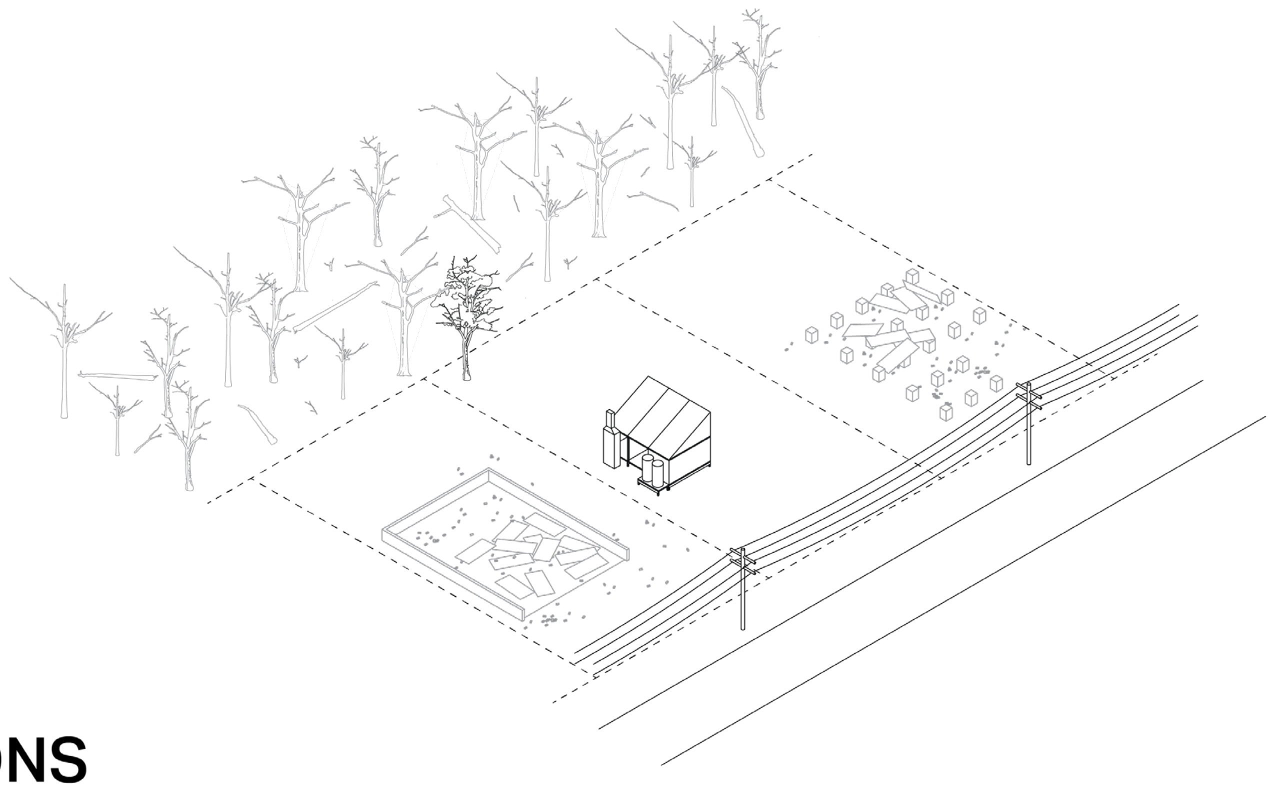


04 CONSTRUCTION

footings and module prefabrication

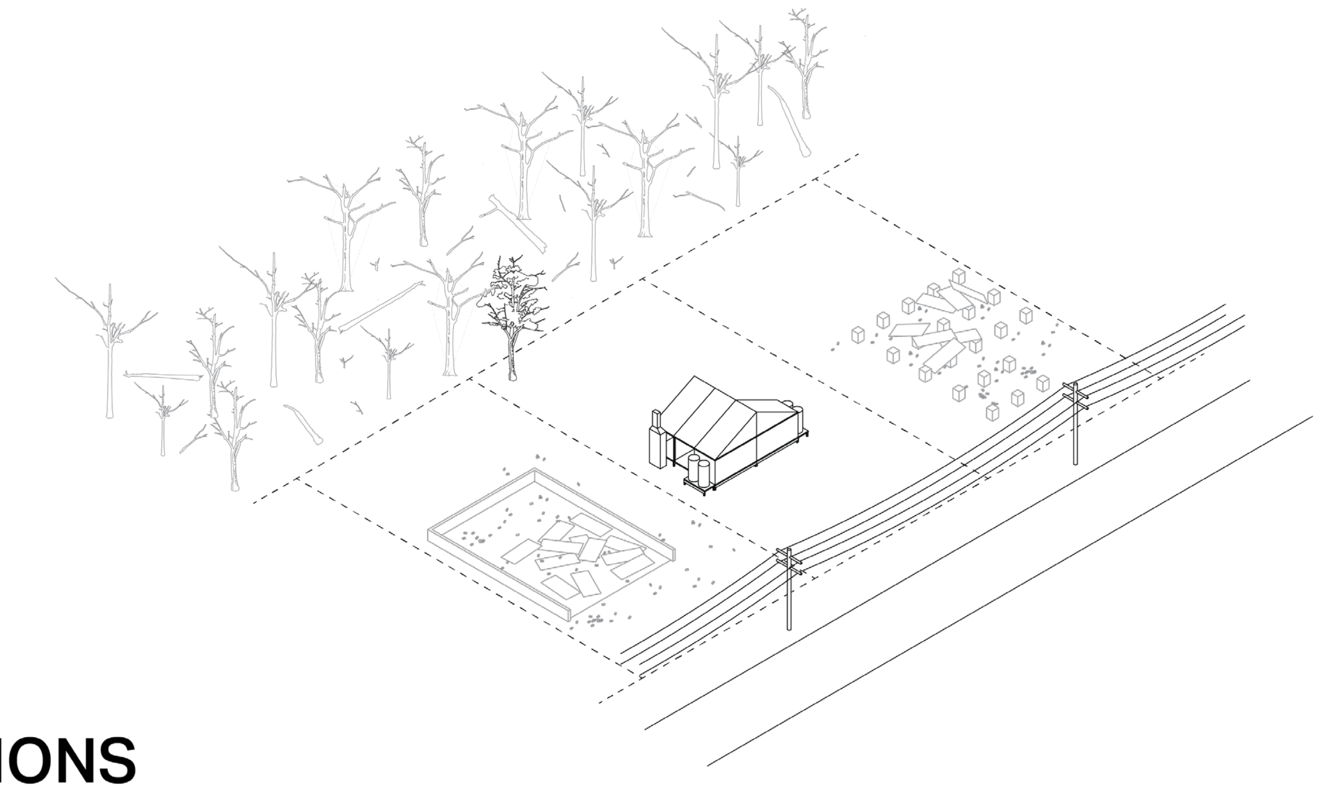


05 CONSTRUCTION
delivery to site



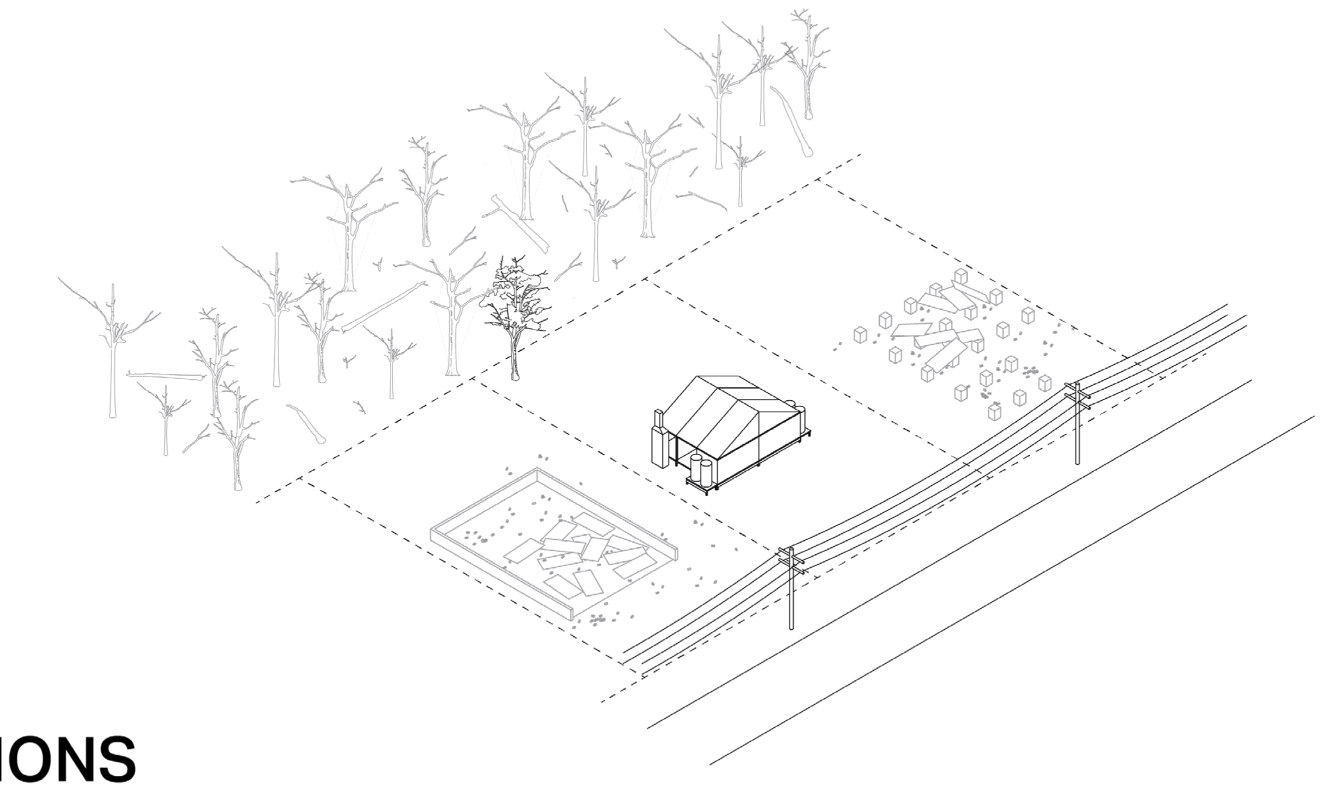
05a POD OPTIONS
emergency shelter

occupants



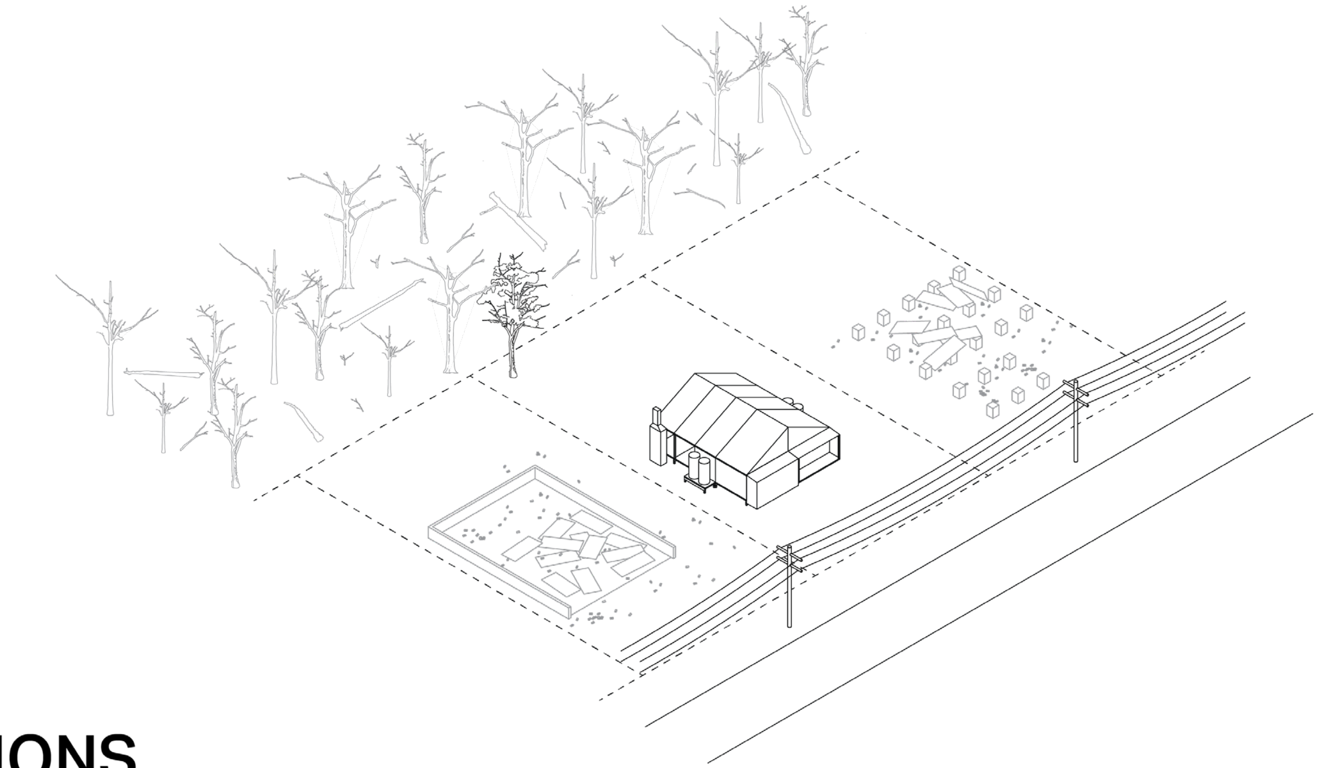
05b POD OPTIONS
single, couple or shared housing

occupants



05c POD OPTIONS
family or shared housing


occupants

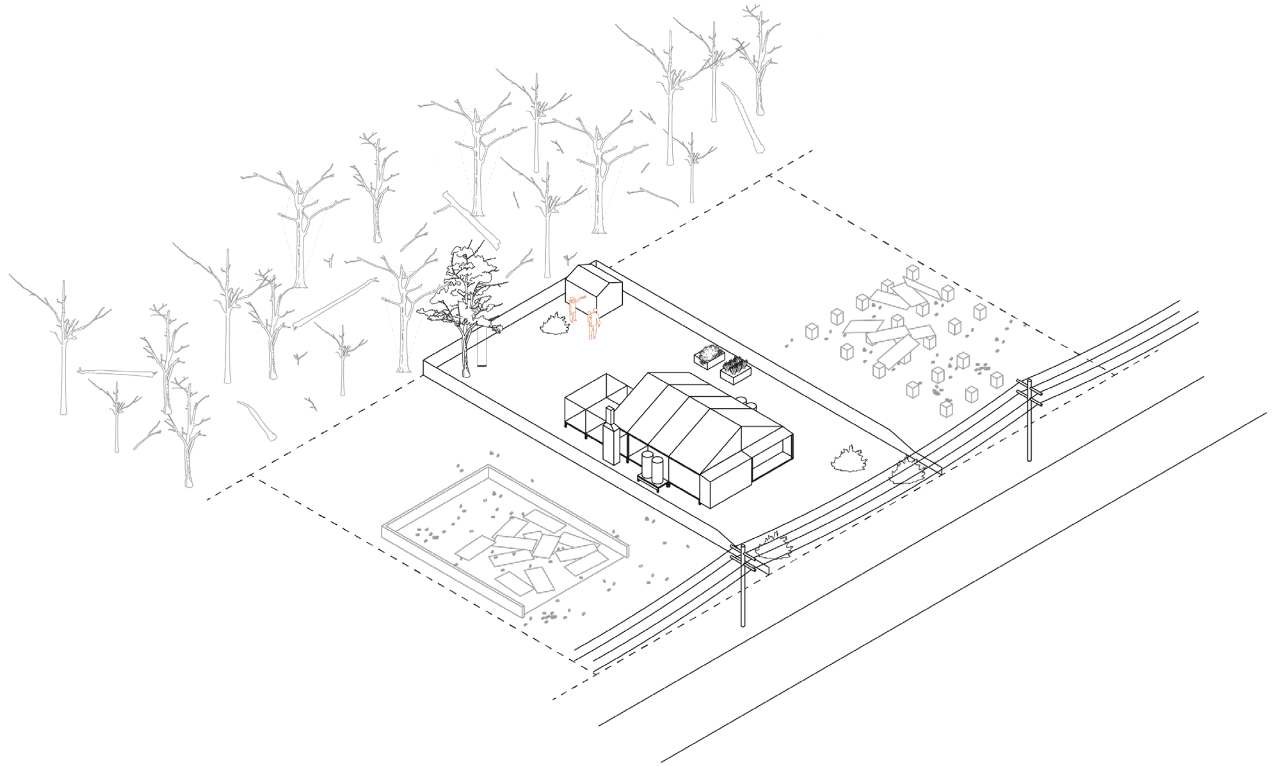


05d POD OPTIONS
multigenerational family or multiple groups

disaster | 1 week | 1 month | 3 months | 6 months | 1 year | 2 years | 5 years | 10 years

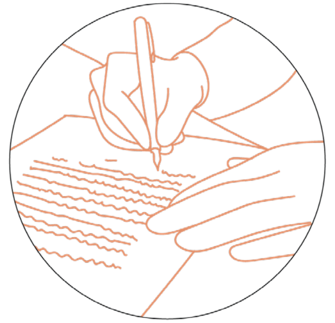

owner-builders


gardening



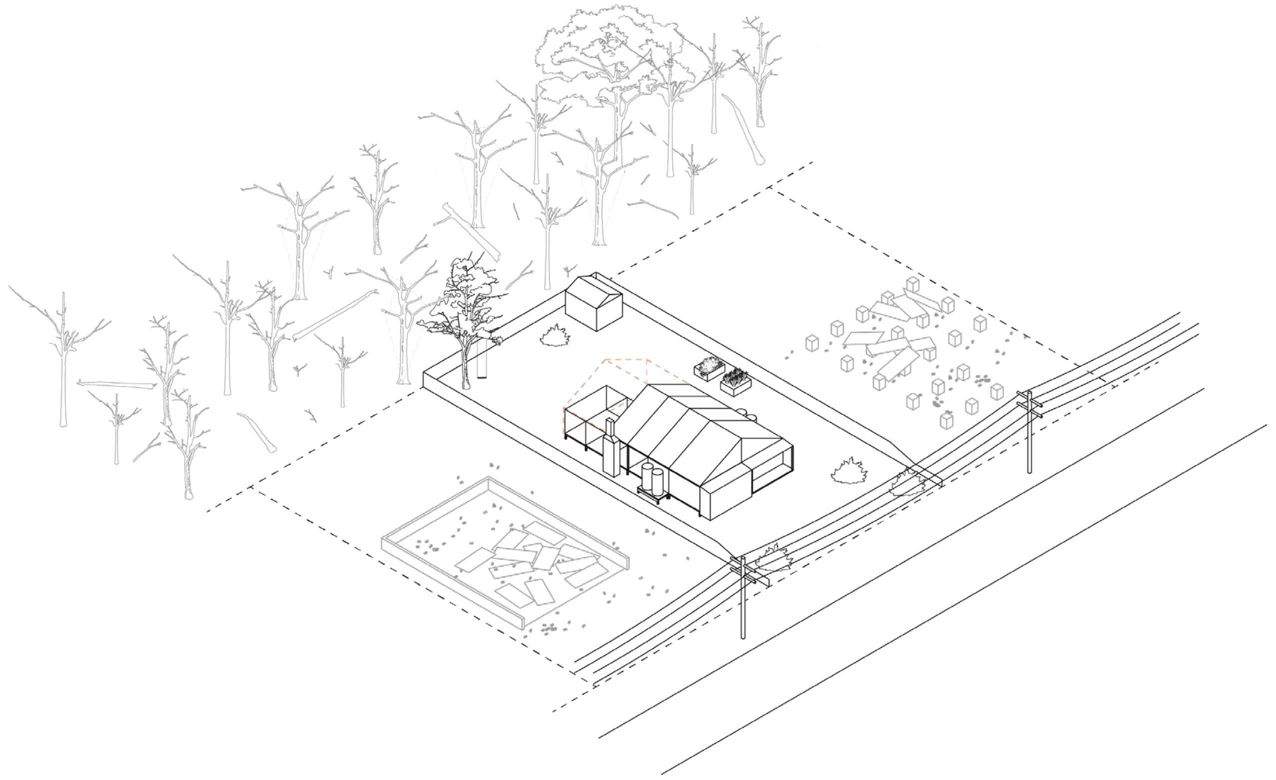
06 ADDITIONS
owner builder changes

disaster | 1 week | 1 month | 3 months | 6 months | 1 year | 2 years | 5 years | 10 years



planning process

BAL assessment



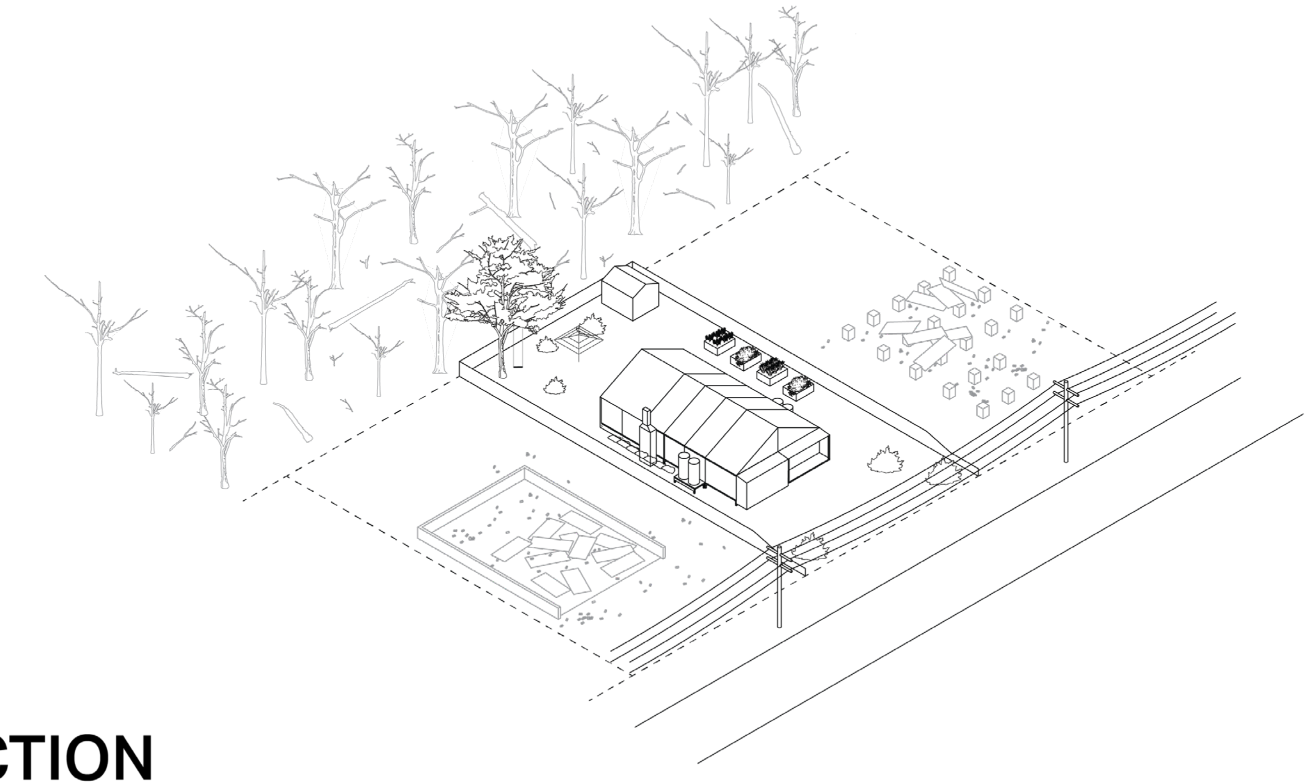
07 PLANNING

short to long term transition

disaster · 1 week · 1 month · 3 months · 6 months · 1 year · 2 years · 5 years · 10 years

prefabricated construction

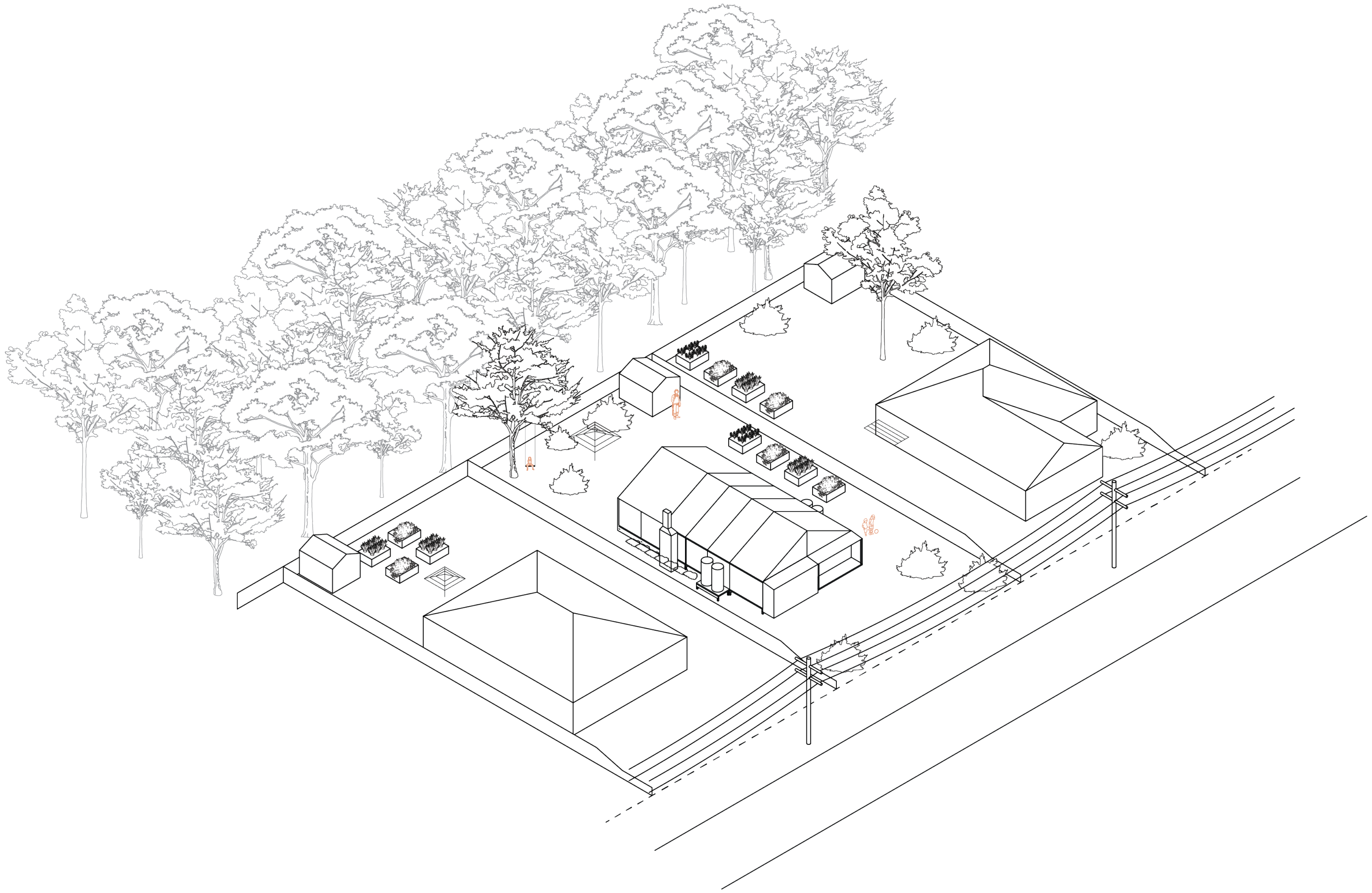
traditional construction



08 CONSTRUCTION

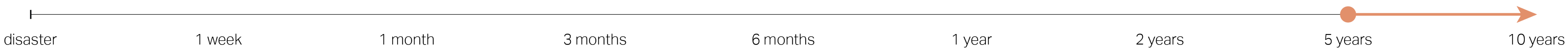
prefabricated or traditional addition

disaster · 1 week · 1 month · 3 months · 6 months · 1 year · 2 years · 5 years · 10 years



09 FUTURE

long term housing solution



CHAPTER 8

Recommendations, Conclusions, and Opportunities

Summary of Challenges

Our research has established that based on the experience of the recent bushfire and flood disasters, suitable temporary accommodation options and timely reconstruction are crucial to helping communities recover and thrive. The 2019/20 Australian bushfires destroyed over 5,900 buildings, including 2,779 homes, and killed at least 34 people. This devastating 2019/20 bushfire season has highlighted the role that prefabricated construction could play in the post-disaster rebuilding process, if it could provide timely and appropriate solutions aligned to communities needs. It is clear however that the particular context creates specific and wide-ranging challenges including:

- the differential requirements of housing solutions, from the short-term needs of post-disaster emergency shelter to the long-term desire for the reconstruction of permanent homes
- the challenges of geography, topography and site location leading to difficulties of logistics, supply chain and transportation to remote and mountainous areas
- the challenges of technical, material and service specifications for fire-resistant or resilient forms of construction in relation to the regulatory constraints of bushfire affected zones, and the process of permissions required
- the economic and financial toll of recovery for individual householders including extended timelines for emergency and longer-term rebuilding
- the specific needs and preferences for housing form and functionality, and the desire for agency and participation in the rebuild process by those affected as a part of the recovery process.

In order to address and problematize the scope of the challenges, we have identified and analysed the 'settings' which are relevant to prefabricated housing -i.e. the 'parts' of the prefabricated industrialized housing system that typically need to be considered when designing a new product or prefab solution for housing.

These components for prefab bushfire and disaster housing are extremely diverse and wide-ranging, and the advantages of prefabrication in terms of design and technical performance are not the only values that need consideration. The parts of the system that are typically most poorly considered, relate to flexibility in procurement. In particular an incremental approach to construction aligned to bushfire and disaster recovery scenarios is a gap in the current prefab housing market.

We identified and analysed the wider contexts, scenarios and conditions that impact upon prefab housing solutions for bushfire and disaster affected areas, identifying 'whole system' components that sit outside the prefabricated industrialized housing system itself, but which are absolutely critical in disaster response and recovery contexts. These include finance, building regulation, land-use control, transport regulation, and supply sector. Further, two more components of the 'whole system' are especially relevant to the prefabricated housing for bushfire and disaster context, namely 'time' and 'community'. Housing for bushfire and disaster affected areas is a specific problem which is aligned to an 'event' or disaster which happens to a community. The temporal and social aspects of a disaster and its aftermath are absolutely integral parts of the broader system impacting the design response to housing.

Preliminary Outcomes

Using the findings established in the review stages, we established a framework of 'Objectives for a Prefabricated Housing Solution for Bushfire and Disaster'. The diagram is characterised as a 'system' diagram, listing objectives within the prefab industrialized housing system (the inner circle) as well as the whole system components at play (the outer circle). This diagram can be used as a conceptual tool when considering the development of new prefabricated housing solutions for this bushfire and disaster affected areas, establishing the specific 'settings' or components required.

Using this conceptual tool, we created a design template – seeking to address all of the 'objectives' within the prefab industrialized housing system. The design template explores, proposes and tests the objectives established by responding to each in turn and then synthesizing together in a design process - to create an integrated solution suitable for varied scenarios. This emerges as a flexible 'kit of parts' or 'product platform' approach where the variability found in the different contexts and situations can be accommodated through the use of different elements of the platform, from volumetric modular pods, to panel components, to traditional construction. In particular, this proposition presents a product platform for immediate post-disaster housing that can be incrementally expanded to create a permanent home, addressing one of the critical gaps in current provision.

Roadmap Recommendations

The CRC #35 Design Template is a 'model' which has been developed by the research team of architects, engineers and researchers within a hypothetical context. It could be explored further as a 1:1 prototype to test its constructional, functional and spatial logics. It could also be explored in collaboration with others. We would therefore recommend:

- Develop the design template to a full scale prototype with an industry partner to road test aspects of the design which have stood outside this study so far including detail costs, alignment to industry and factory manufacture and assembly process, supply chain, material and structural / transport logistics.

Given that the broader 'whole system' components – including finance, building regulation, land-use control, highway regulation, time and community - have been established as important, we recommend a further stage of this study could include specific collaborative research with relevant external partners as follows:

- Further explore the dimensions of finance and procurement in the context of local and national policy initiatives for disaster response and recovery. This might include identifying relevant Victorian, NSW or state / federal government authorities, exploring connections to policy and the needs of emergency and recovery. An example is the Department of Families, Fairness and Housing White Paper on temporary accommodation for disaster displaced communities and individuals.
- Further explore the dimensions of land-use and building regulation in the context of efforts to harmonise and simplify regulation in the context of response and recovery. This might include exploring examples of local / state government BAL assessments, addressing regulatory processes generally.
- Further explore the time and community dimensions of the design template, by testing a prototype in a community recovery setting, incorporating aspects of community co-design and community-led implementation. This could include identifying an appropriate community in the Fire to Flourish Program (Monash MSDI, Australian Centre for Social Innovation, Paul Ramsay Foundation).

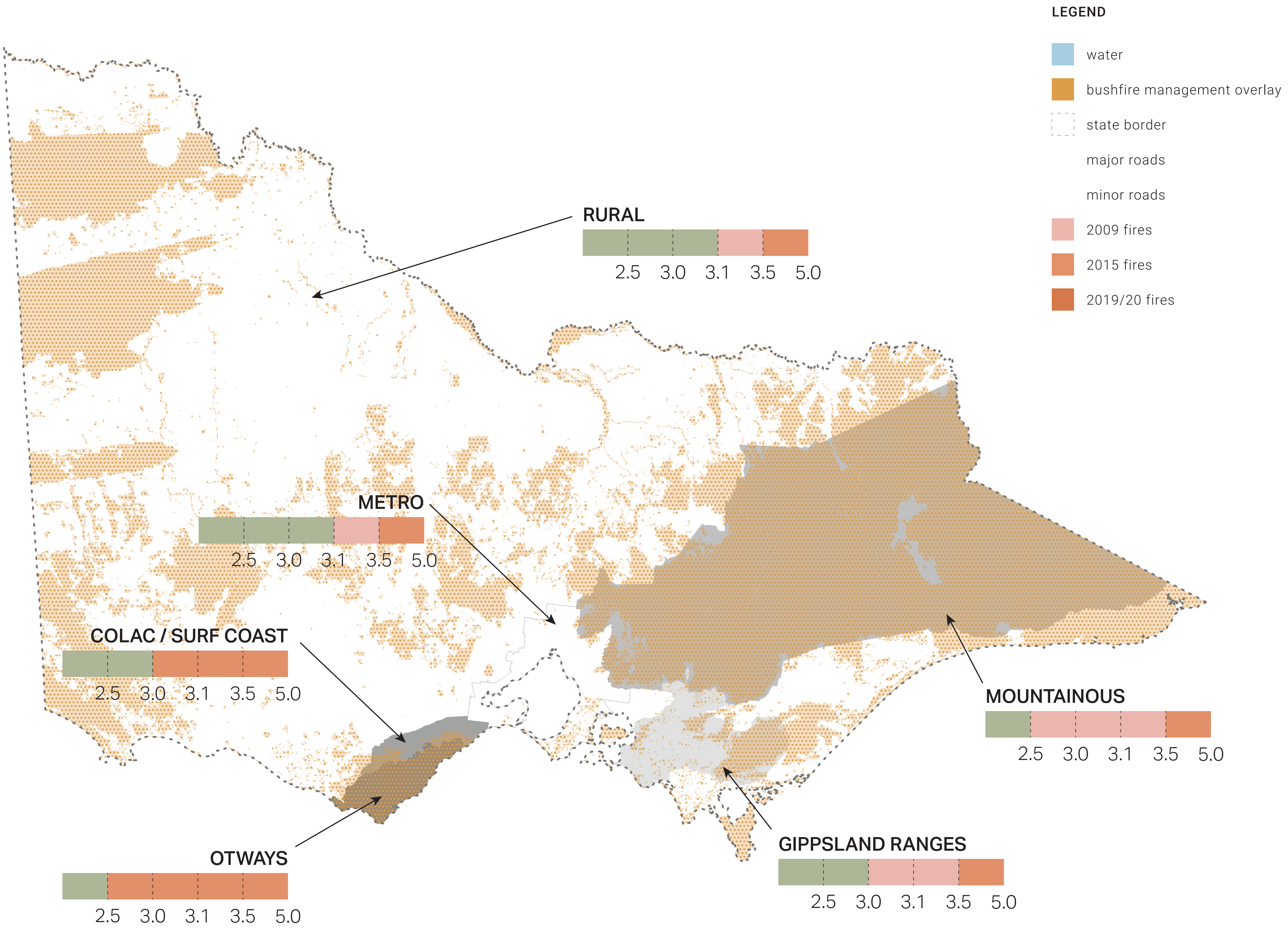


Figure xx: Victorian Bushfire Map, 1:2,500,000

CRC AMGC #35

Prefab Housing Solutions for Bushfire and Disaster Relief

Design research

PRECEDENT PROJECT CATALOGUE

Authors

Prof. Mel Dodd
Oscar Sainsbury
Dr Rachel Couper

Contents

Precedent Projects Catalogue

Catalogue Outline

The selected precedent projects are catalogued into the following categories for evaluation and analysis. The categories were defined through their type, location and function and serve as a way of understanding the commonalities of various projects under consideration.

Category 1: Prefabricated Short-Term Housing (Bushfire and Other Disaster Relief)

Projects in this category, while not bushfire resistant, are used as temporary housing for people affected bushfire other disasters such as flood, tsunami and earthquake. The small size of the units allows them to be transported to a variety of sites meaning people can continue living on their land even after their home has been damaged or destroyed. While the accommodation may be connected to mains services, it is not seen as a permanent house and in some cases, there is a time limit associated with its use.

Category 2: Prefabricated Housing (Bushfire Resistant)

This category contains prefabricated permanent housing built with bushfire resistance, that reaches the two highest levels of resistance in Australia being BAL FZ and BAL 40. The types of prefabrication include modular construction where the complete house is constructed off site and then delivered to site in modules as a finished product, prefabricated panels which is defined by panels being a structural element, as well as component or 'kit of parts' construction where various elements are prefabricated off site and then delivered for assembly and completion on site. Some projects are a combination of these three categories. Different structural and material systems are also investigated through these projects including lightweight timber frame, steel and aluminium structures, SIPS (structurally insulated panel systems) and CLT (cross laminated timber).

Category 3: Prefabricated Housing (General)

Projects in this category range from guest accommodation suites, off-grid cabins to permanent housing but are distinguished from Category 1 as they are not used on a short-term basis. The types of prefabrication, structural and material systems are the same as listed in Category 2 but these projects are more general in their focus and only achieve a lower level of bushfire resistance being BAL 12.5, BAL 19 or BAL 29.

Category 4: Non-Prefabricated Housing (Bushfire Resistant)

This category contains permanent houses that have been designed and constructed to directly respond to environments affected by bushfire. The response may be different depending on the site conditions, regulatory requirements and client needs but each project has a direct relationship with bushfire through their site access, structural systems and material use.

Category 5: Housing (Half-house / Owner Builder / Social Models)

These projects may be individual houses but are often multi-residential developments where a number of houses are constructed simultaneously. These projects are defined by the involvement of the client and broader community in both the design and construction process. These projects also show a more flexible approach to construction timing giving owners the option to build the project in stages depending on their financial, spatial and emotional needs.

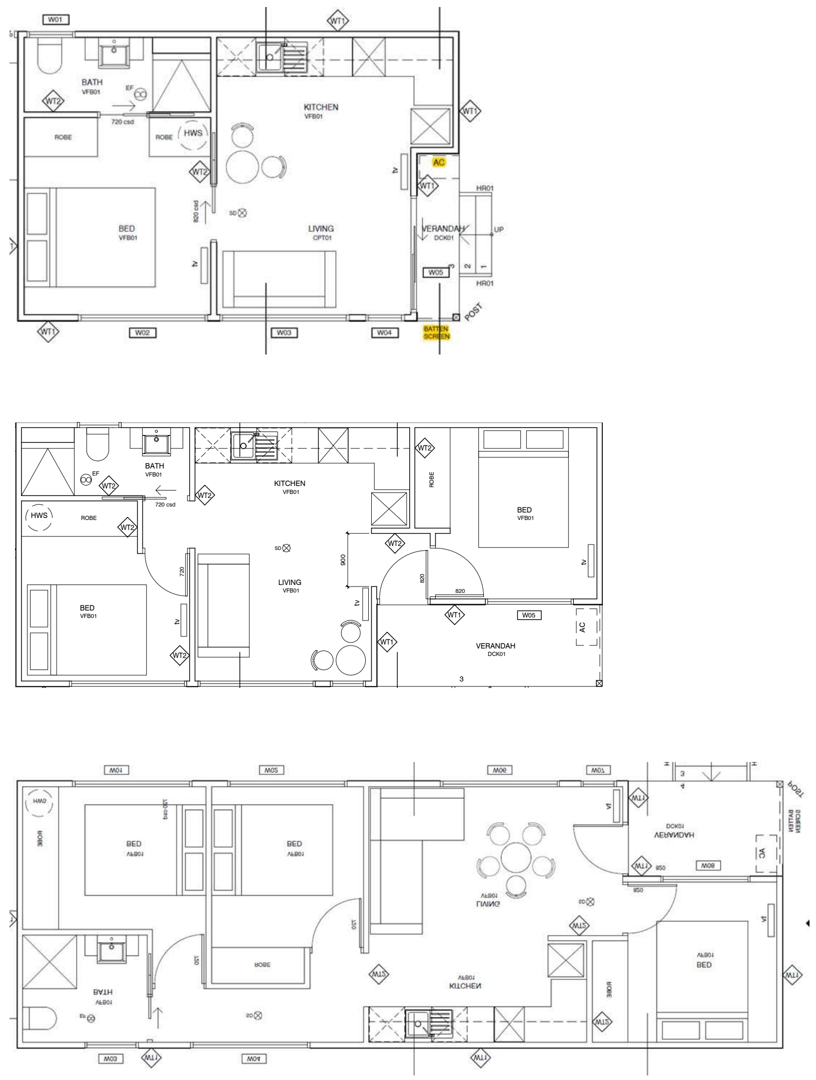
Category 6: Other

This category contains projects that don't easily fit in the preceding five categories. Rather than housing they may be projects such as community buildings, tourist accommodation or infrastructures, yet still contain learnings or examples of value – such as prefabricated construction techniques, minimal accommodation requirements or a particular relationship to bushfire conditions and environments.

Category 1: Prefabricated Short Term Housing (Bushfire and Other Disaster Relief)

Catagory 1: Prefabricated Short Term Housing (Bushfire / Disaster Relief)

Short-Term Modular Housing
Bushfire Recovery Victoria (BRV)
Various, Victoria, 2020 - 2022



1, 2, 3 bed plans

project images

Project Information

Built / Unbuilt:	Built (multiple)	Onsite Lifting Req:	Med-heavy capacity crane (10-30T)
Architect / Designer:	BRV	Transport Req:	Semi-trailer oversized; 3.5+m width restriction (4.3m)
Construction Company:	Ausco and Modular System		
Manufacture Type:	Modular	BAL Rating:	BAL 29
Assembly Process:	Factory	SQM	32 sqm
Structure:	Timber frame	Cost (per sqm):	unknown
Materials:	Cement cladding, metal windows	Construction Time:	12 - 24 hrs for site preparation and assembly

Project Summary (from BRV)

Short-term modular housing is an option available for a number of families who lost their primary place of residence in the 2019/20 Victorian Bushfires.

The housing will be delivered to your property, or another location as agreed by authorities, property owners and the resident. You will be able to live in these homes for a period of up to three years while you progress your permanent rebuild. Short-term modular housing is a 'bridge' between accommodation provided in the weeks and months after the fires, and the long-term rebuild of your home.

Everyone who lost their primary place of residence in the bushfires can access emergency accomodation by contacting the Victorian Bushfires Case Support Program.

Catagory 1: Prefabricated Short Term Housing (Bushfire / Disaster Relief)

Temporary Accommodation Pods
Minderoo Foundation
Various, Australia

delivery images

Project Information

Built / Unbuilt:	Built (multiple)	Onsite Lifting Req:	Low capacity crane <10T
Architect / Designer:	Minderoo	Transport Req:	Semi-trailer truck; No width restriction
Construction Company:	Australian Portable Camps	BAL Rating:	unknown
Manufacture:	Modular	SQM	unknown
Assembly:	Factory	Cost (per sqm):	unknown
Structure:	Altered Shipping Container	Construction Time:	1-2 hour for lifting.
Materials:	Steel		

project images

Project Summary (from Minderoo Foundation)

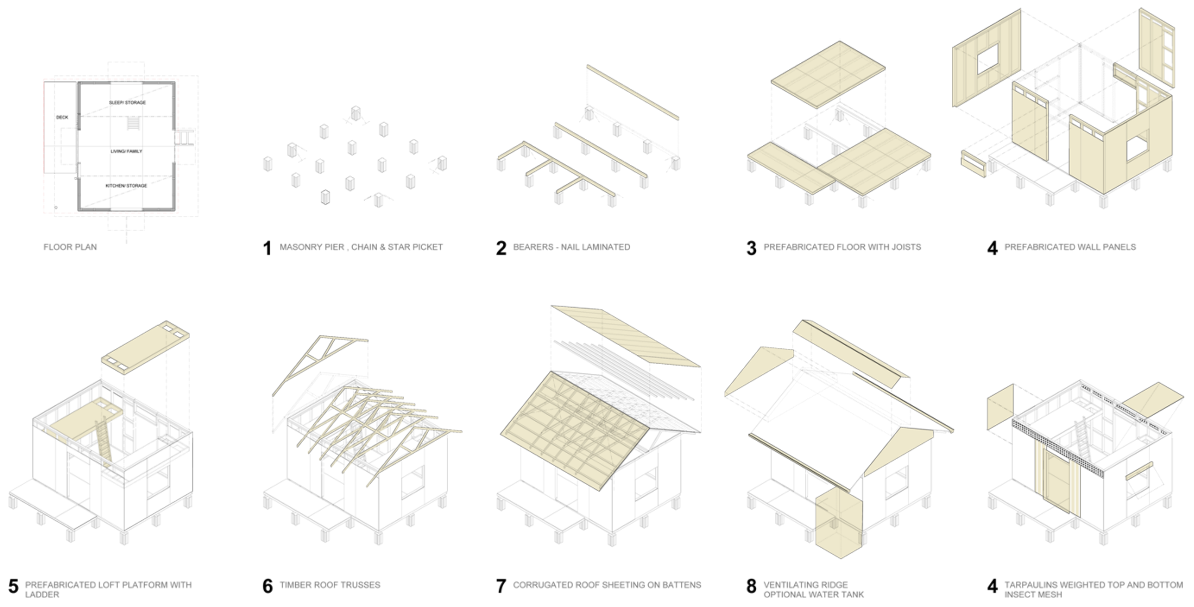
Our innovative team designed, developed and created a construction process for the deployment of the Fire Fund Recovery Pod to be used as temporary housing to help those who have lost their homes. The recovery pods are self-contained and equipped with a 2,300-litre water tank and 5 KVA generator. Internally, they have a toilet, shower, two bunk beds and a small open kitchen.

The idea for temporary accommodation was conceived on a pocket notepad at an emergency meeting at Kangaroo Island in January. The idea was born from listening to the community members express their desperate need to get back on to their land. The construction of the pods commenced in February 2020 from South Australian manufacturer Australian Portable Camps, based at Monarto.

As of August 2020, 182 pods had been delivered in 216 days to families in New South Wales and South Australia. Our commitment of AU$3.7 million was supplemented by AU$8.7 million from our partners which will enable 256 pods to be delivered in 259 days.

Catagory 1: Prefabricated Short Term Housing (Bushfire / Disaster Relief)

Disaster Relief Housing.
Sam Crawford Architects
Aceh, Indonesia 2005



plan / construction axo

Project Information

Built / Unbuilt:	Built (Canberra Biennale)	Onsite Lifting Req:	None
Architect / Designer:	Sam Crawford Architects	Transport Req:	Small tray truck; No width restriction
Construction Company:	Built by Architect and volunteers	BAL Rating:	unknown
Manufacture:	Kit of Parts	SQM	17.25sqm (3.6m x 4.8m + deck)
Assembly:	Mix	Cost (per sqm):	unknown
Structure:	Plantation timber structural frame	Construction Time:	2 hours
Materials:	Plywood, metal and polycarb cladding		

project images

Project Summary (from Sam Crawford Architects)

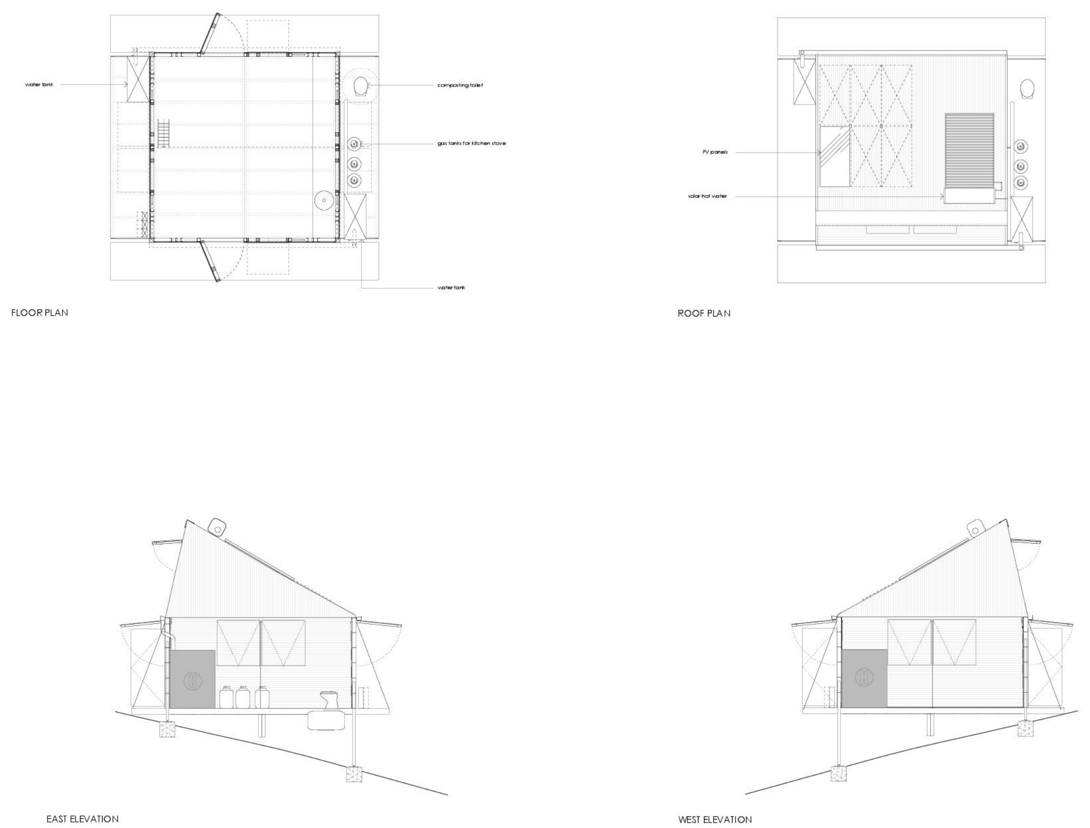
The Disaster Relief Housing was designed as a submission for, and selected for exhibition in, the inaugural Canberra Bienale of Architecture & Design which focused on temporary dwelling. Our chosen brief was to develop a temporary dwelling to address the then current housing crisis in Aceh Province, Indonesia, following the 2004 Tsunami.

Due to complete devastation of housing & infrastructure in Aceh, permanent housing for many of the 500,000 displaced people would not be available for 3 to 5 years after the disaster. The sheer volume of building materials required for rebuilding posed an environmental disaster if sourced locally. Illegal logging was – and likely still is – stripping Aceh of one of Indonesia's last relatively intact tropical forests. Our design utilised prefabricated components made from Australian grown plantation timbers to provide temporary dwellings that could later be either demolished & recycled, or modified to suit more permanent needs. Prefabrication was to initially occur in Australia, with prefabrication facilities (using donated materials) being developed in Aceh with local business/ village groups as soon as possible thereafter. The prefabricated panels could then be erected by one skilled person with a team of five or six local people in a matter of hours. Twelve teenage apprentices managed to erect the structure in two hours for the Bienale in Canberra.

The Disaster Relief Housing is a very simple, lightweight, low cost shelter suited to a hot humid climate. We felt that the appearance should not be alien to the vernacular architecture. People in crisis need stability and familiarity, not cutting edge design produced by an alien culture/ designer seeking to bolster their own ego or identity. It was a very interesting and educative process. Having been selected to exhibit our design in Canberra we sought out aid organisations who might want to utilise it. In our earnest effort to design a culturally and climatically appropriate dwelling, we had not appreciated one very important fact. Habitat For Humanity advised us that whilst traditional house construction in Aceh Province, Indonesia has generally been of lightweight materials (timber, bamboo, thatch), the current cultural preference is for solid, masonry construction – something our design certainly is not, and could never really be. This was a salutary lesson for us.

Catagory 1: Prefabricated Short Term Housing (Bushfire / Disaster Relief)

Emergency Shelter
Carter Williamson Architects
Australia, 2012



plans

project images

Project Information

Built / Unbuilt:	Built (1l)	Onsite Lifting Req:	None
Architect / Designer:	Carter Williamson Architects	Transport Req:	Small tray truck; No width restriction
Construction Company:	unknown	BAL Rating:	unknown
Manufacture:	Kit of Parts	SQM	37.5sqm
Assembly:	Mix	Cost (per sqm):	unknown
Structure:	Light Gauge Steel	Construction Time:	unknown
Materials:	Plywood and metal cladding		

Project Summary (from Sam Crawford Architects)

In a world increasingly challenged by both man-made and natural disasters, the Shelter has been designed as a sustainable housing prototype that can be configured to suit almost any climate or orientation and can be readily and cheaply transported to diverse and remote locations around the globe. Arriving flat-packed, the Shelter can be assembled quickly and has the potential to make a significant difference when applied to a range of medium- to long-term housing solutions; it could also provide immediate solutions to industry as it moves to frontier locations. Most importantly, by providing refuge and security for families and communities in crisis, the Shelter can give back to societies in need everywhere. Beyond emergency relief, the Shelter is known as Pavilion, a flexible module of space that could be used as a holiday house, a remote research laboratory, even mining accommodation; whatever can be conceived of in 37.5 sqm.

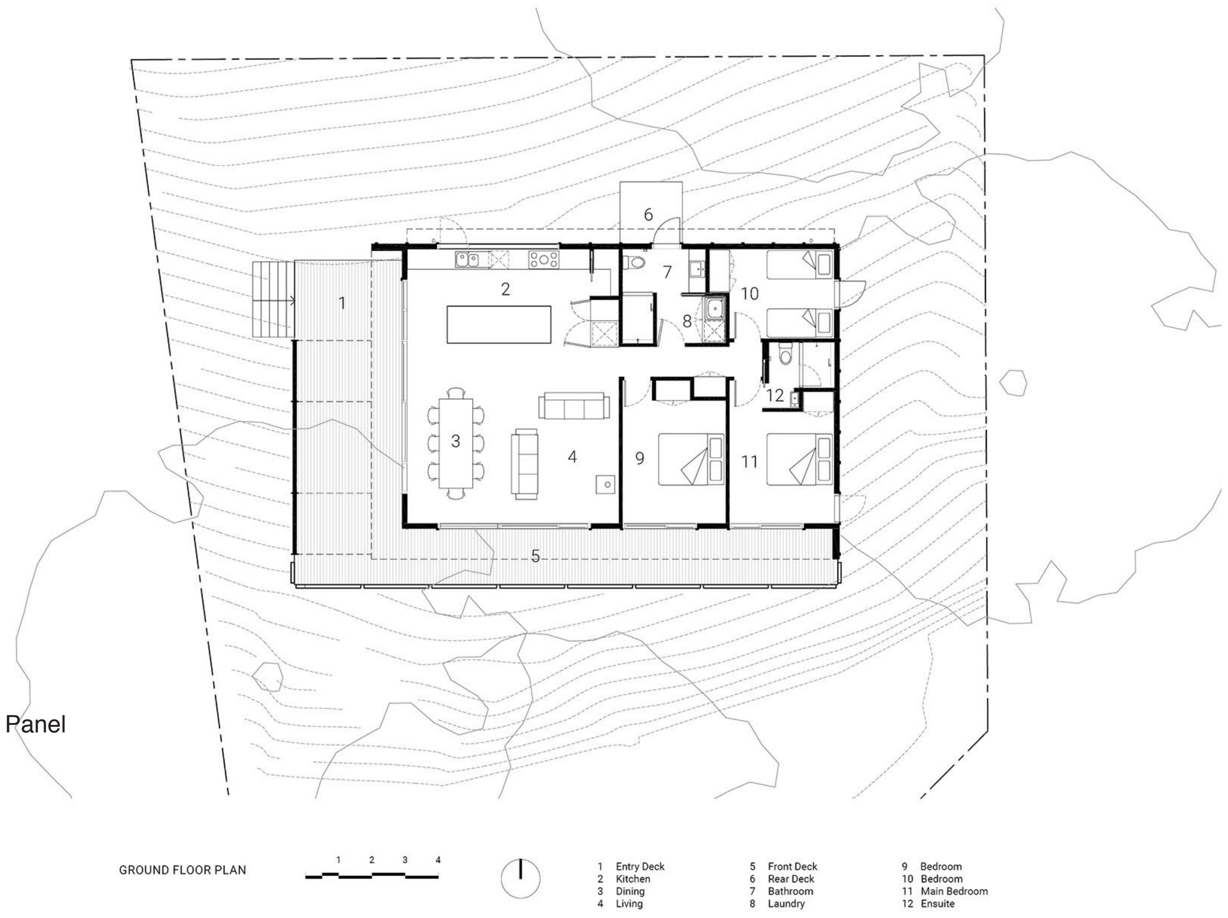
Category 2: Prefabricated Housing (Bushfire Resistant)

Catagory 2: Prefabricated Housing (Bushfire Resistant)

Tucker House

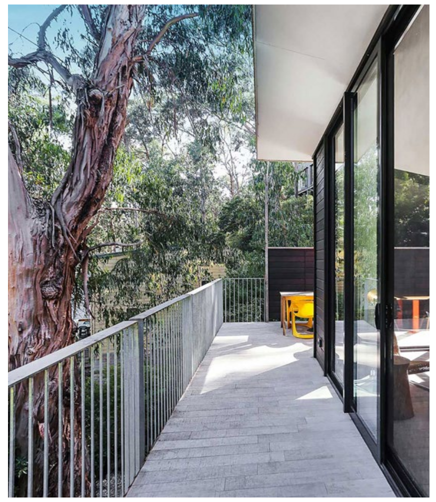
Arkit

Wye River, Victoria, 2014



Panel

plan



project images

Project Information

Built / Unbuilt:	Built 2014 - Destroyed by fire 2015 (rebuilt 2016)	Onsite Lifting Req:	Low capacity crane <10 T (panel lifting)
Architect / Designer:	Arkit	Transport Req:	Small tray to semi-trailer truck (prefab panels); No width restriction
Construction Company:	Arkit	BAL Rating:	BAL 40
Manufacture:	Panel	SQM	140sqm + decking and undercroft
Assembly:	Mix	Cost (per sqm):	$635,000 incl GST, design, consultant, authority fees and construction.
Structure:	Structural steel and timber frame.	Construction Time:	Subject to on-site construction
Materials:	Timber cladding		

Project Summary (from Arkit)

Located in a steep and densely vegetated area, key considerations for the project included achieving a Bushfire Attack Level rating of BAL 40, constructing the building in a sensitive manner on the challenging and largely inaccessible site and delivering a design respectful of the unique setting. Spatial requirements for the project included three bedrooms, two bathrooms, laundry, open plan kitchen, living and dining room and an expansive, elevated wrap around deck. Finished externally in black stained timber cladding, internal treatments include 100% plantation harvested hoop pine plywood interior lining, 95% recycled composite plasterboard, very high insulation levels and thermally broken double glazed doors and windows. The project was site built with prefabricated wall, roof and floor components constructed on an elevated structural platform to maximise sea views.

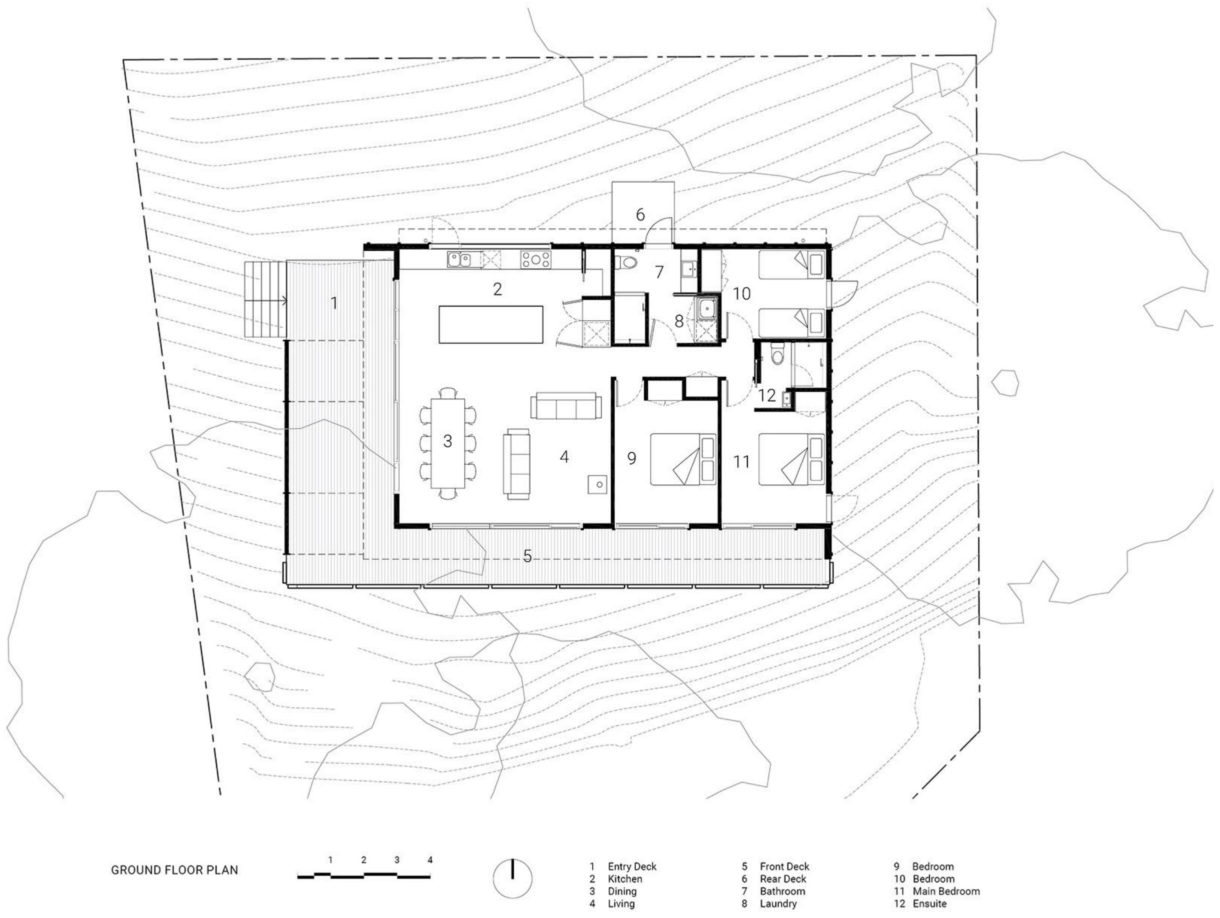
Catagory 2: Prefabricated Housing (Bushfire Resistant)

Make Remake (Formally Tucker House)

Arkit

Wye River, Victoria

2016



plan

Project Information

Built / Unbuilt:	Built 2014 - Destroyed by fire 2015 (rebuilt 2016)
Architect / Designer:	Arkit
Construction Company:	Arkit
Manufacture:	Panel
Assembly:	Mix
Structure:	Structural steel and timber frame.
Materials:	Timber cladding
Onsite Lifting Req:	Low capacity crane <10 T (panel lifting)
Transport Req:	Small tray to semi-trailer truck (prefab panels); No width restriction
BAL Rating:	BAL 40
SQM	140sqm + decking and undercroft
Cost (per sqm):	unknown
Construction Time:	Subject to on-site construction

project images

Project Summary (from Arkit)

Make Remake is a unique project. In December 2015, a bushfire destroyed 2500 hectares of forest and 116 houses in Wye River and Separation Creek. One of the homes destroyed in the fire was a previous ARKit project.From the outset the owners were intent on rebuilding. While the original brief for the new dwelling was to replicate the design of the previous house, this requirement soon evolved to allow for a new building of its own making.A key consideration for the design changes was the significantly altered landscape that the new house was to occupy. Whilst the previous house was nestled into the treetops, the new house, with an absence of vegetation, would have greater visual prominence within the site.Clad in a chevron pattern of fibre cement sheet and tonal greys, that echo those found in local blackwood and manna gums, the building's presence will recede over time as revegetation occurs.The new building is perched high on the steeply sloping site that now offers expansive ocean views. In response to the changed outlook, a generous indoor/ outdoor living space has been created through an extended wrap around deck that adjoins the open plan kitchen, living and dining room and provides a link through to the three bedrooms and two bathrooms.A key aspect of the original brief that remained unchanged was the owner's desire for the home to be highly sustainable. To that end, many of the original finishes were reworked into the new design. These included 100% plantation harvested hoop pine plywood interior lining, 95% recycled composite plasterboard, very high insulation levels and thermally broken double-glazed doors and windows.

Catagory 2: Prefabricated Housing (Bushfire Resistant)

Fortis House

Bushfire Building Council of Australia (BBCA)

Various

2022

plan

project images

Project Information

Built / Unbuilt:	Unbuilt
Architect / Designer:	BBCA
Construction Company:	Various
Manufacture:	Kit of Parts
Assembly:	Mix
Structure:	Unknown
Materials:	Metal Cladding and Screens
Onsite Lifting Req:	Medium to heavy capacity crane (10 - 30 T)
Transport Req:	Semi-trailer oversized; 3.5+ m width restriction (3.6m).
BAL Rating:	BAL FZ
SQM	173sqm
Cost (per sqm):	unknown
Construction Time:	n/a

Project Summary (from fortishouse.com)

FORTIS House is an exemplar home design, created in collaboration with the Shoalhaven community, to assist communities recovering from the 2019-20 bushfires.The purpose of FORTIS House is to save time and money by fast-tracking the re-building process with an affordable, sustainable, adaptable and highly resilient home design. FORTIS House will be designed to meet BAL FZ (the highest BAL rating), so it can be used to comply with any BAL rating requirements. FORTIS House is being developed by the Bushfire Building Council of Australia, a national, independent, not-for-profit network of Australia's leading bushfire experts including fire safety engineers, structural engineers, bushfire architects and research scientists.

FORTIS House will make the re-building process easier, with free architectural drawings, construction manual and consumer handbook that shows community members, building designers and trades how to adapt the design to a homeowner's site requirements, style and required BAL rating.

The project is sponsored by NRMA and supported by Shoalhaven City Council.

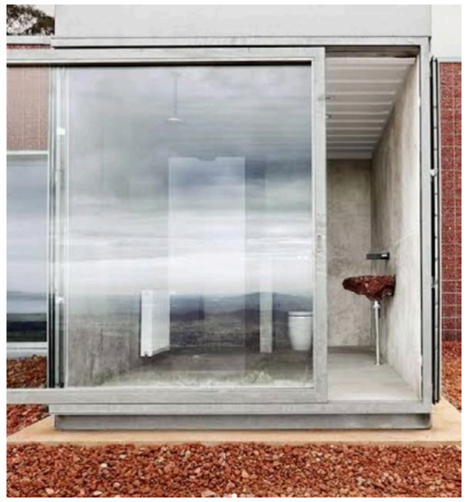
Catagory 2: Prefabricated Housing (Bushfire Resistant)

Bushfire Proof House

Built by Joost

Kinglake

2015



project images

Project Information

Built / Unbuilt:	Built	Onsite Lifting Req:	Small capacity crane <10 T (panel lifting)
Architect / Designer:	Built by Joost	Transport Req:	Small tray truck to semi-trailer truck (prefab panels); No width restriction.
Construction Company:	Built by Joost	BAL Rating:	BAL 40
Manufacture:	Panel / Kit of Parts	SQM:	unknown
Assembly:	Mix	Cost (per sqm):	$600,000
Structure:	Concrete slab, structural steel frame	Construction Time:	unknown
Materials:	Crushed recycled brick, straw bale		

Project Summary (from Built by Joost)

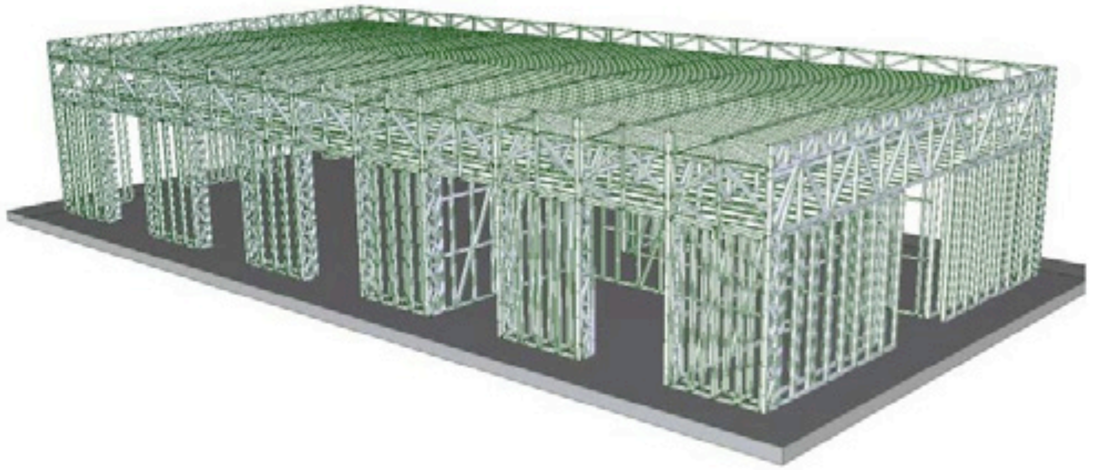
Before the construction of Bakker's Kinglake house started, its building system was successfully burn tested by the CSIRO under extreme conditions. The roof is covered in soil making it highly fire-resistant. The off-grid house is built entirely with recycled or recyclable materials, including a 100% recycled concrete slab and a steel frame made with crushed recycled brick and insulated with straw bales. Completed in 2015, the construction cost about $600k. The plans are freely available via the Bushfire Building Council of Australia (BBCA).

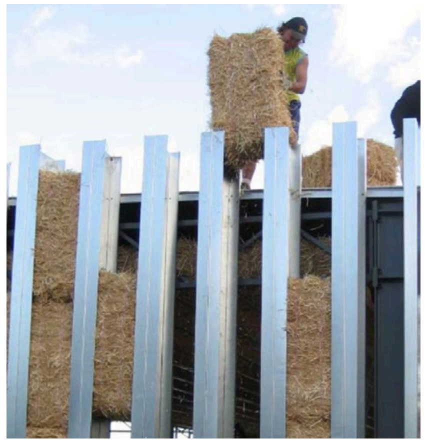
Catagory 2: Prefabricated Housing (Bushfire Resistant)

Monbulk House

Built by Joost

Monbulk





construction

project images

Project Information

Built / Unbuilt:	Built
Architect / Designer:	Built by Joost
Construction Company:	Built by Joost
Manufacture	Kit of Parts
Assembly:	On Site
Structure:	Concrete slab, structural steel frame
Materials:	Concrete blocks, straw bale

Onsite Lifting Req:	Low capacity crane (<10 T)
Transport Req:	Small tray truck to semi-trailer truck (small modules + panels); No width restriction.
BAL Rating:	BAL 40
SQM:	unknown
Cost (per sqm):	unknown
Construction Time:	unknown

Project Summary (from Built by Joost)

Built by Joost integrates design and construction with a complete project focus to deliver the most cost effective outcome. The Productive Building SystemTM is fast to construct and delivers a building with low embodied energy. Other benefits include:

- The prefabrication of building components ie.framework and trusses and the containerised kitchen and bathroom, accelerates the on-site building process and removes the need for plumbers, tilers and other tradesman to be on site

- Fire resistant and ideal for Australia's bush fire prone areas (CSIRO tested and approved)

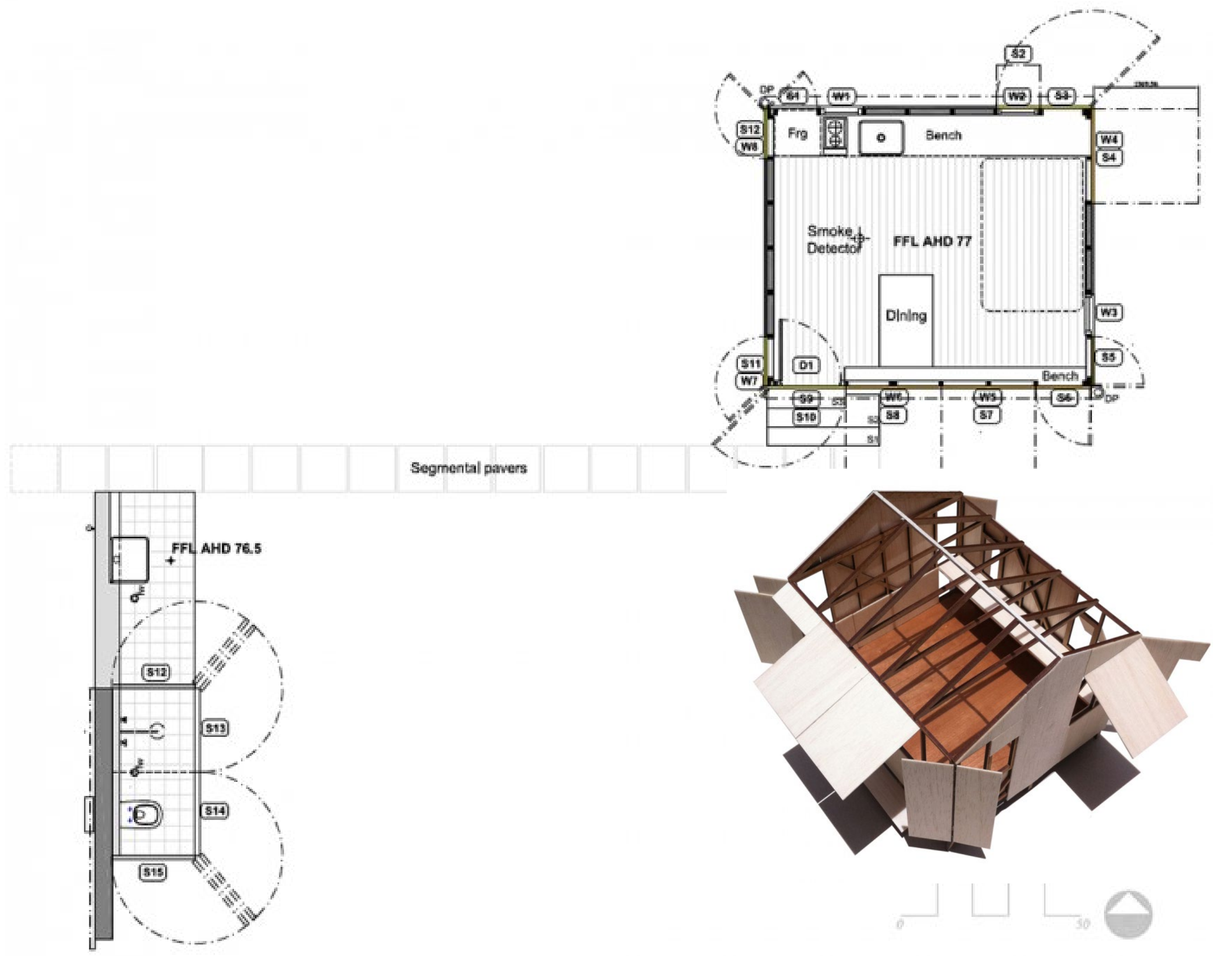
- Straw bale insulation in the walls and ceiling combined with good thermal mass (internal solid block walls) controls summer heat gain and winter loss.

Catagory 2: Prefabricated Housing (Bushfire Resistant)

Camera Botanica

Ian Weir Architect

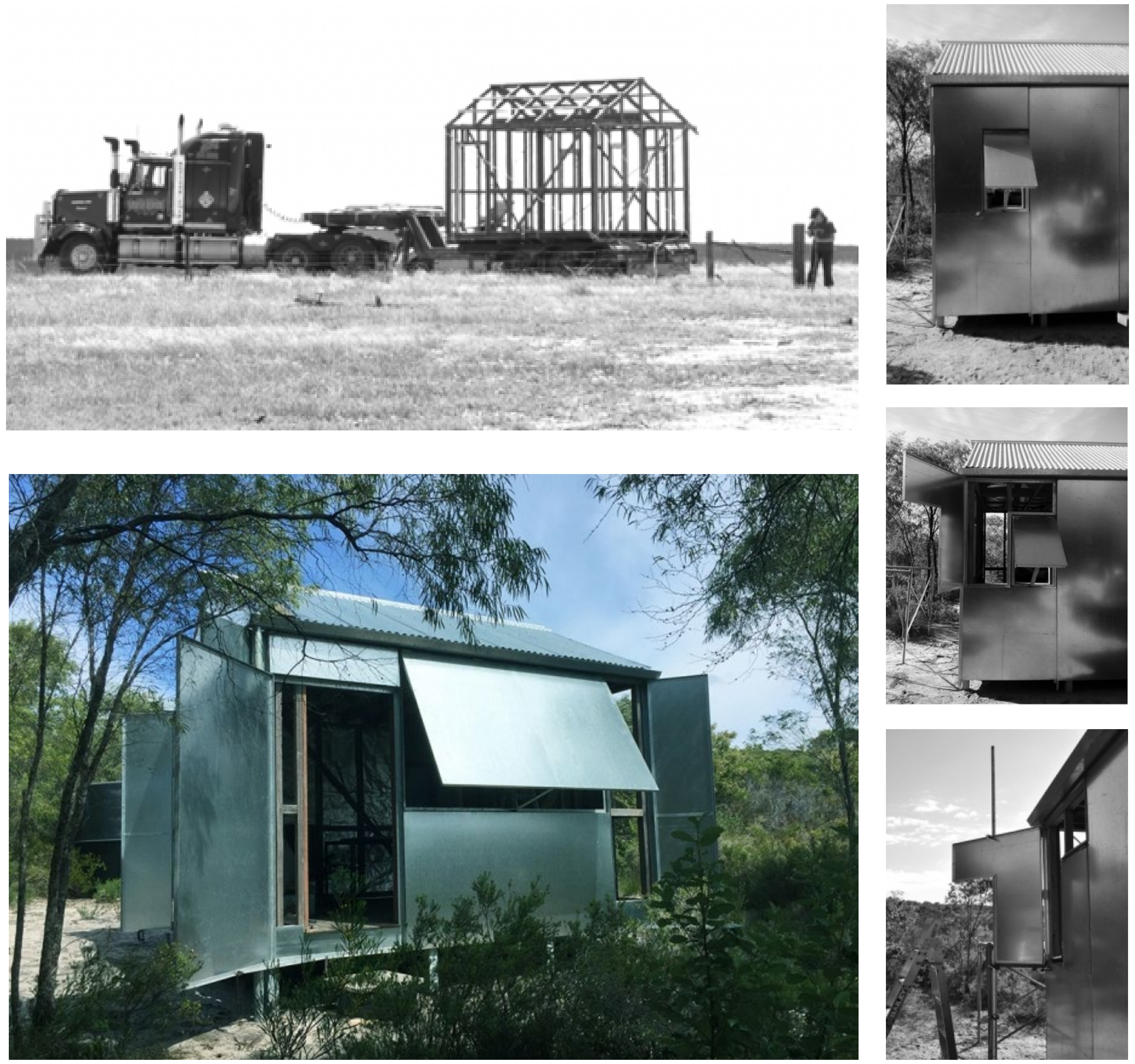
Point Henry, WA



plan

Project Information

Built / Unbuilt:	Built	Onsite Lifting Req:	Low capacity crane <10 T
Architect / Designer:	Ian Weir Architect	Transport Req:	Small tray truck to semi-trailer truck (panels and flatpack); No width restriction
Construction Company:	Ian Weir Architect		
Manufacture	Modular / Kit of Parts		
Assembly:	Mix	BAL Rating:	BAL 40
Structure:	Hardwood Frame	SQM	10sqm approx.
Materials:	Metal roof sheets, galvanised steel cladding	Cost (per sqm):	unknown
		Construction Time:	unknown



project images

Project Summary (from Ian Weir Architect)

Camera Botanica is an architectural intervention under construction on Content Too, Ian's study site at Point Henry, WA. This design research seeks to question how the kwongkan heath of Content Too might provide a catalyst for rethinking an architectural response to biodiversity and bushfire.

Camera Botanica involves the relocation of a 60 year old hardwood house frame from the agricultural landscape of Ian's childhood. The extraction of the structure from a once highly biodiverse and now degraded site to one where the botany is celebrated (on Content Too) provides opportunities to question notions of place, aesthetics and functionality.

Camera Botanica is built to Bushfire Attack Level of BAL40, the second highest BAL level in the Australian Standard AS3959:2009. But is it not merely a technical solution. It also embraces the cultural dimensions of the agricultural landscape of the Bremer Bay hinterland which was itself cleared by fire and developed, first as the last and largest of Australia's War Settlement Schemes and then as a part of the state's 'Million Acres a Year' agricultural development program.

Camera Botanica is clad in a shield of heavy gauge galvanised steel, with 13 operable bushfire shutters, each protecting apertures of stainless steel mesh and glazing. Fixed wall panels are lined internally with fire-proof sarking which provides a second line of defence. Roof, wall and floor insulation is mineral wool and fire rated batts. The hardwood frame (Jarrah and Wandoo) has thermal conductivity from high temperatures, this frame being lined with low VOC hardwood plywood as the very last line of defence.

Catagory 2: Prefabricated Housing (Bushfire Resistant)

Modscape
Wye River
2013

project image

Project Information

Built / Unbuilt:	Built	Onsite Lifting Req:	Low capacity crane <10T
Architect / Designer:	Modscape	Transport Req:	Small tray truck (small modules and panels); No width restriction.
Construction Company:	Modscape	BAL Rating:	BAL 40
Manufacture:	Modular	SQM	unknown
Assembly:	Factory	Cost (per sqm):	unknown
Structure:	Structural Steel subfloor	Construction Time:	unknown
Materials:	Steel cladding, cement sheet underfloor.		

project images

Project Summary (from Modscape)

On Christmas Day 2015 a raging fire tore through the Wye River and Separation Creek region. Over 100 homes were destroyed with roughly 80% of buildings in the fire area lost to fire. Following the fire the CSIRO reviewed the houses that were impacted in the Wye River fire footprint with the aim of identifying factors that led to the loss, damage and survival of these houses. A Modscape home at Wye River survived the fire and was assessed as part of the CSIRO's report. Completed in 2013, the design of the home utilises four modules and is raised high off the sloping ground, taking full advantage of the stunning sea views. The home was constructed to Bushfire Attack Level 40 (BAL40) construction requirements. This meant certain non-combustible materials were selected. Colourbond steel was selected for the cladding as it both complied with bushfire regulations and didn't compete visually with the surrounding bush.The home survived the fire with some charring to its decking, and the report identified a number of design factors that led to the survival of the home, stating: "The house's steel support structure and non-combustible subfloor, cladding, window frames and doors were effective in resisting ignition in combination with aerial suppression activities." The report also highlighted that: "The decking and support structure appeared to be effective in retarding flame development from the ember attack. (The inclusion of gutter guards and a simple roof profile also appeared to limit the likelihood of a roof ignition.) The deck was supported by galvanised steel bearers and posts, which were effective in supporting the decking structure and building throughout the fire event."

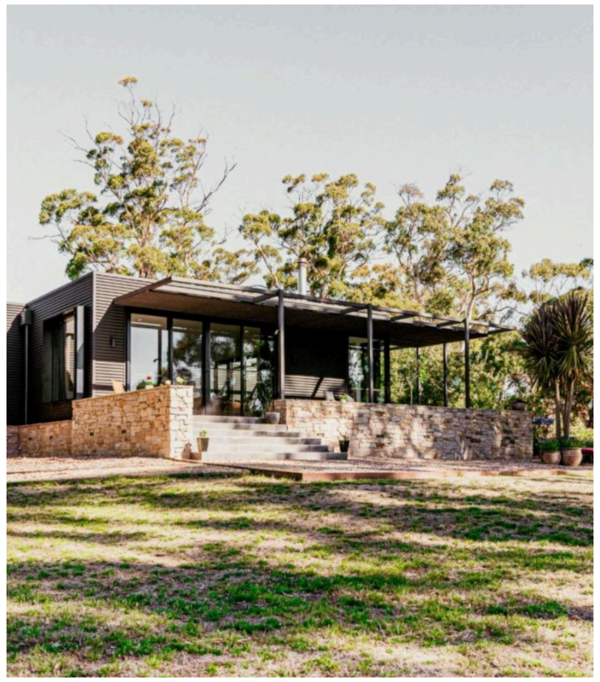
Catagory 2: Prefabricated Housing (Bushfire Resistant)

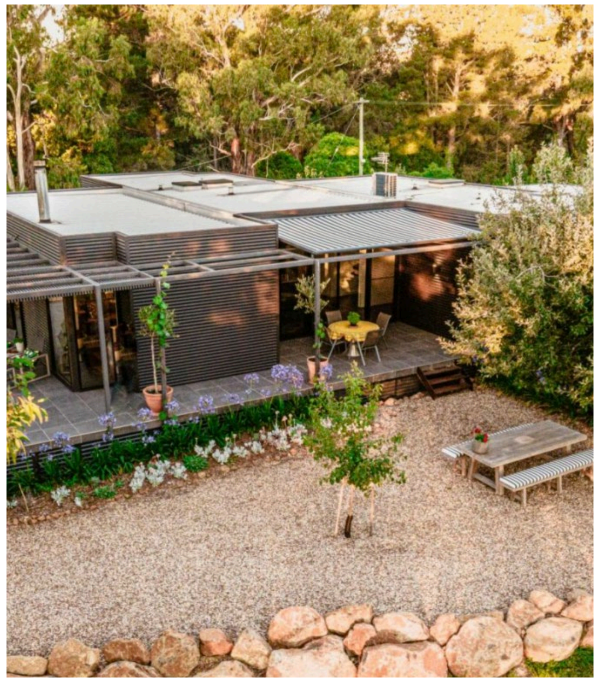
Daylesford House

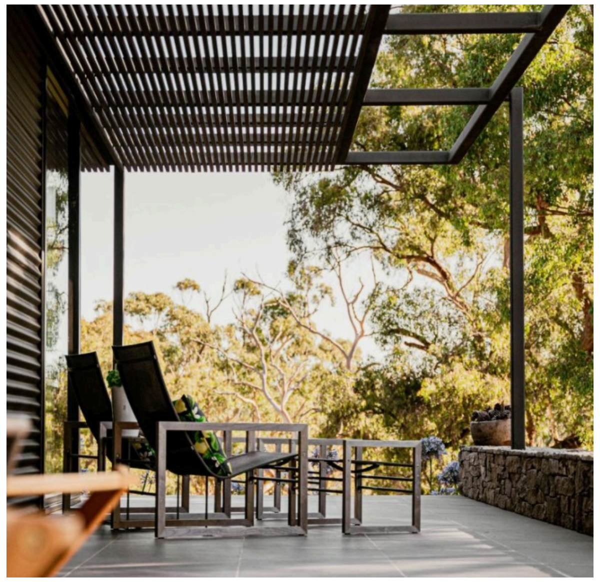
PreBuilt

Daylesford

project image







project images

Project Information

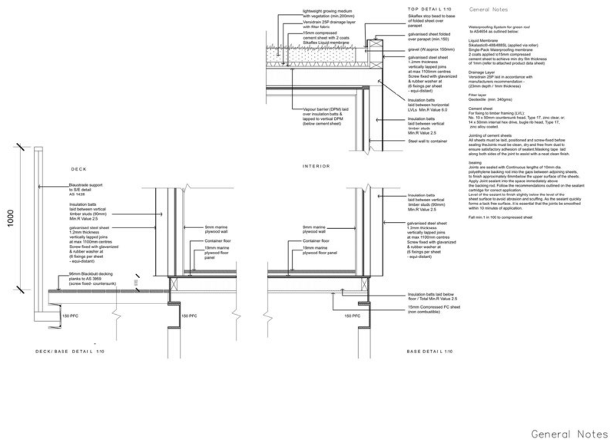
Built / Unbuilt:	Built (1)	Onsite Lifting Req:	Med to heavy capacity crane (10 - 30T)
Architect / Designer:	Prebuilt	Transport Req:	Semi-trailer oversize (modulars); 3.5+m width restriction (4.9m).
Construction Company:	Prebuilt	BAL Rating:	BAL 40
Manufacture:	Modular	SQM	unknown
Assembly:	Factory	Cost (per sqm):	unknown
Structure:	Unknown	Construction Time:	unknown
Materials:	Metal cladding and windows, cement sheet underlay.		

Project Summary (from Prebuilt)

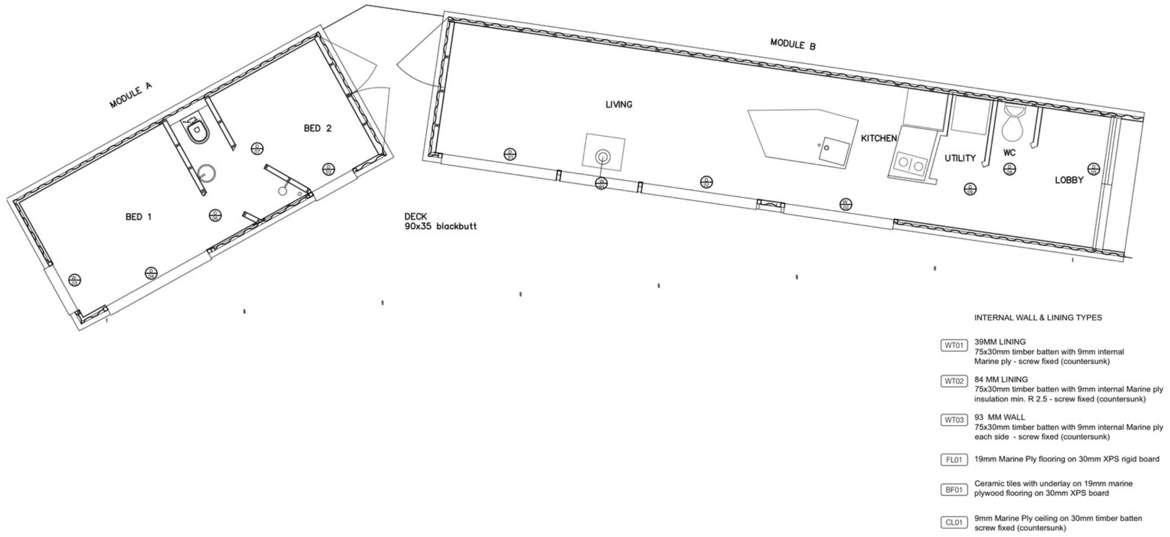
Prebuilt's Daylesford home showcases a typical response to a BAL 40 rating, where all external materials must be non-combustible. Subfloors are built to include cement sheet underlay while windows and doors are metal with glazing upgrades and / or the inclusion of BAL 40 rated window shutters. The ability to interchange the cladding throughout the facade means our clients do not need to compromise on sleek and sophisticated design when complying to a BAL 40 rating. Our Daylesford pergola was built without timber components, utilising steel for the outdoor structure and non-combustible outdoor flooring with a tiled finish.

Catagory 2: Prefabricated Housing (Bushfire Resistant)

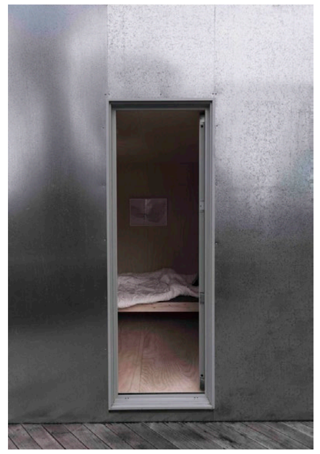
House 28
Studio Edwards
Wye River, VIC
2018



details



plan



project images

Project Information

Built / Unbuilt:	Built (1)	Onsite Lifting Req:	Med to heavy capacity crane (10 - 30T)
Architect / Designer:	Studio Edwards	Transport Req:	Semi-trailer truck. No width restriction (2.5m)
Construction Company:	Dimpat	BAL Rating:	BAL 40
Manufacture:	Modular	SQM	43 sqm
Assembly:	Factory	Cost (per sqm):	unknown
Structure:	Concrete footings, steel substructure, shipping containers	Construction Time:	unknown
Materials:	Steel cladding, plywood lining.		

Project Summary (from Studio Edwards)

This container house on the Surf Coast in Wye River, Victoria was designed as a weekend retreat & made from three 20ft shipping containers.Two connect to form the living space with toilet, laundry & entry. The third is a sleeping wing with two bedrooms, toilet & shower. The containers are connected by a external deck on steel stilts which sit on deep concrete pile foundations- anchoring the house to the hillside. Internally the spaces are lined with marine plywood. Externally they are insulated & clad with galvanised steel sheeting. The northern face of the house has fixings to allow for planting wires to connect to the ground, encouraging native plants to grow over the house. The Southern facade is predominately glazed with a series of double glazed doors & windows opening onto the decking which looks southwards through the trees towards the ocean. A green roof planted with native dichondra sits above providing additional thermal insulation & blends into the surrounding landscape.

Catagory 2: Prefabricated Housing (Bushfire Resistant)

Archiblox FZ

Unbuilt

plan

project images

Project Information

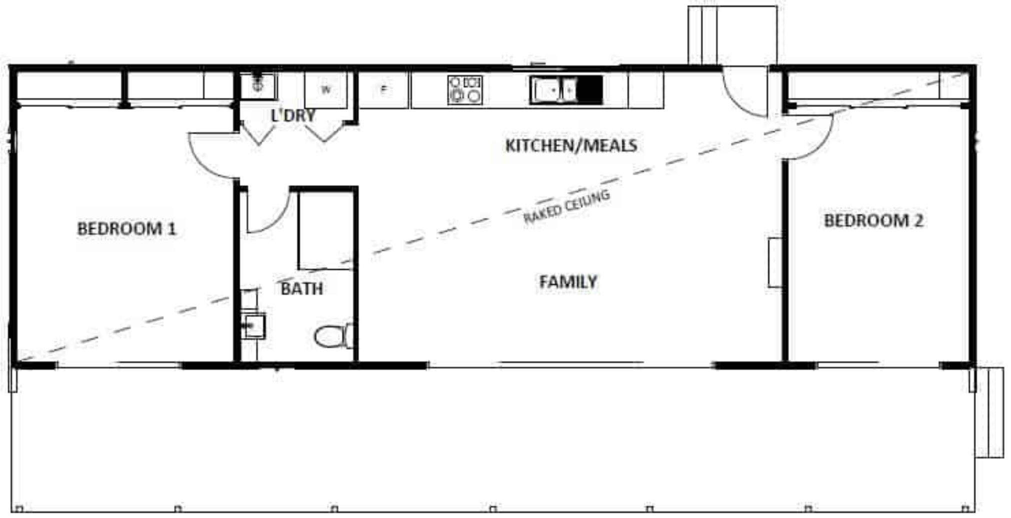
Built / Unbuilt:	Unbuilt	Onsite Lifting Req:	Med to heavy capacity crane (10 - 30T)
Architect / Designer:	Archiblox	Transport Req:	Semi-trailer oversized (modulars); 3.5+m width restriction (4.2m)
Construction Company:	n/a	BAL Rating:	BAL FZ
Manufacture	Modular	SQM	unknown
Assembly:	Factory	Cost (per sqm):	unknown
Structure:	Timber frame	Construction Time:	unknown
Materials:	Steel cladding		

Project Summary (from Archiblox)

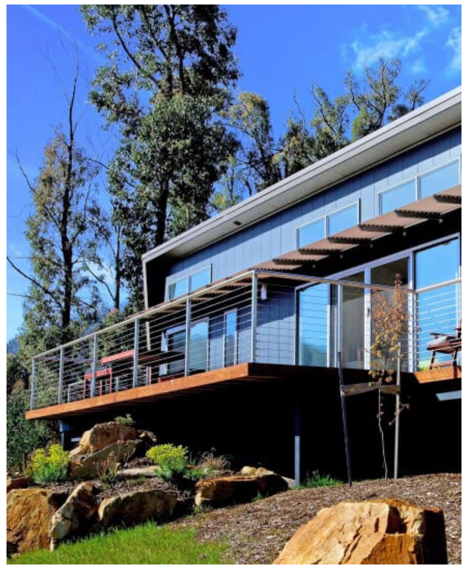
This three bedroom house has been designed to create visual and sensory connections between residents and their natural environment. Large windows were carefully placed to frame views of the surrounding bushland. A deck with stepped seating was incorporated to create and outdoor space where residents can listen to sounds of the nearby creek.

Category 3: Prefabricated Housing (General)

Catagory 3: Prefabricated Permanant Housing (General)
Marysville
Anchor Homes
Marysville



plan



project images

Project Information

Built / Unbuilt:	Built (quantity unknown)
Architect / Designer:	Anchor Homes
Construction Company:	Anchor Homes
Manufacture:	Modular
Assembly:	Mix
Structure:	Timber frame
Materials:	Steel cladding and windows
Onsite Lifting Req:	Medium capacity crane (10 - 20 T)
Transport Req:	Semi-trailer oversized (modulars); 3.5+m width restriction (4m).
BAL Rating:	BAL 29
SQM	60sqm + deck
Cost (per sqm):	unknown
Construction Time:	unknown

Project Summary (from Anchor Homes)

Set in an elevated position and surrounded by breathtaking views, this beautiful accomodation venue is the perfect place to relax and unwind. With ample windows and sliding door access to the front verandah through the living area and both bedrooms, this compact rural retreat is a popular choice for couples and small groups looking for a weekend escape.

Catagory 3: Prefabricated Housing (General)
Hunter Valley Winery
Blok Modular
Hunter Valley
2017

plan

project images

Project Information

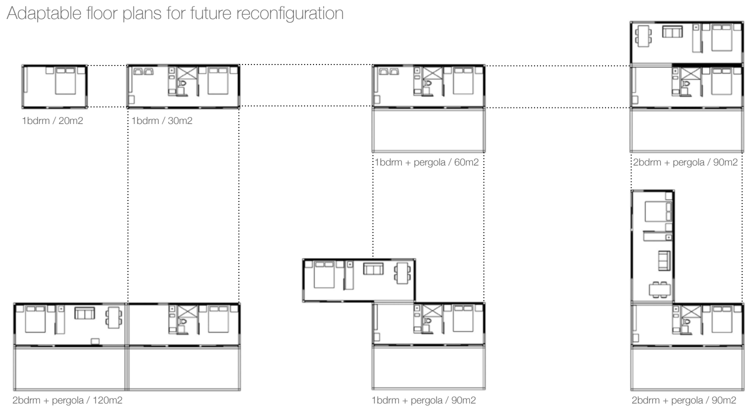
Built / Unbuilt:	Built (1)	Onsite Lifting Req:	Medium capacity crane (10 - 20 T)
Architect / Designer:	Blok Modular	Transport Req:	Semi-trailer oversized (modulars); 3.5+m width restriction
Construction Company:	Blok Modular	BAL Rating:	unknown
Manufacture:	Modular	SQM	42sqm
Assembly:	Factory	Cost (per sqm):	unknown
Structure:	Steel frame	Construction Time:	unknown
Materials:	Metal cladding and windos.		

Project Summary (from Blok Modular)

Blok Modular was born out of Future City Architects' director, Dan Burnett's dream of using modular production to produce highly refined, precision-built architecture, affordably. Here at Blok Modular, we believe that the emerging modular construction movement is not only the future of housing and construction around the world but that it will bring with it a shift in architectural style, changing the built environment significantly.We believe considered architecture should be accessible to anyone contemplating building a new home or addition. Dan and his team of highly passionate project architects are on a modular mission, changing the way the world views modular buildings by producing architecturally bespoke masterpieces that inherently respond to their site, brief and budget, all the while limiting their impact on the environment.

Catagory 3: Prefabricated Housing (General)

Adaptable Living
Breath Architects / Spacecube
Various, Australia
2021



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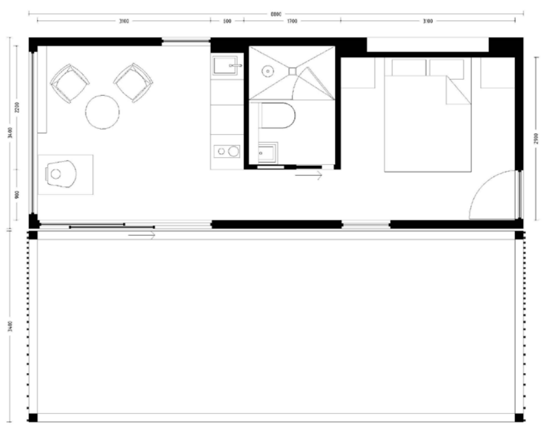


plan

project images

Project Information

Built / Unbuilt:	Built	Onsite Lifting Req:	Low to medium capacity crane (< 20 T)
Architect / Designer:	Breathe Architects	Transport Req:	Semi-trailer truck (flatpack); No width restriction (<2.5m)
Construction Company:	Spacecube	BAL Rating:	unknown
Manufacture:	Modular	SQM	30sqm
Assembly:	Factory	Cost (per sqm):	unknown
Structure:	Unknown	Construction Time:	unknown
Materials:	Metal and timber cladding. Timber doors.		

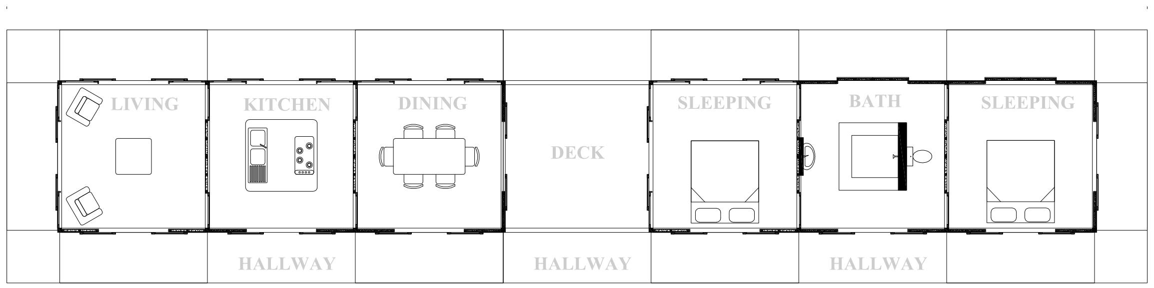
Project Summary (from Breathe)

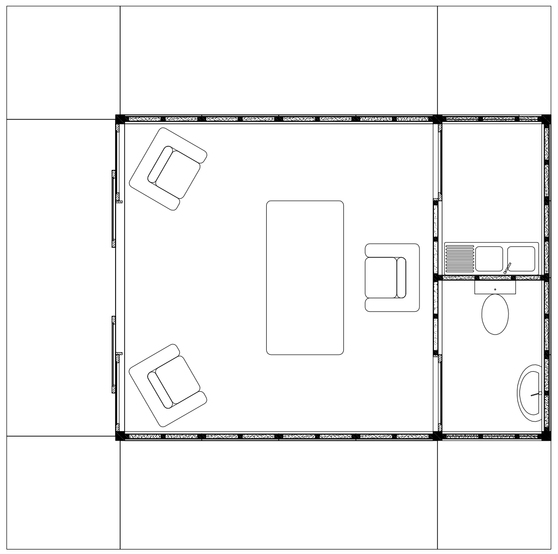
Currently situated in north-west Tasmania, this high-spec relocatable dwelling is a collaboration between Breathe and Spacecube. It evolves and adapts over time, as circumstances or geographic locations change. It's part of Spacecube's Adaptable Living range, with sustainability being a key driver of the design. Fixtures and fittings throughout are locally made, as are the hardwood timber floor-to-ceiling doors and windows, allowing lots of natural light to shine in.

Sustainability is at the core of the Adaptable Living range with full off-grid solar integration. Careful attention has been paid to the dwelling's reusability. Each is designed with quality manufacturing and Australian made products have been used throughout.

Catagory 3: Prefabricated Permanant Housing (General)

EcoShelta
Stephen Sainsbury Architect
Various, Australia & International





plan options

axo

project images

Project Summary (from EcoShelta)

The Ecoshelta system has been designed and developed by Stephen Sainsbury Architect over 30 years in response to the repeated deployment of similar structural frames and modular panel system buildings for remote and difficult sites around the country. The system has been designed and engineered to meet all Building Code of Australia requirements and relevant Australian Standards, which makes it suitable for national and international projects. The system can be used across the continent from the alpine south to the cyclones of the tropical north, with appropriate selection of options.

Ecoshelta e.pods and t.pods are high quality, high tech, sustainable, architect designed, prefabricated, modular dwelling systems. They are extendable, relocatable, robust and long-lived. They have been designed and developed over 25 years, these are state-of-the-art, practical and environmentally sound buildings. This system allows for a high degree of flexibility in floor plan and functionality of the buildings. There are no fixed patterns of wall and door elements as these are fully interchangeable and can be easily modified and altered at any stage. Full width sliding or bi-folding door tracks are integrated into the portal frames. The t.pods and e.pods are alloy framed and the base model is roofed and clad in corrugated zincalume sheet. They can be made to order to meet any Bushfire rating up to and including BAL Flame Zone.

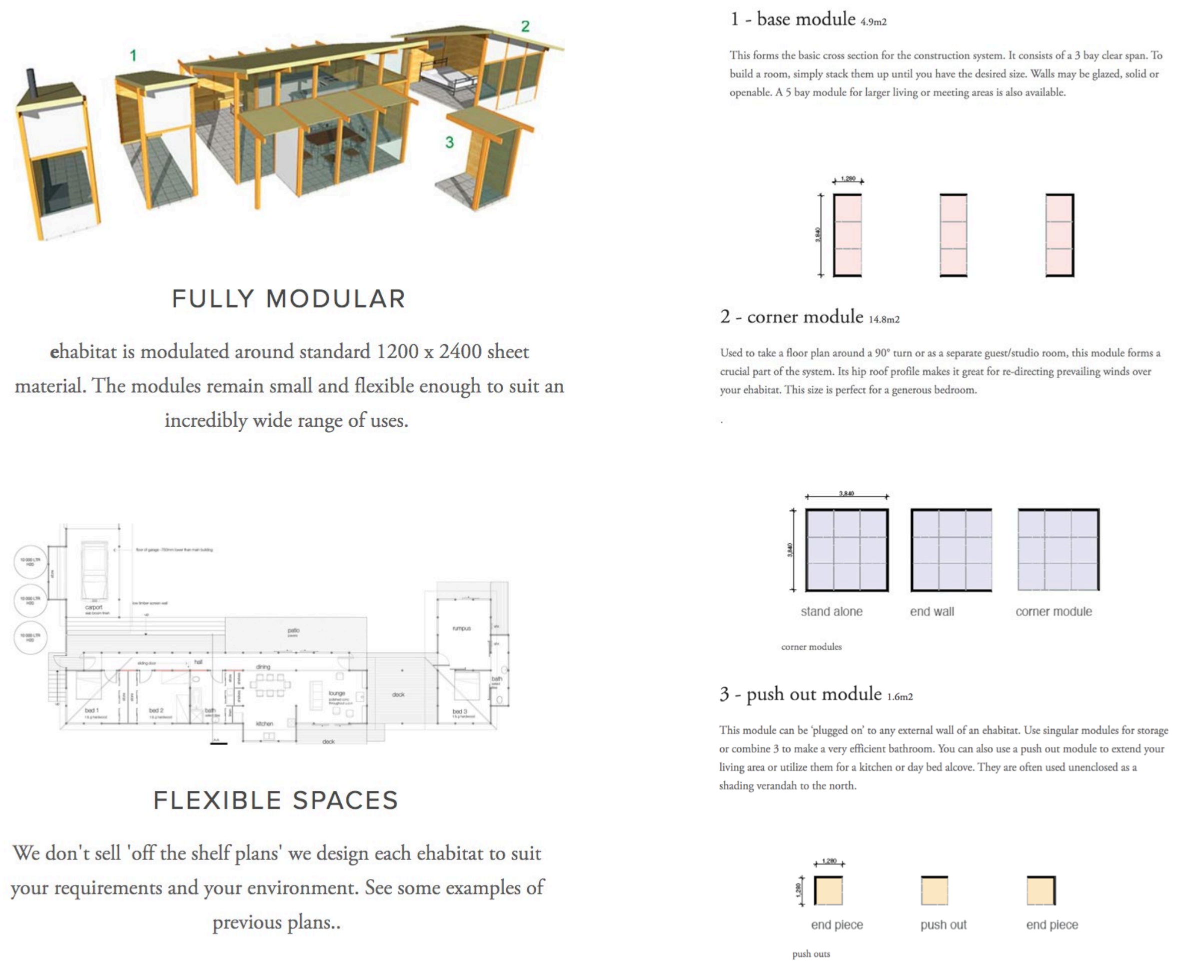
Project Information

Built / Unbuilt:	Built (200+)	Onsite Lifting Req:	Low to medium capacity crane <20 T
Architect / Designer:	Stephen Sainsbury Architect	Transport Req:	Small tray truck (panels); No width restriction.
Construction Company:	Ecoshelta	BAL Rating:	Various (including BAL FZ)
Manufacture:	Kit of parts / Panel	SQM	23 sqm (large pod)
Assembly:	Mix	Cost (per sqm):	unknown
Structure:	Aluminium portal frame	Construction Time:	4 - 6 days
Materials:	Metal cladding, interchangable wall / door panels.		

Catagory 3: Prefabricated Housing (General)

ehabitat

Various VIC, TAS



plan

Project Information

Built / Unbuilt:	Built (15+)	Onsite Lifting Req:	Low capacity crane < 10 T
Architect / Designer:	ehabitat	Transport Req:	Small tray truck (small modules and panels); No width restriction.
Construction Company:	ehabitat / registered builder / owner	BAL Rating:	Various (including BAL 40)
Manufacture:	Kit of parts	SQM	4.9sqm base module
Assembly:	Mix	Cost (per sqm):	unknown
Structure:	Timber structural frame	Construction Time:	4 days
Materials:	Metal roofing, metal, cement sheet and timber cladding		

project images

Project Summary (from ehabitat)

economical: ehabitat's pre-fab system allows quick construction, reducing on site labour costs by up to 40%. ehabitat's modular system utilizes low cost, 'off the shelf' materials which can be used with no cutting. This means all internal and external cladding (including glass) just 'plugs' straight into the frame. The system is space efficient and there are many clever built in storage and space saving options.

evolving: ehabitat's simple cross section and modular nature allows you to add, adapt or transform your habitat to a changing budget, family or lifestyle.

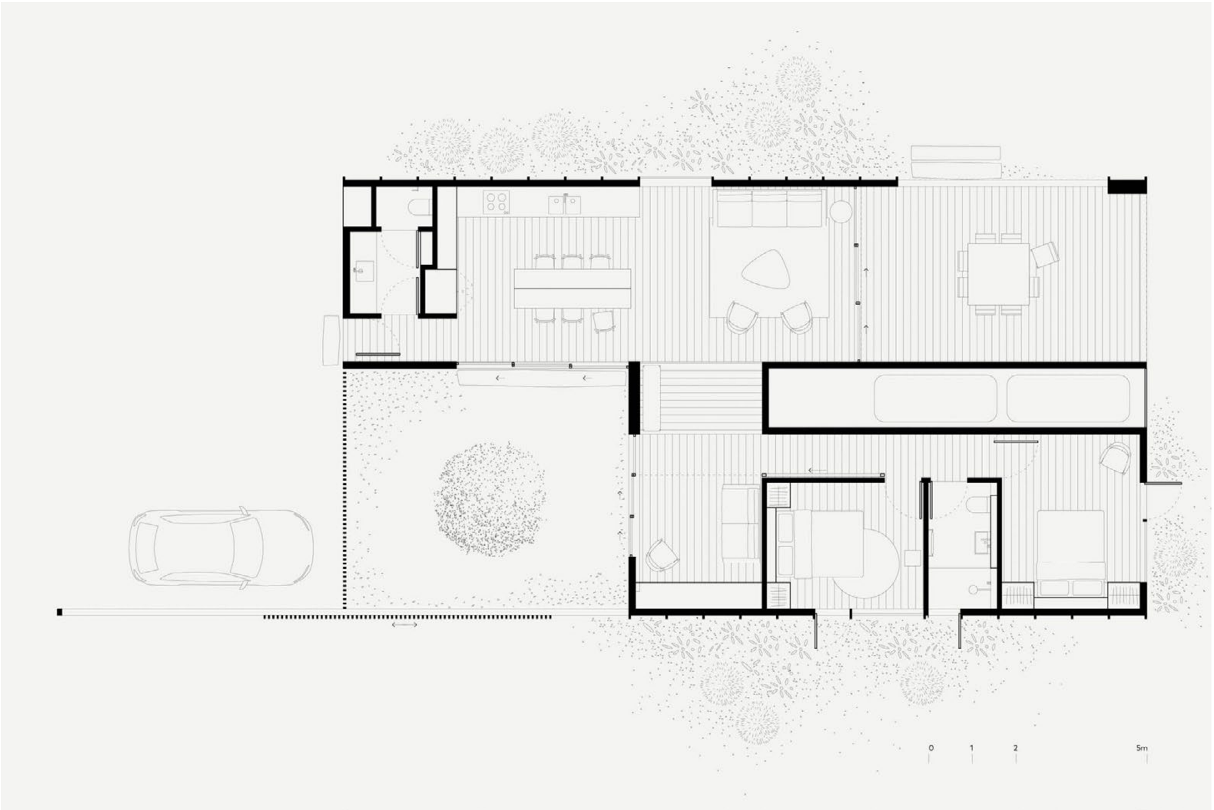
energy efficient: The entire system was conceived with passive solar principles in mind. This makes every ehabitat extremely cheap to run and good for the environment. They are designed for the temperate regions of Australia, but can be simply adapted for more tropical environs. We use low embodied energy and non 'off gassing' materials throughout.

expressive: The simple design components allow limitless individual configurations, enabling you to shape and sculpt a plan to suit your way of life. The aesthetic is modern without being stark, many have remarked upon its elegant Japanese look.

ergonomic: ehabitat includes exciting storage features, climatic control devices and built in furniture options which make your habitat a pleasure to live in.

Catagory 3: Prefabricated Housing (General)

Courtyard House
Fabprefab / Chrofi
Hawks Nest, NSW.
2020

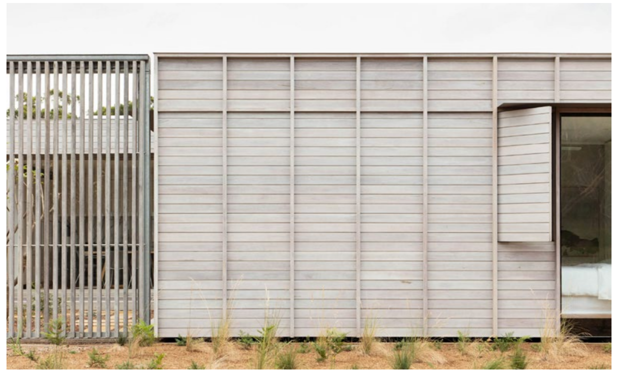


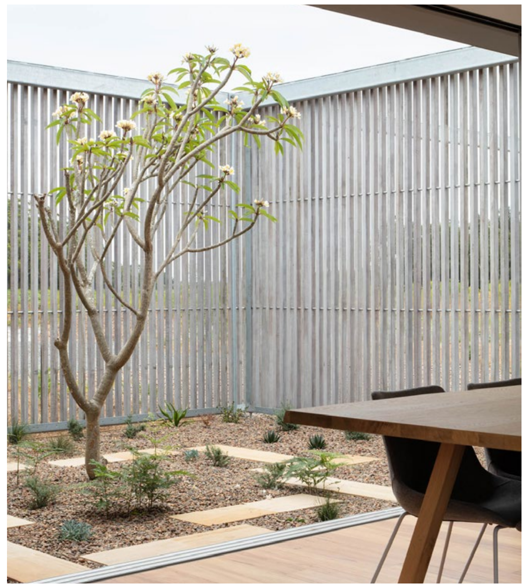
plan

Project Information

Built / Unbuilt:	Built (1)
Architect / Designer:	Chrofi
Construction Company:	Fabprefab
Manufacture / Assembly:	Modular
Structure:	CLT wall and floor panels
Materials:	Timber cladding, metal roofing.

Onsite Lifting Req:	Medium capacity crane 10 - 20 T
Transport Req:	Semi-trailer oversized (modular); 3.5+m width restriction
BAL Rating:	BAL 29
SQM	105 sqm
Cost (per sqm):	unknown
Construction Time:	unknown





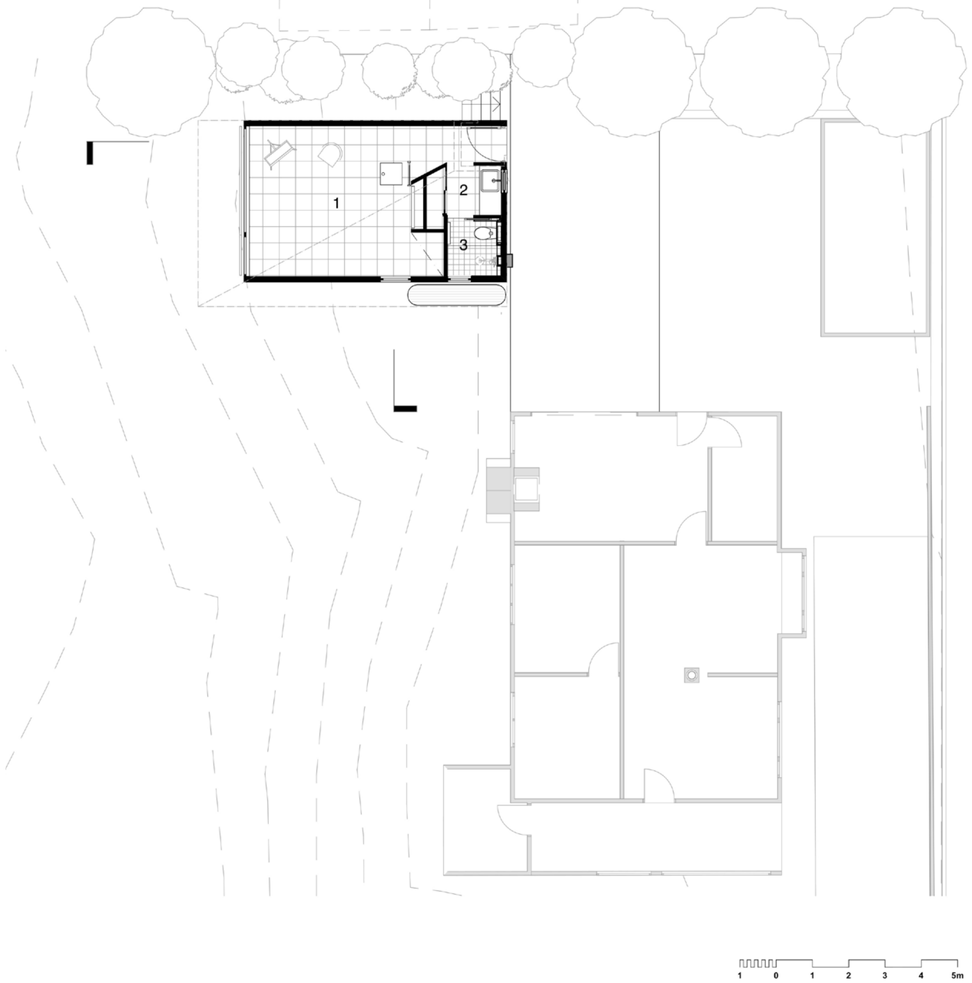
project images

Project Summary (from Fabprefab)

Courtyard House is a compact dwelling that supports low impact living in a variety of settings. Courtyard House is built with high-quality, environmentally friendly materials with ethically sourced Australian timber as its hero material. This includes the use of Cross Laminated Timber (CLT) as the mass timber structural element, and hardwood timber products, for elements such as the external cladding and batten system, ventilation panel to the bedrooms and bathroom. This is complemented by full height, double-glazed fixed glass panels to the living area and bedrooms and large aluminium sliding doors, which surround the courtyard and entry to the deck. Passive design strategies have also been implemented throughout to ensure maximum comfort and efficiency. The courtyard and outdoor room mediate the Australian environment to provide ventilation and shade while extending the time that outdoor living can be enjoyed in comfort. Slender awnings sit above windows to shade the summer sun while ventilation panels open out to capture the breeze. Courtyard House is available in an off-grid version. A water tank captures rainwater for re-use, a roof-mounted solar PV system with battery storage provides electricity for the home, while a bio-septic treatment system, treats waste and irrigates the house's surrounding gardens. It also has a Bushfire Attack Level (BAL) rating of 29.

Catagory 3: Prefabricated Housing (General)

Blue Mountains CLT Studio
John King / Design King
Blue Mountains, NSW.
2019



plan

project images

Project Information

Built / Unbuilt:	Built	Onsite Lifting Req:	Low capacity crane <10 T
Architect / Designer:	Design King	Transport Req:	Small tray truck (panels). No width restriction
Construction Company:	XLam Australia	BAL Rating:	BAL 29
Manufacture	Panel	SQM	28sqm(+ loft and lower levels)
Assembly:	Mix	Cost (per sqm):	unknown
Structure:	Blockwork, CLT wall and roof panels	Construction Time:	unknown
Materials:	Timber cladding, metal roofing.		

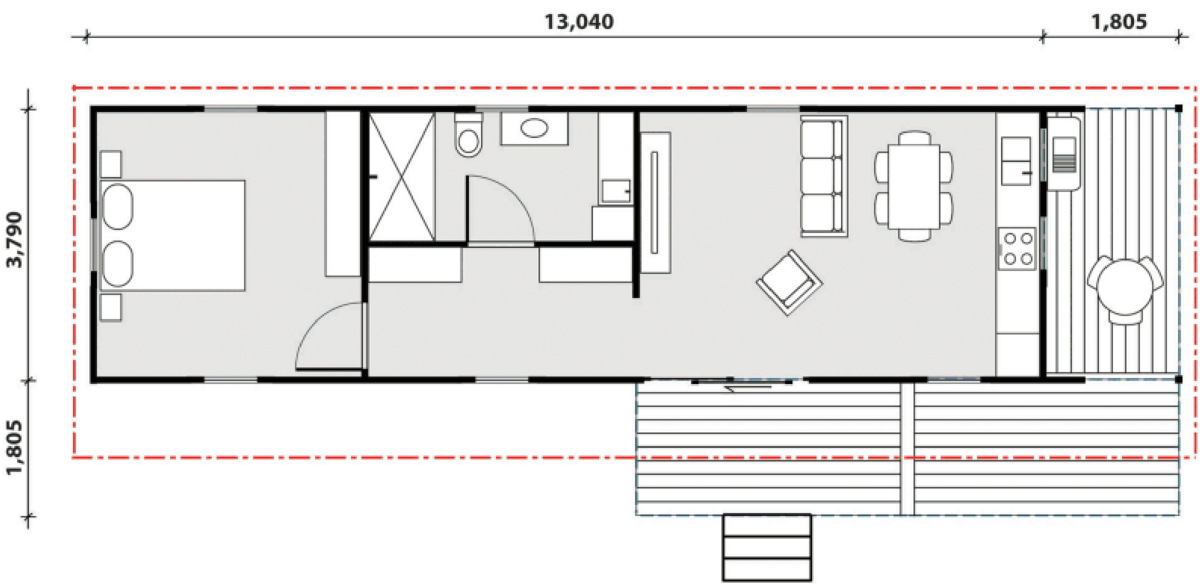
Project Summary (from Design King)

Designed to be versatile, this little building contains a mezzanine level, a living level with kitchen, bathroom, laundry and an office on the lower ground level with its own bathroom. The aim was not to create a radical building but one that speaks to domestic comfort and well being.

Blue Mountains CLT Studio is designed to mediate the roof forms, improving the privacy for the clients and maintaining the suburban scale.

Clad in hard wood timber the building recedes into its semi rural environment and will grey with age. Like Dr Who's 'Tardis', it seems to expand when entering the space. Light pours down through an operable opening at the peak of the building, flooding the timber clad interior in a wash of light. The rear of the studio faces west towards the Kanimbla Valley and consequently receives strong afternoon sun and westerly winds off the range. Large double-glazed windows with thermally broken frames provide insulation while taking advantage of the view, and eaves and external blinds provide protection from the summer sun.

Catagory 3: Prefabricated Housing (General)
Clovelly
MAAP



plan



project images

Project Information

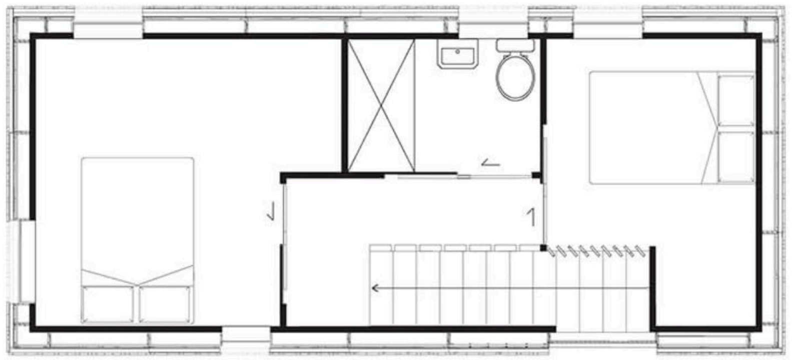
Built / Unbuilt:	Built
Architect / Designer:	MAAP
Construction Company:	?
Manufacture:	Modular
Assembly:	Factory
Structure:	Steel sub-structure
Materials:	Metal cladding
Onsite Lifting Req:	Low capacity crane <10 T
Transport Req:	Small truck (panels); Semi-trailer oversized (modules); 3.5+m width restriction (3.8m)
BAL Rating:	unknown
SQM	50sqm (+ decks)
Cost (per sqm):	unknown
Construction Time:	3 - 5 weeks onsite

Project Summary (from MAAP)

Weekend Accomodation: Nestled amongst the trees, this luxury modular granny flat has been built on stilts to take full advantage of water views. It is classed as a granny flat for ease in passing council. The long floorplan of the Clovelly means each room has a connection to the outdoors. This home is perfectly situated in a country setting where occupants or visitors can enjoy the delights of nature from their doorstep. The design encourages ventilation and captures natural light.

Catagory 3: Prefabricated Housing (General)

Warrander Studio
Makers of Architecture / Makers Fabrication
Canterbury, New Zealand
2015



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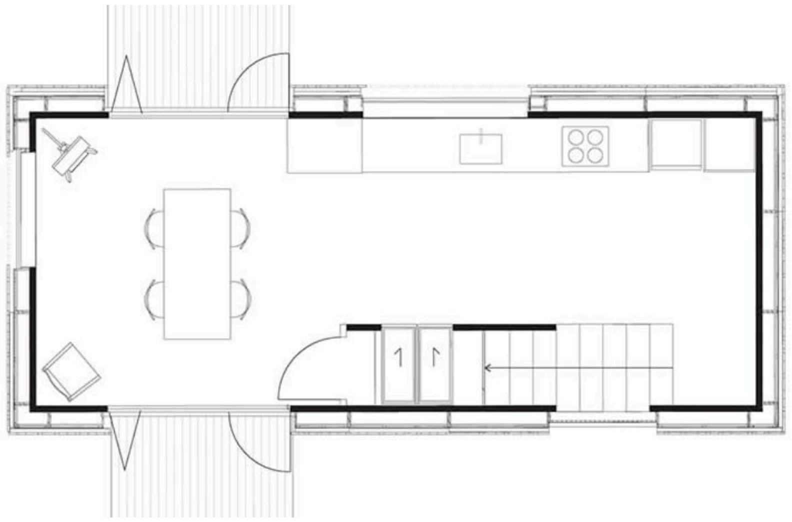

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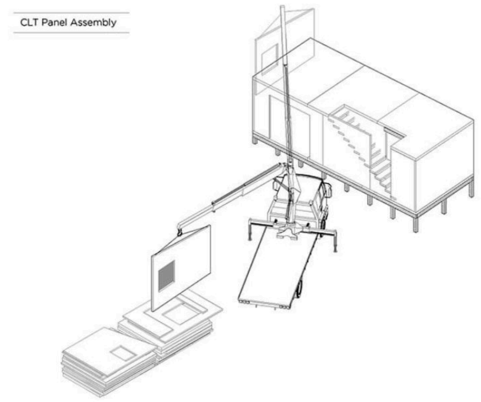


project images

Project Information

Built / Unbuilt:	Built (1)	Onsite Lifting Req:	Low capacity crane <10 T
Architect / Designer:	Makers of Architecture	Transport Req:	Small tray truck (panels); No width restriction.
Construction Company:	Makers Fabrication	BAL Rating:	n/a
Manufacture:	Panel	SQM	45sqm
Assembly:	Mix	Cost (per sqm):	unknown
Structure:	CLT	Construction Time:	3 days assembly + cladding.
Materials:	Timber cladding, metal roofing.		

Project Summary (from Makers of Architecture)

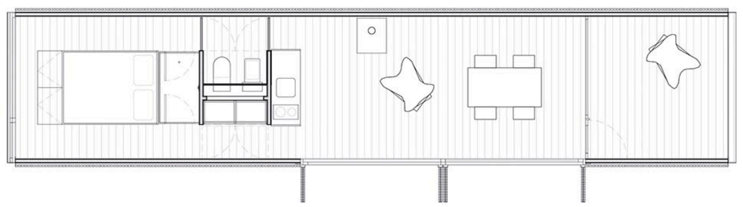
The Warrander Studio is the first of an innovative new building typology. The Studio is New Zealand's first full CLT (Cross Laminated Timber) home, designed and fabricated utilising BIM (Building Information Modelling) and CNC (Computer Numerical Control) precision manufacturing technologies. Using these technologies/tools during the design, manufacturing and construction enabled the Studio's structure to be assembled in three days and clad with an innovative plywood based cassette system developed by Makers of Architecture. The accuracy of this construction system enables precise manufacturing, assembly & pricing, while minimising material waste through digital optimisation.

The Studio was designed as a transitional home for the clients, after their previous home experienced extensive damage in the 2011 February Earthquake. It was imperative the building responded to the client's brief: utilising sustainably sourced materials and chemical free interior surfaces, being seismically sound, cost effective & warm, while engaging with the stunning outlook and environment beyond.

Catagory 3: Prefabricated Housing (General)

Minimod (2 projects)
Mapa
Fazenda Catuçaba Estate, Brazil
2015

plan 2



plan 1

project images

Project Information

Built / Unbuilt:	Built (2)
Architect / Designer:	MAPA
Construction Company:	CG Sistemas / Crosslam
Manufacture:	Modular
Assembly:	Factory
Structure:	CLT
Materials:	Timber cladding, metal roofing.
Onsite Lifting Req:	Low to medium capacity crane (<20 T)
Transport Req:	Semi-trailer oversized (modular); 2.5-3.0m width restriction?
BAL Rating:	n/a
SQM	various
Cost (per sqm):	unknown
Construction Time:	unknown

Project Summary (from Mapa)

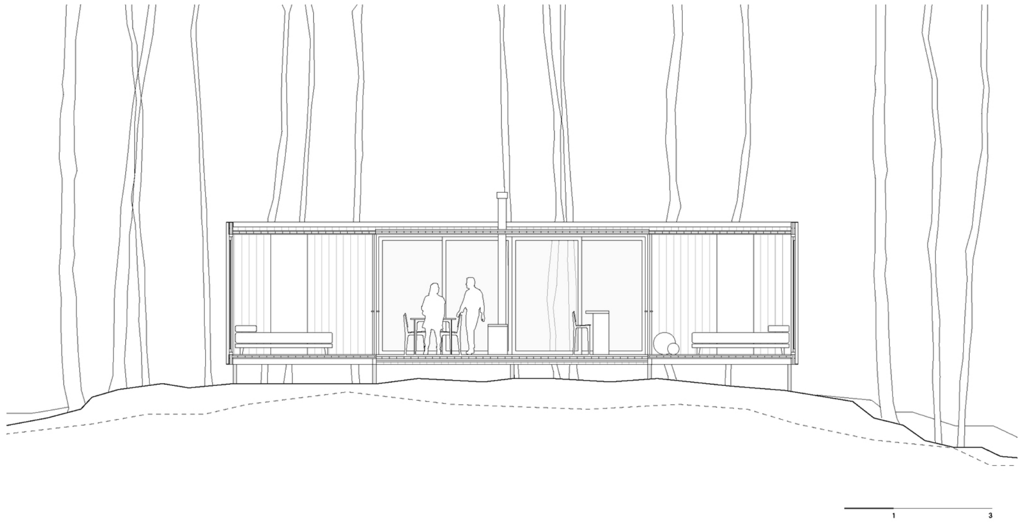
Living in Remote Landscapes. MINIMOD CATUÇABA is a primitive retreat with a contemporary reinterpretation, which more than an object aims to become an every-remote-landscape experience.

MINIMOD presents an alternative to traditional construction: based on prefab plug&play logics, it incorporates the benefits that a newly-born industry has to offer. Quiet but not shy, its unique-in-Brazil CLT Wood-Technology combines industrialized products`efficiency and new technologies` sustainability with the sensitivity of the natural material par excellence.

Both MINIMOD Catuçaba have been built in a factory in an industrial town near São Paulo metropolis. They were transported separated by modules for over 150km, before being installed on site with the help of crane trucks.

Catagory 3: Prefabricated Housing (General)

Minimod Curucaca
Mapa
Curucaca, Brazil
2018



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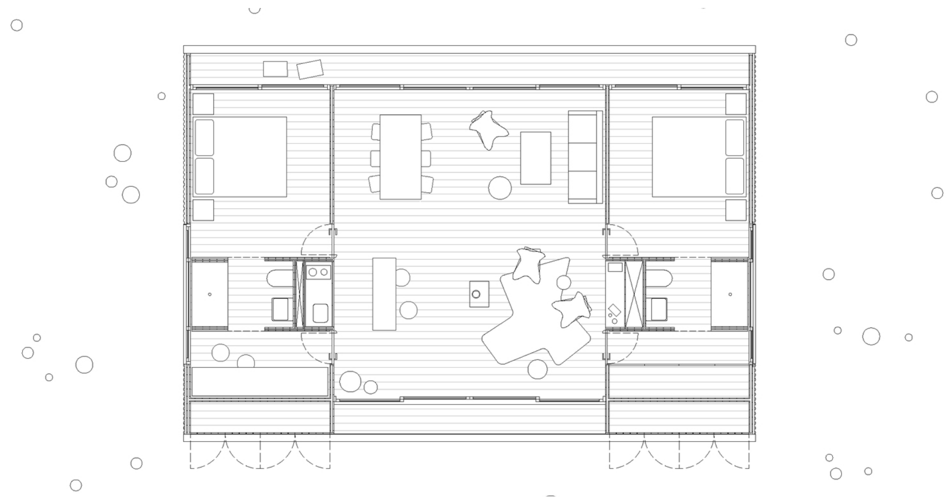


plan

project images

Project Information

Built / Unbuilt:	Built (1)
Architect / Designer:	MAPA
Construction Company:	CG Sistemas / Crosslam
Manufacture:	Modular
Assembly:	Factory
Structure:	CLT
Materials:	Timber cladding, metal roofing.
Onsite Lifting Req:	Low to medium capacity crane (<20 T)
Transport Req:	Semi-trailer oversized (modular); 2.5-3.0m width restriction?
BAL Rating:	n/a
SQM	various
Cost (per sqm):	unknown
Construction Time:	unknown

Project Summary (from Mapa)

MINIMOD is an exploration of the experience of landscape and technology. It presents itself as a primitive retreat with a contemporary reinterpretation, which more than an object aims to become an every-remote-landscape experience.

MINIMOD presents an alternative to traditional construction: based on prefab plug&play logics, it incorporates the benefits that a newly-born industry has to offer. Quiet but not shy, its unique-in-Brazil CLT Wood-Technology combines industrialized products`efficiency and new technologies` sustainability with the sensitivity of the natural material par excellence.

A plug&play device is one that we receive ready to be connected and used without complications. As such, the necessary steps to install and enjoy a MINIMOD must be simple and fast -from the factory to the landscape.

Catagory 3: Prefabricated Housing (General)

Met-Kit Homes
PAAL
Various, Australia

plan

project images

Project Information

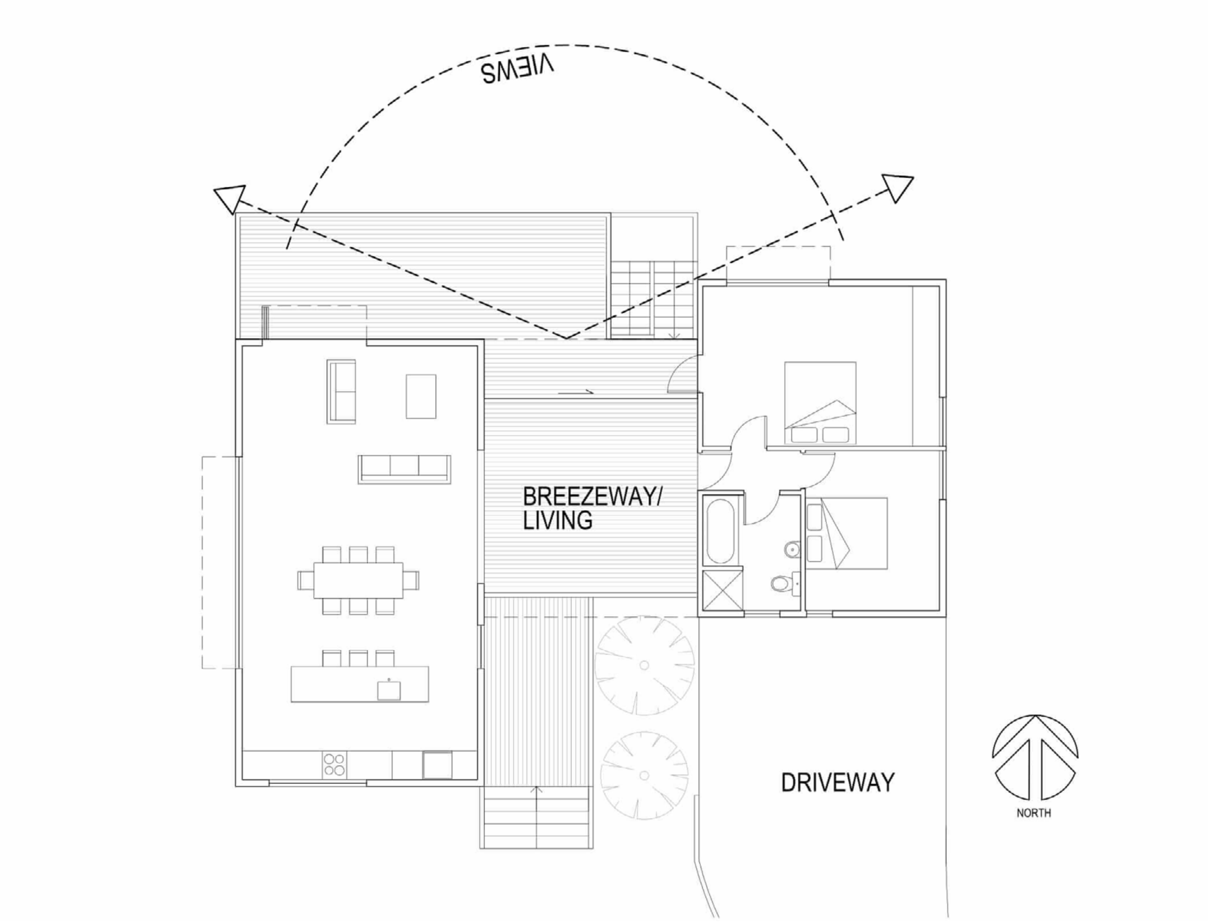
Built / Unbuilt:	Built (1)	Onsite Lifting Req:	Low capacity crane <10 T
Architect / Designer:	Met-Kit Homes	Transport Req:	Small tray truck (panel); No width restriction.
Construction Company:	PAAL	BAL Rating:	unknown
Manufacture:	Kit of parts	SQM	125sqm (incl verandah)
Assembly:	On-site	Cost (per sqm):	$78,190
Structure:	Modular steel frame	Construction Time:	unknown
Materials:	Various cladding,		

Project Summary (from PAAL)

Met-Kit has an attractive new range of quality homes for people who want to choose from standardised, easy-to-build steel frame kit home designs at affordable economical budget prices. The standard range of Met-Kit plans can be modified and additions made to suit your individual requirements. Using our unique Design Online program you can add a carport, garage, verandahs, portico, alfresco. You can change orientation, ceiling height, windows, cladding and more.....and you get an instant quote online. You will save money up to 70% savings compared with a project home build. While Met-Kit Homes gives the best possible value for money, there is no skimping on the quality of materials and fittings that Paal Kit Homes has become renowned for over the years. Our steel frame is made from 100% Australian Bluescope Hi-tensile steel and is tested by the CSIRO. You also get the same full quality service & support. Met-Kit provide a simple, easy to build, bolt together modular steel frame system which is ideal for the Owner Builder and Owner Manager.

Catagory 3: Prefabricated Housing (General)

Elizabeth Beach Home
Mode Homes
Elizabeth Beach, NSW



plan

Project Information

Built / Unbuilt:	Built
Architect / Designer:	Mode Homes
Construction Company:	unknown
Manufacture:	Modular
Assembly:	Factory
Structure:	Steel sub structure
Materials:	Metal cladding and windows
Onsite Lifting Req:	Medium capacity crane (10 - 20 T)
Transport Req:	Semi-trailer oversized; 3-3.5m width restriction
BAL Rating:	BAL 29
SQM	120sqm
Cost (per sqm):	$2200 per module
Construction Time:	unknown

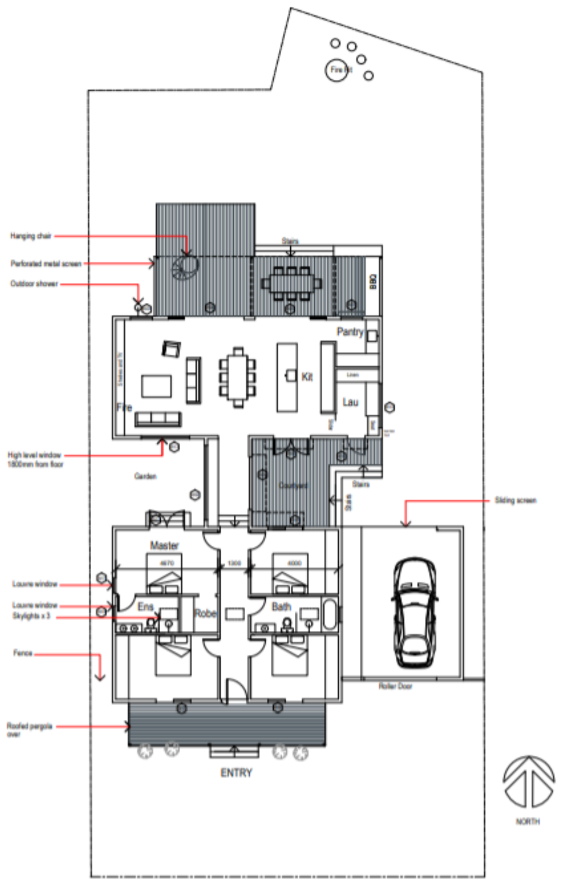
project images

Project Summary (from Mode Homes)

The home was designed to sit high above the site to take the best advantage of the water views to the north. Raising the home also provided an opportunity for a garage and workshop under the bedrooms. The home sits well on the sloping site allowing easy access to upper living areas and the lower garage from street level. This has been achieved via a series of retaining walls. The home is composed of two modules with a breezeway in between. One module contains the kitchen and main living spaces. The other module contains two bedrooms and a large bathroom. The breezeway is roofed and glazed on both sides. The internal floor area not including the garage and workshop is 120m2. It was delivered from Blacktown to Elizabeth beach in two folded modules for a cost of $2,200 per module. Entry to the home is via an entry deck to the breezeway. The breezeway window frames a view of the distant water that is visible as one approaches the home. The owners love the transparency of the home and the many views that can be enjoyed from any spot in the home. Native hardwood Spotted Gum decks are at the back sitting 3.5m above ground level and protected with reclaimed hardwood posts and handrails with stainless steel wire balustrades. The deck is framed in galvanised steel members to comply with the Bushfire Attack Level of 29. The cladding is crisp and modern. Custom orb profile in Surf Mist colorbond has been used. Monument coloured window frames and sun blades offer a good contract on the façade with feature spotted gum cladding in selected areas. Bathroom walls are fully tiled in matte white tiles. The living area floors are covered in engineered Oak timber. The kitchen is charcoal colour with American Oak bench tops.

Catagory 3: Prefabricated Housing (General)

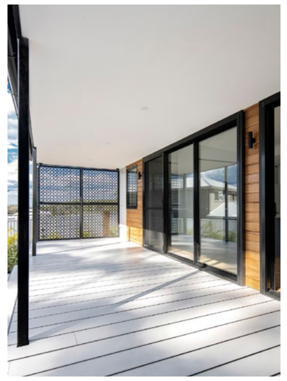
Modern Beach House
Mode Homes
Manyana, NSW



plan

Project Information

Built / Unbuilt:	Built	Onsite Lifting Req:	Medium capacity crane (10 - 20 T)
Architect / Designer:	Mode Homes	Transport Req:	Semi-trailer oversized; 3-3.5m width restriction
Construction Company:	unknown		
Manufacture:	Modular	BAL Rating:	BAL 29
Assembly:	Factory	SQM	180sqm
Structure:	Steel sub structure	Cost (per sqm):	$2200 per module
Materials:	Metal cladding and windows	Construction Time:	unknown



project images

Project Summary (from Mode Homes)

This home was designed to take full advantage of the relaxed coastal charm of Manyana. A relaxed floor plan separates the 4 bedrooms and 2 bathrooms via a link passage from the living areas. The home responds to the site's gradual slope by stepping down a half meter at the link. A 1300mm central hallway acts as a spine to efficiently connect all spaces. Three large decks, one at the front, one in the middle and one at the rear of the home provide easy connection between outside and inside. The internal floor area not including the garage and workshop is 180m2. It was delivered from Blacktown to Manyana in two folded modules for a cost of around $2,200 per module. Using both Axon and Linea cladding creates a crisp and modern look. Black coloured window frames and sun blades offer a good protection for openings and shadowing on the façade. Feature Silver top ash hardwood cladding has been used in selected areas to soften up the feel of the external living spaces. Bathroom walls are fully tiled in matte white tiles with customer selected feature tiles on the floors to add personalisation and interest. Both of the bathrooms have skylights which provide light and the feeling of space. The living area, bedrooms and hallway floors are covered in engineered Oak timber. The kitchen, laundry and butler's pantry are completed in coastal colours and Caesarstone benchtops. The large garage has been clad internally with plywood and has a large sliding timber screen that allows the whole of the back wall to open up to the side passage and middle courtyard entry into the home.

Catagory 3: Prefabricated Housing (General)

Dimensions X
Peter Stutchbury Architects
Various, Australia

plan

Project Information

Built / Unbuilt:	Built (1)	Onsite Lifting Req:	Medium capacity crane (10 - 20T)
Architect / Designer:	Peter Stutchbury	Transport Req:	Semi-trailer oversized (modular); 3-3.5m width restriction
Construction Company:	unknown	BAL Rating:	unknown
Manufacture:	Modular	SQM	27sqm (OM1)
Assembly:	Factory	Cost (per sqm):	unknown
Structure:	Surefoot footings, CLT	Construction Time:	6 weeks
Materials:	Cement sheet cladding, timber windows and decking.		

project images

Project Summary (from Peter Stutchbury)

Module building developments are incredibly economic, but traditionally have minimal flexibility in terms of what you can do with them. Ours is different. Like testing a car, you can add additional elements and features. The intent is to manage the order online and change and modify elements, like its length and size [which is dependent on the number of modules you order], vertical or horizontal orientation, joinery, finishes, and window and door placement.

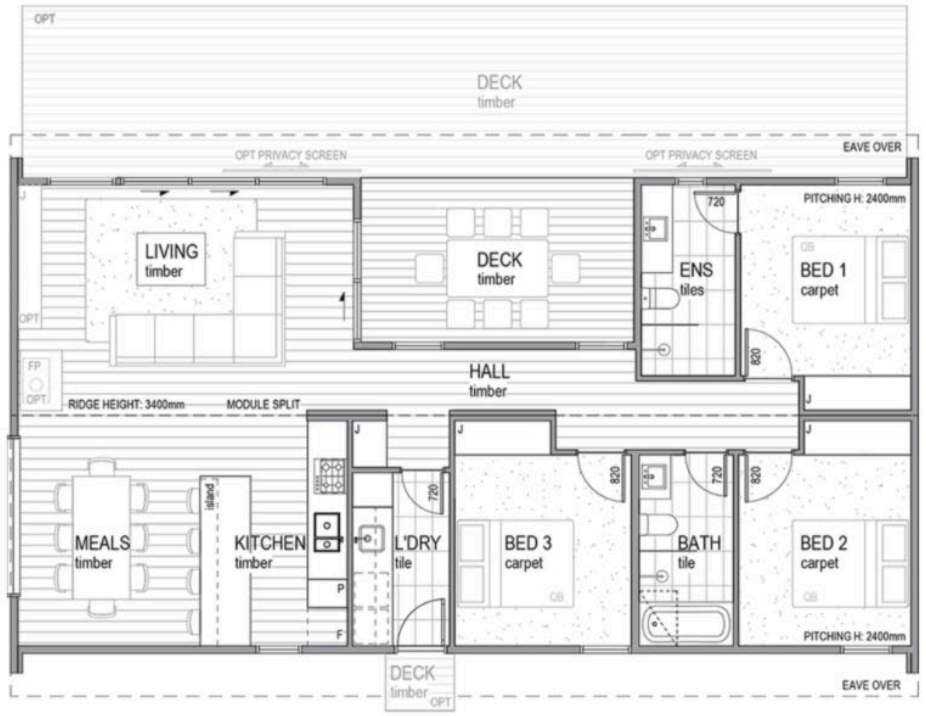
The key initiative is the environment skylight system that features a variety of panels that can be placed and designed to orientate, which is dependent on site rather than footprint of building. It is that adaptable.

We explored energy-efficient construction materials and CLT was absolutely the standout; I predict it will one day replace concrete and steel as an identically robust and planet-friendly alternative. It is made from plantation trees and as soon as one tree is taken down, another is planted, so you are farming, removing and replacing. It makes sense.

The home is erected over a six-week period and can be executed by any builder. We offer two finish options – a utilitarian interior finish which is cost-effective, low-maintenance and more typical of my work, or a highly polished look.

Catagory 3: Prefabricated Housing (General)

Habitat
Prebuilt
Various, Australia



plan

project images

Project Information

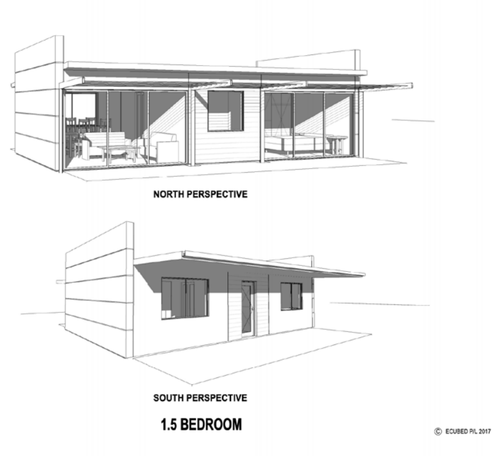
Built / Unbuilt:	Built (1)	Onsite Lifting Req:	Med to heavy capacity crane (10-30T)
Architect / Designer:	Prebuilt	Transport Req:	Semi-trailer oversized; 3.5+m width restriction (4.9m)
Construction Company:	Prebuilt		
Manufacture:	Modular	BAL Rating:	BAL 19
Assembly:	Factory	SQM	119sqm
Structure:	Timber frame	Cost (per sqm):	from $4000 per sqm
Materials:	Cement sheet cladding	Construction Time:	unknown

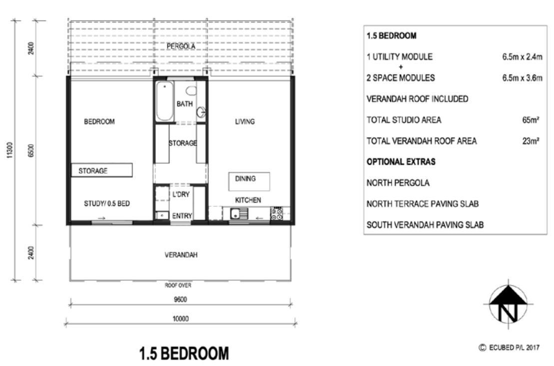
Project Summary (from Prebuilt)

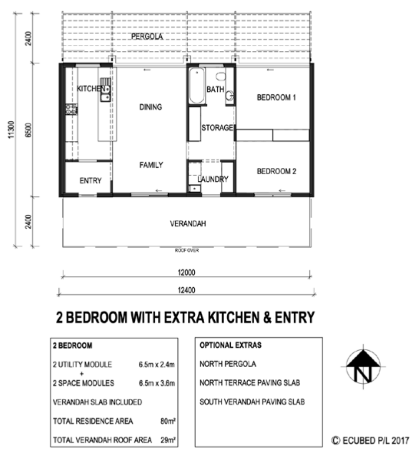
Habitat reflects the craft of modernist architecture for contemporary living. Comfortably accommodating three or four bedrooms, the Habitat floorplan offers two unique layouts.This two-module design thoughtfully incorporates a full-width open kitchen, dining and living spaces to create a plan that effortlessly opens up to the outdoors across two orientations. Celebrating a 1960s-era modernist aesthetic, the Habitat house sits beautifully within a country or beach setting.Crafted internal linings bring a natural warmth to the interiors. The Habitat's cathedral-style ceilings rise to 3.4 metres, bringing a generosity of space to the rooms, and reflecting the sculpted exterior form.

Catagory 3: Prefabricated Housing (General)

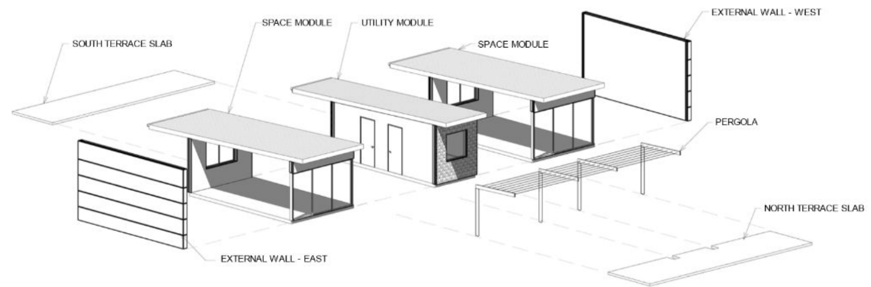
Eco Modular
Strine Environments (Ric Butt)
Various, Australia

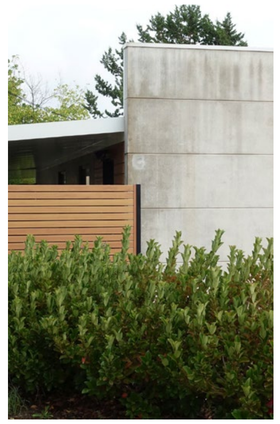






plan





project renders

Built / Unbuilt:	Built (mulitple)
Architect / Designer:	Strine Environments - Ric Butt
Construction Company:	Strine Construction
Manufacture	Modular and Panels
Assembly:	Mix
Structure:	Concrete slab and precast panels
Materials:	Metal roof, various cladding
Onsite Lifting Req:	Med to heavy capacity crane (10 -30 T)
Transport Req:	Semi-trailer oversized; 3.5+m width restriction (3.6m)
BAL Rating:	Various
SQM	65sqm (1.5 bedroom)
Cost (per sqm):	$450k - $500k
Construction Time:	unknown

Project Summary (from Strine Environments)

These ecologically sustainable, modular and climate proof homes have been designed to fit on a truck in prefabricated modules. Perfect for a weekend getaway, retirement downsizing, granny flats and secondary dwellings, our eco modular homes are compact enough to fit into the back yard of many suburban blocks as well as being ideal for rural properties. We have pared the size and costs back while maintaining our four core principles of sustainability to achieve optimum thermal performance requiring minimum heating and no cooling requirements. Reduce your energy bills and footprint with the option to live grid free. We have a floor plan range to suit every budget and cover everything from studio living to four bedroom options.

Catagory 3: Prefabricated Housing (General)

Krawarree
Strine Environments (Ric Butt)
Krawarree, NSW

plan

project renders

Project Information

Built / Unbuilt:	Built (1)	Onsite Lifting Req:	Low capacity crane <10 T
Architect / Designer:	Strine Environments - Ric Butt	Transport Req:	Small tray truck (panels); No width restriction.
Construction Company:	Strine Construction	BAL Rating:	unknown
Manufacture:	Precast Panels	SQM	70.5sqm
Assembly:	On-site	Cost (per sqm):	$2275 per sqm ($310k total)
Structure:	Concrete slab and precast panels	Construction Time:	unknown
Materials:	Metal roof and cladding		

Project Summary (from Strine Environments)

With a floor of just 70.5m2, this is a deceptively simple design. The open plan design is based on Zen principles allowing occupants to interact freely with nature unrestricted by decks, verandahs or fences. Embracing a quiet simplicity, minimalism, and the inherent beauty of natural materials and finishes including natural concrete, timber and glass, this is a retreat from urbanisation. The building is fully autonomous, off the grid (no service connections) and passive solar including photovoltaic solar panels, solar hot water system, composting toilet and rainwater tank. The pyramidal roof structure houses the loft space and supports the photovoltaic panels and solar chimney. The client brief was to provide a modest, secluded and aesthetically pleasing retreat from the city to be achieved with minimal footprint, disturbance to the site and energy requirements. There is a discipline and restraint present in this minimalist design, using materials that translate into a contemplative and simple series of spaces at one with the environment.

Catagory 3: Prefabricated Housing (General)
Tranmere
Valley Workshop
Tranmere, TAS

plan

project renders

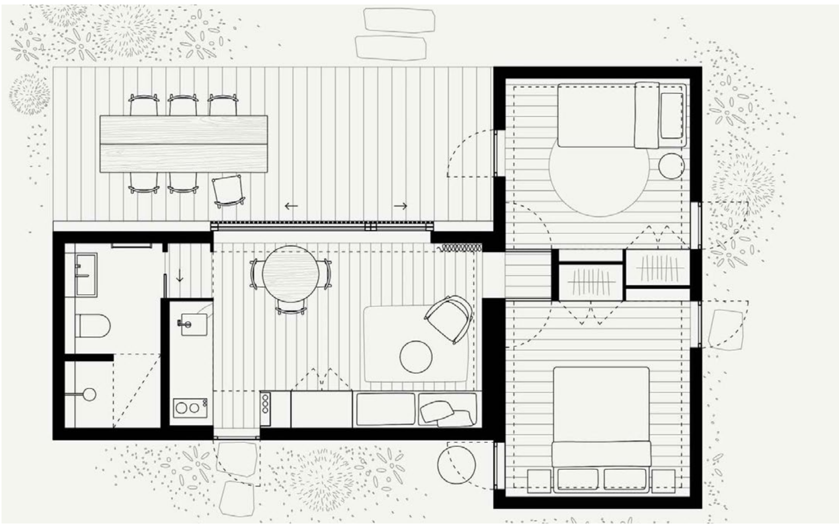
Built / Unbuilt:	Built (1)	Onsite Lifting Req:	Low capacity crane <10 T
Architect / Designer:	Valley Workshop	Transport Req:	Small tray truck (panels); No width restriction.
Construction Company:	Valley Workshop	BAL Rating:	unknown
Manufacture:	Panels	SQM	unknown
Assembly:	Mix	Cost (per sqm):	unknown
Structure:	Insulated wall and roof panels	Construction Time:	unknown
Materials:	Metal roof, cement sheet cladding.		

Project Summary (from Valley Workshop)

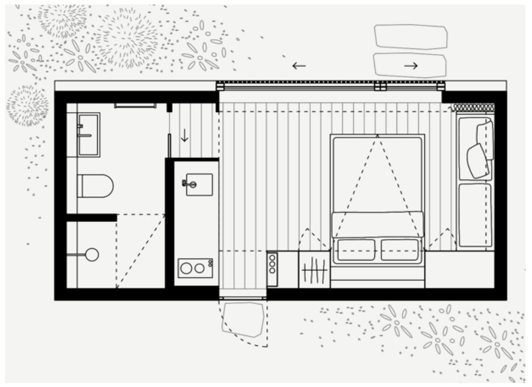
Tranmere Build is a small family home situated atop an eastern hill in Tranmere. Perched up on stilts, the Tranmere captures view aspects out over the River Derwent, across to the Western shore with Mount Wellington in the background. Set against a grassy backdrop, the floor panels are delivered in the steep site and craned into place. The hyper insulated wall panels, fit with condensation control membranes, are stood up in place on the floor panels.The windows are high performing. To complete the building envelope, the hyper insulated panels are craned on top of the walls and fixed together. Clad in James Hardie easy lap cement sheet, the spotted gum decking and window seat stand out as features with spotted gum trim creating a vertical rhythm around the exterior of the build. To create a sealed building envelope, all panels are hyper insulated and fixed together with air tight seals. The windows are UPVC triple glazed which means that the window unit is insulated and prevents heat conductivity. Utilising cross ventilation for cooling summer breezes ensures that when the build becomes too hot from the airtight seal, natural air can flow through the space cooling the occupants.

Catagory 3: Prefabricated Housing (General)

Minima
Trias / Fabprefab
Various, Australia



plan 2



plan 1

project images

Project Information

Built / Unbuilt:	Built (1)	Onsite Lifting Req:	Medium capacity crane (10 - 20 T)
Architect / Designer:	Trias	Transport Req:	Semi-trailer oversized; 2.5-3.5m width restriction (3.5m)
Construction Company:	Fabprefab	BAL Rating:	unknown
Manufacture:	Modular	SQM	24.5sqm (single module)
Assembly:	Factory	Cost (per sqm):	unknown
Structure:	CLT	Construction Time:	unknown
Materials:	Timber cladding and decking		

Project Summary (from Fabprefab)

The Minima[1] is the original design that offers small footprint living with a big impact. This module, which includes a kitchen, bathroom, and flexible sleeping and living spaces, can be configured as a mini apartment or guest room, or can be simplified as a home office. Minima[2] offers a double module design, which is arranged as a striking T-shaped compact house. It expands to include one or two bedrooms, living and dining areas, a kitchen, and a bathroom.

Minima is a small footprint home by design. Its compact nature and environmentally friendly qualities support a low-impact mode of living in a variety of settings. A well-crafted, high-quality dwelling made to be enjoyed for the long term, sustainability is at the forefront of its design and construction. Cross-laminated timber (CLT) is a renewable and highly sustainable building material that has been used extensively in Minima. CLT panels form the walls, floor, and roof of each structure.

The Minima was originally developed as a single, 24.5m^2 design. However, we were so excited by the opportunities its clever design offered we went on to develop six versions of Minima.

Catagory 3: Prefabricated Housing (General)

Fox
Archiblox
Various, Australia

plan options

project images

Project Information

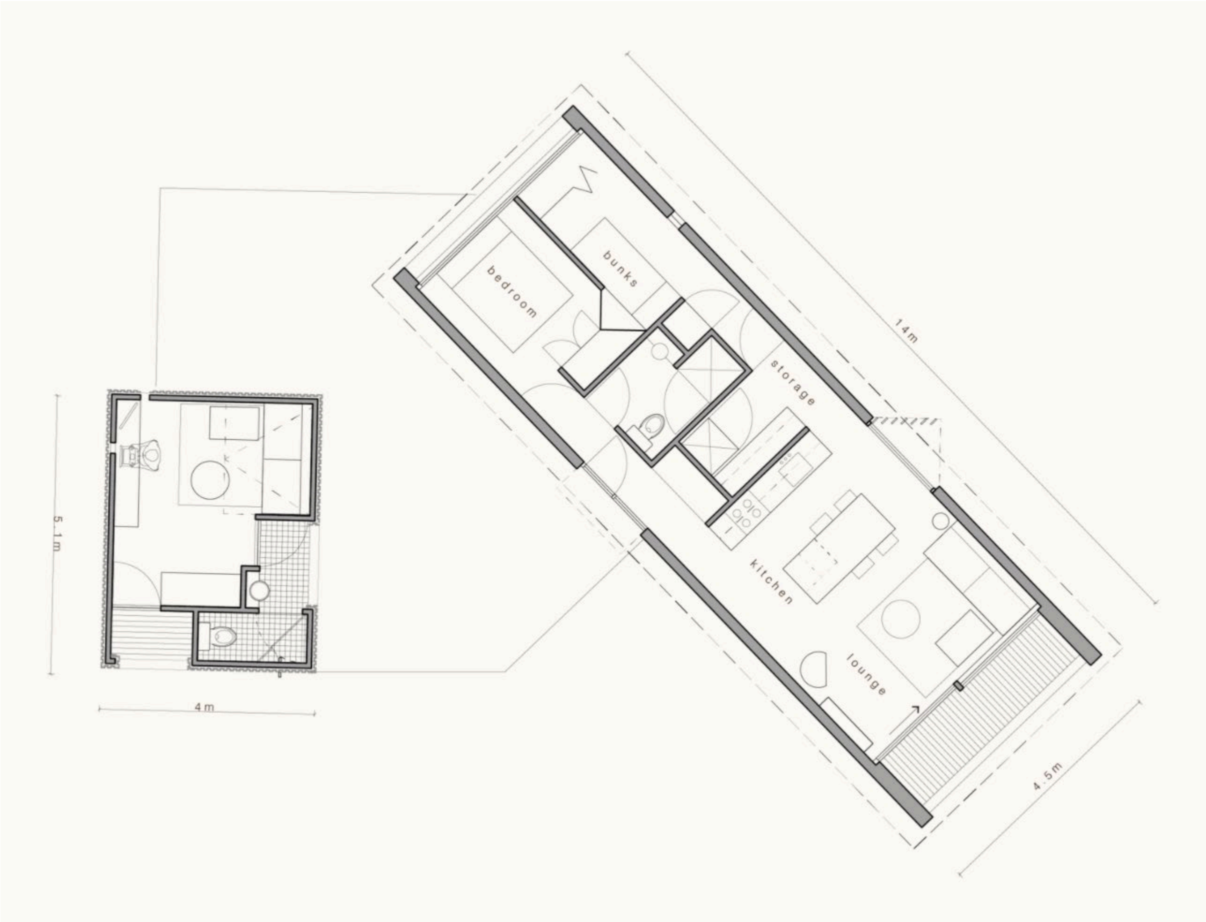
Built / Unbuilt:	Unbuilt	Onsite Lifting Req:	Med to heavy capacity crane (10 - 30T)
Architect / Designer:	Archiblox	Transport Req:	Semi-trailer oversized; 3.5+ width restriction (4.2 - 4.3m)
Construction Company:	Archiblox	BAL Rating:	BAL 29
Manufacture:	Modular	SQM	39sqm (small module)
Assembly:	Factory	Cost (per sqm):	unknown
Structure:	Timber frame	Construction Time:	unknown
Materials:	Timber cladding		

Project Summary (from Archiblox)

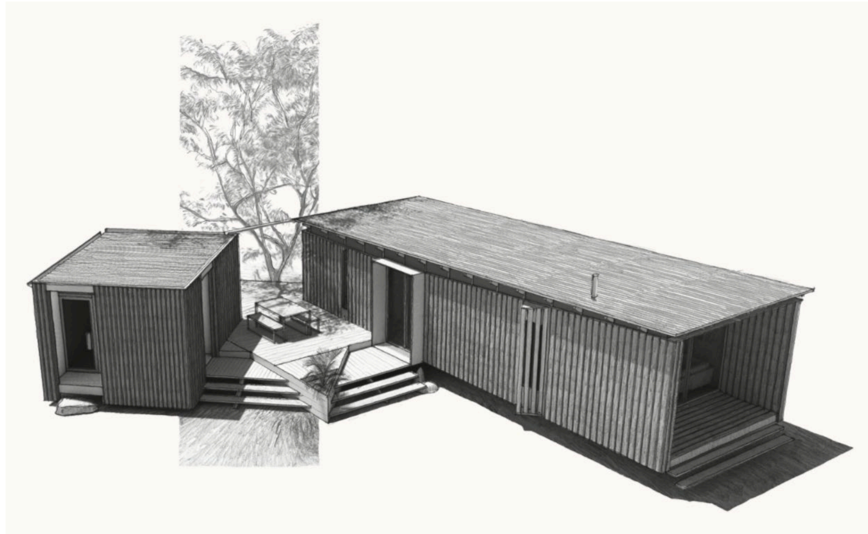
This light, bright and clever layout demonstrates our Smart Design philosophy of ‘design big rather than build big’, which focuses on making a space feel generous, open and shared on a smaller footprint. It’s the perfect get-out-of-town retreat to slow down and recharge. It’s designed to maximise solar gain and natural air-flow, providing warmth and amazing comfort throughout the year. Fox can also act as a separate studio, granny flat detached from your primary home.

Catagory 3: Prefabricated Housing (General)

The Shepherd
Small Not Tiny
Various, Australia



plan



project renders

Project Information

Built / Unbuilt:	Unbuilt
Architect / Designer:	Small Not Tiny
Construction Company:	n/a
Manufacture:	Modular
Assembly:	Factory
Structure:	Structural Steel subfloor
Materials:	Timber cladding
Onsite Lifting Req:	Med to heavy capacity crane (10-30 T)
Transport Req:	Semi-trailer oversized; 3.5+m width restriction (4 - 4.5m)
BAL Rating:	unknown
SQM	63sqm (base module)
Cost (per sqm):	unknown
Construction Time:	n/a

Project Summary (from Small Not Tiny)

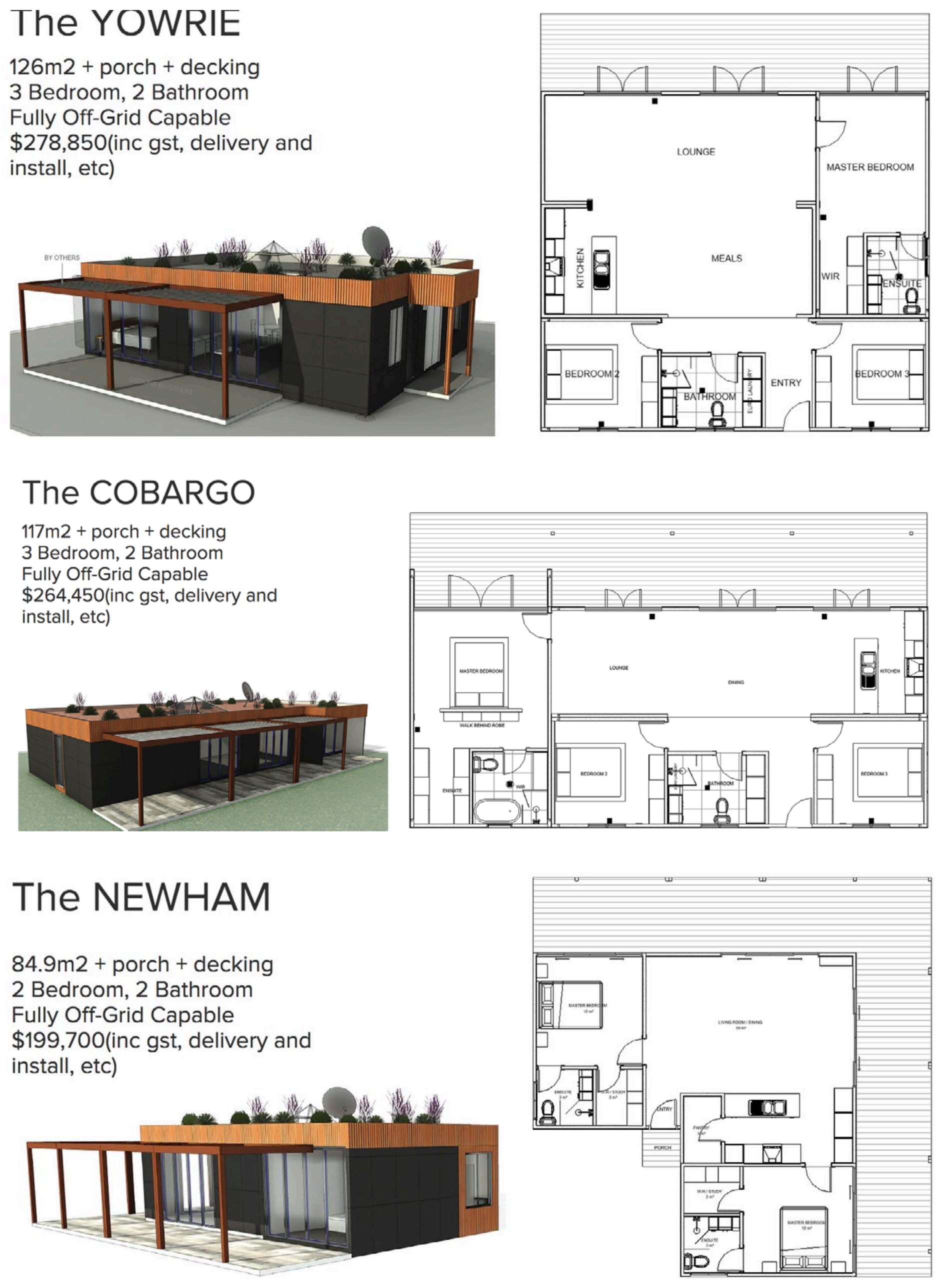
This is a home designed for a small family. The Shepherd allows the dynamic to change as your life evolves. Working with your site, a deck can be constructed to link the Shepherd and its companion building, encouraging outdoor living or maximising privacy. These two designs can be purchased individually. The Shepherd's gently angled hardwood exterior cloaks a two bedroom home focused on open-plan living around a utility core. This space champions a relaxed brightness by pairing pale timber walls and strategic natural light positioning. The core includes bathroom, kitchen pantry and ample storage in both bedroom and shared spaces, ideal for long term living or as a separate source of income on your chosen site.

Catagory 3: Prefabricated Housing (General)

Atomic 6

Various, NSW

plan modules



project images

Project Information

Built / Unbuilt:	Unbuilt	Onsite Lifting Req:	Med to heavy capacity crane (10-30 T)
Architect / Designer:	Atomic 6	Transport Req:	Semi-trailer oversized; 3-3.5m 3.5+m width restriction
Construction Company:	Atomic 6	BAL Rating:	unknown
Manufacture:	Modular	SQM	90sqm (the newham)
Assembly:	Factory	Cost (per sqm):	unknown
Structure:	Timber frame	Construction Time:	unknown
Materials:	Metal cladding		

Project Summary (from Atomic 6)

Atomic 6 set out to provide a range of designs for bushfire rebuilds. The designs are all made using 5 modules. Pricing is done based on a base price to cover the fundamentals of any build, plus a m2 rate. As the houses / modules are built mostly in a factory, we can predict costs which allows for accurate m2 pricing. A spreadsheet download allows you to price your own project and select options.

Category 4: Non-Prefabricated Housing (Bushfire Resistant)

Catagory 4: Non-Prefabricated Housing (Bushfire Resistant)

Off Grid House

Anderson Architecture

Blue Mountains, NSW

2020

plan

section

project images

Project Information

Built / Unbuilt:	Built (1)	Onsite Lifting Req:	n/a
Architect / Designer:	Anderson Architecture	Transport Req:	n/a
Construction Company:	Against the Grain	BAL Rating:	BAL FZ
Manufacture:	Panels	SQM	unknown
Assembly:	On-site	Cost (per sqm):	unknown
Structure:	Concrete precast panels on slab	Construction Time:	unknown
Materials:	Metal screens, cement sheet cladding		

Project Summary (from Anderson Architecture)

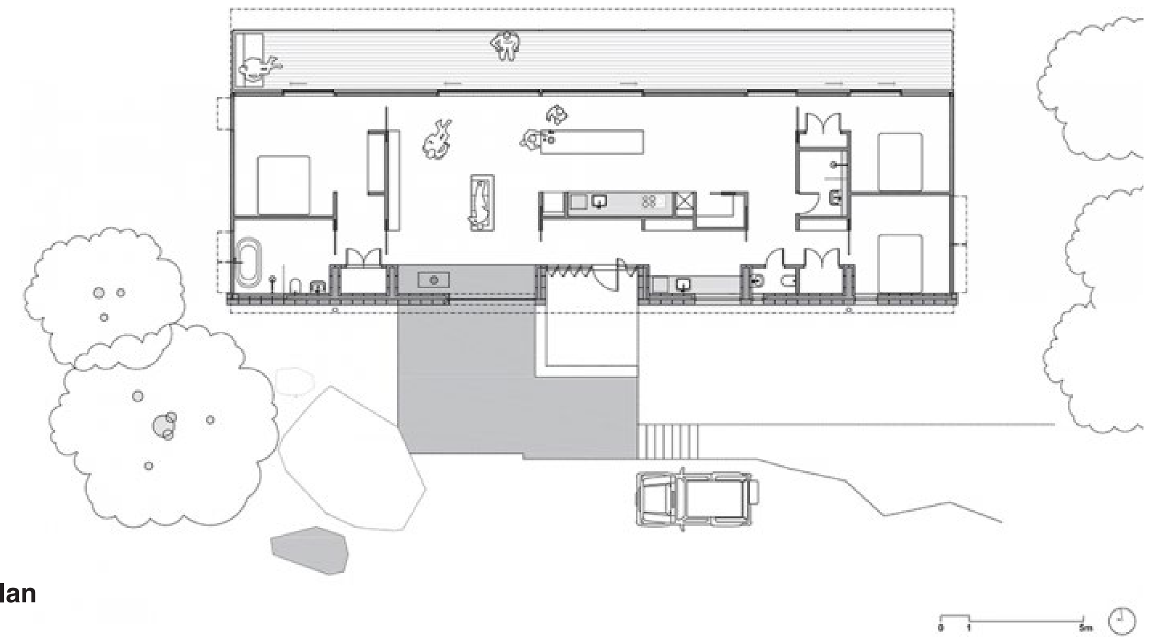
We opted for a fireproof concrete house that would be resistant to insect attack as well. Low-carbon fibre cement board cladding and decking gives the added appearance of timber with the durability of a high bushfire attack BAL 40 & BAL FZ house design performance. Keen to trial additional weather protection measures, we designed an experimental 2.4m external metal screen here. This acts as a wall that can be winched away out of sight, is deployed as heavy rain protection, or could be lowered completely as a BAL FZ (flame zone) barrier in the event of a fire. Motorised screens add further fire protection on other windows. Conversely, when it rains, both roofs feed water tanks with a capacity for 30,000L.

Catagory 4: Non-Prefabricated Housing (Bushfire Resistant)

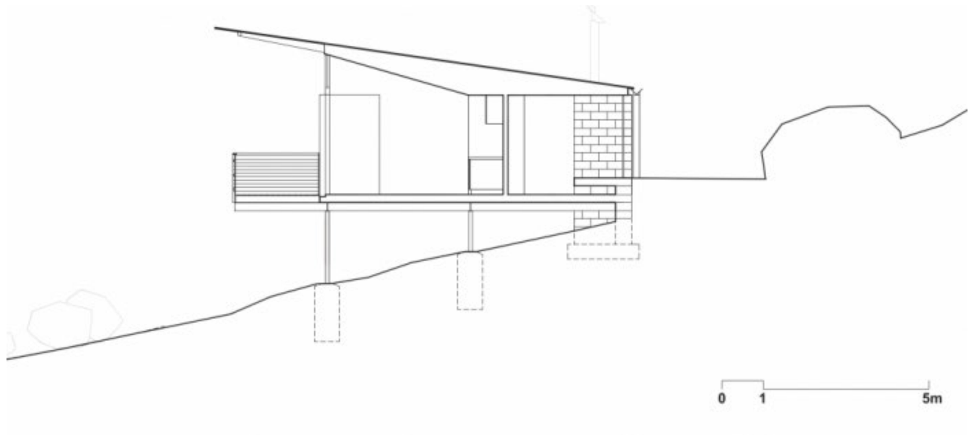
Karri Fire House

Ian Weir Architect

Denmark, WA.



plan



section

project images

Project Information

Built / Unbuilt:	Built (1)	Onsite Lifting Req:	n/a
Architect / Designer:	Ian Weir	Transport Req:	n/a
Construction Company:	Owner Builder	BAL Rating:	BAL 40
Manufacture:	n/a	SQM	170sqm (+ deck)
Assembly:	On-site	Cost (per sqm):	unknown
Structure:	Structural steel frame	Construction Time:	unknown
Materials:	Concrete blocks, metal cladding and roofing		

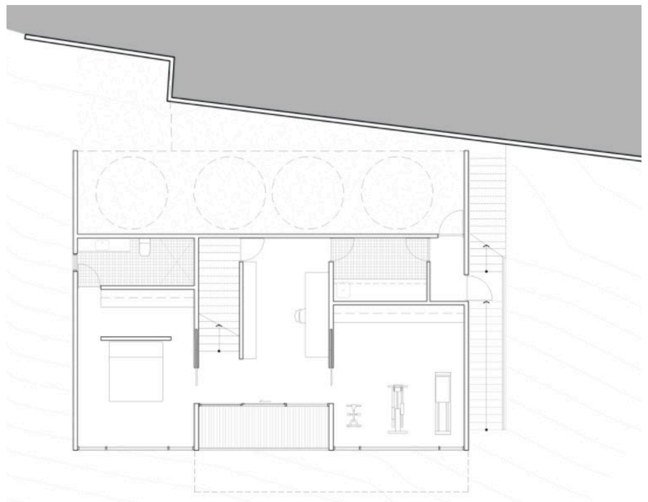
Project Summary (from Ian Weir Architect)

The Karri Fire House is an exemplar of affordable construction for extreme levels of bushfire attack.Sited in a Eucalyptus diversicolor (Karri) forest, south of the town of Denmark WA, this house conserves and celebrates its remarkable setting by prioritizing bushfire resilience above vegetation clearing. It does so by achieving a Bushfire Attack Level of BAL 40 through the industrial design of architectural components and the integration of technologies and materials from commercial construction and fire fighting apparel. With a thorough understanding of AS3959 - the Australian Standard for Building in Bushfire Prone Areas – the architects and client have, together, developed a highly integrated design wherein energy efficiency and bushfire safety features are cross-purposed. Here bushfire shutters are used on a daily basis for sun, glare and insect control. The spatial planning of the house links the daily pattern of life to the performance of the shutters which slide between full and half-width structural steel bays on the north (most fire prone) elevation.

Catagory 4: Non-Prefabricated Housing (Bushfire Resistant)

A020 Wye River House
Matt Goodman Architect
Wye River, VIC
2016

plan



plan (lower)

project images

Project Information

Built / Unbuilt:	Built (1)	Onsite Lifting Req:	n/a
Architect / Designer:	Matt Goodman Architect	Transport Req:	n/a
Construction Company:	unknown	BAL Rating:	BAL 40
Manufacture:	n/a	SQM	195sqm
Assembly:	On-site	Cost (per sqm):	unknown
Structure:	Structural steel frame	Construction Time:	unknown
Materials:	Metal cladding and roofing		

Project Summary (from Matt Goodman Architect)

On Christmas day 2015, an out of control bush fire swept through Wye River; 116 homes were lost in the fire. This project replaces one of these homes. The site is located on a steeply sloping block, obliquely facing Bass Straight. Perched high on the hill side, the house sits where the tree canopy once stood, anxiously awaiting the regrowth of the surrounding bushland. The building's form loosely references the skillion roofed beach shacks built during the 60's and 70's. The rational footprints, expressed with simple construction methods and common materials produce a modest, humble quality to the village. This project aims to continue that legacy. Upon approach, the building presents an impenetrable skin, yet once inside the building gradually opens itself up, revealing the stunning view toward the ocean and the village beyond, seen through a foreground of mature trees which the clients fought to save.

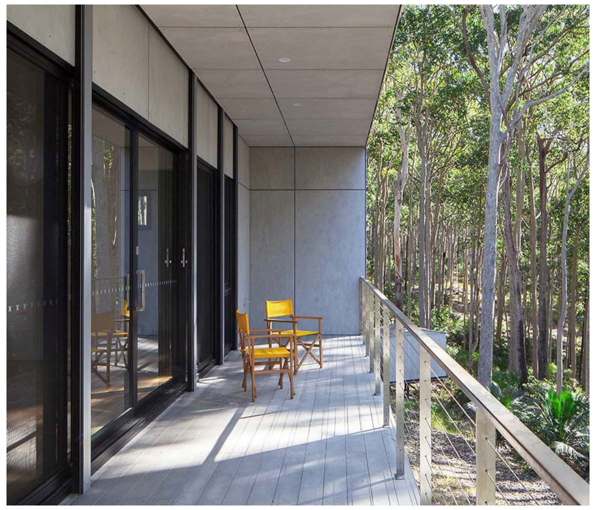
Catagory 4: Non-Prefabricated Housing (Bushfire Resistant)

Rosedale Beach House

Thomas Caddaye Architects

North Rosedale, NSW

project images - post fire



project images - pre fire

Project Information

Built / Unbuilt:	Built (1)	Onsite Lifting Req:	n/a
Architect / Designer:	Thomas Caddaye Architects	Transport Req:	n/a
Construction Company:	?	BAL Rating:	BAL FZ
Manufacture:	n/a	SQM	unknown
Assembly:	On site	Cost (per sqm):	unknown
Structure:	Structural steel and timber frame	Construction Time:	unknown
Materials:	Cement sheet cladding, metal doors, window shutters.		

Project Summary (from Thomas Caddaye Architects)

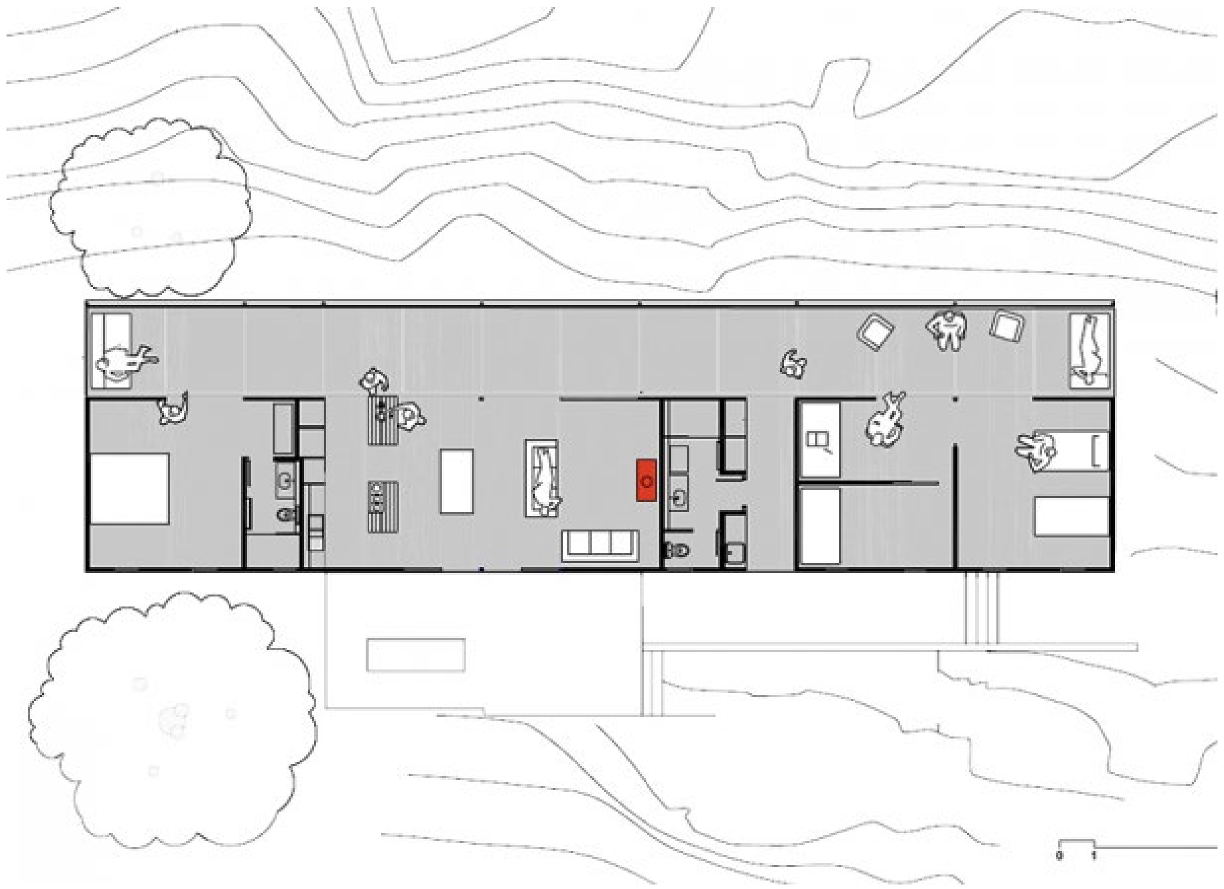
Located in a beautiful bushland setting backing onto reserve this coastal site was subject to the highest bushfire attack level category 'Flame Zone'. A steeply sloping block combined with the client's requirement to avoid any stairs presented additional challenges. Metal roller shutters were carefully integrated into the design enabling compliance with the strict bushfire resistant construction requirements while still allowing large expanses of glazing to capture the spectacular filtered views to the ocean. The design employs a contemporary and controlled architectural language while also paying homage to the traditional fibro beach house.

Catagory 4: Non-Prefabricated Housing (Bushfire Resistant)

Nornalup House

Ian Weir Architect

Unbuilt, WA.



plan

project images

Project Information

Built / Unbuilt:	Unbuilt	Onsite Lifting Req:	n/a
Architect / Designer:	Ian Weir Architect	Transport Req:	n/a
Construction Company:	n/a	BAL Rating:	BAL FZ
Manufacture:	n/a	SQM	144sqm (incl. covered verandah)
Assembly:	n/a	Cost (per sqm):	n/a
Structure:	Steel frame	Construction Time:	n/a
Materials:	Precast concrete, metal cladding and roofing.		

Project Summary (from Ian Weir Architect)

This project (unbuilt) presents an exemplar for building in bushfire prone landscapes which have high to extreme levels of bushfire exposure. At 120m2 the space planning of the house is highly efficient, with the north facing, wind-protected veranda facilitating the primary circulation and linking a reconfigurable sleeping pavilion to the communal and private areas of the home.

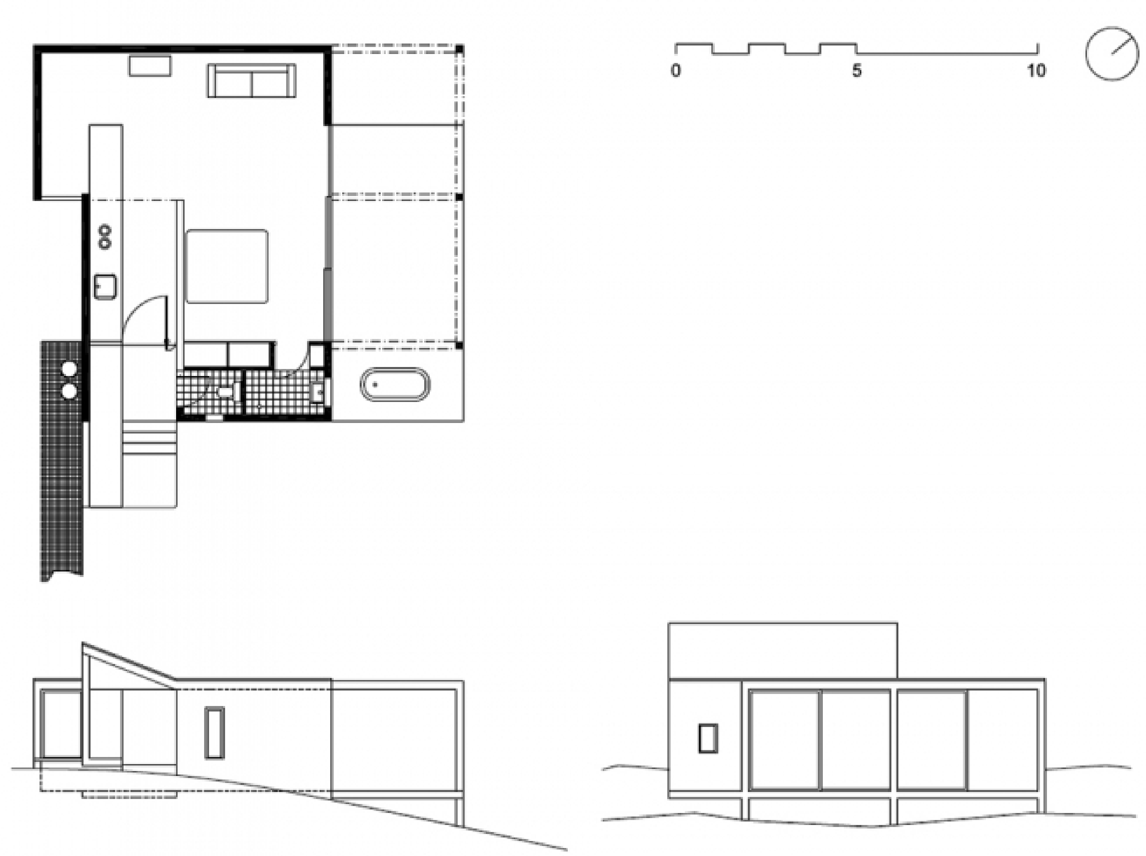
Sited in a remarkable setting, adjacent the Blackwood River, the vegetation conservation provisions of the river setback necessitated designing to BAL 40 – the second highest level of bushfire protection in the Australian Bushfire Standard AS3959:2009. Bushfire design responses include precast concrete verandah decking; elimination of conventional bargeboards, fascias and exposed timber; and the dual-purposing of stainless steel insect screens which double as ember and radiant heat shields as well as security screens when the house in unoccupied.

Catagory 4: Non-Prefabricated Housing (Bushfire Resistant)

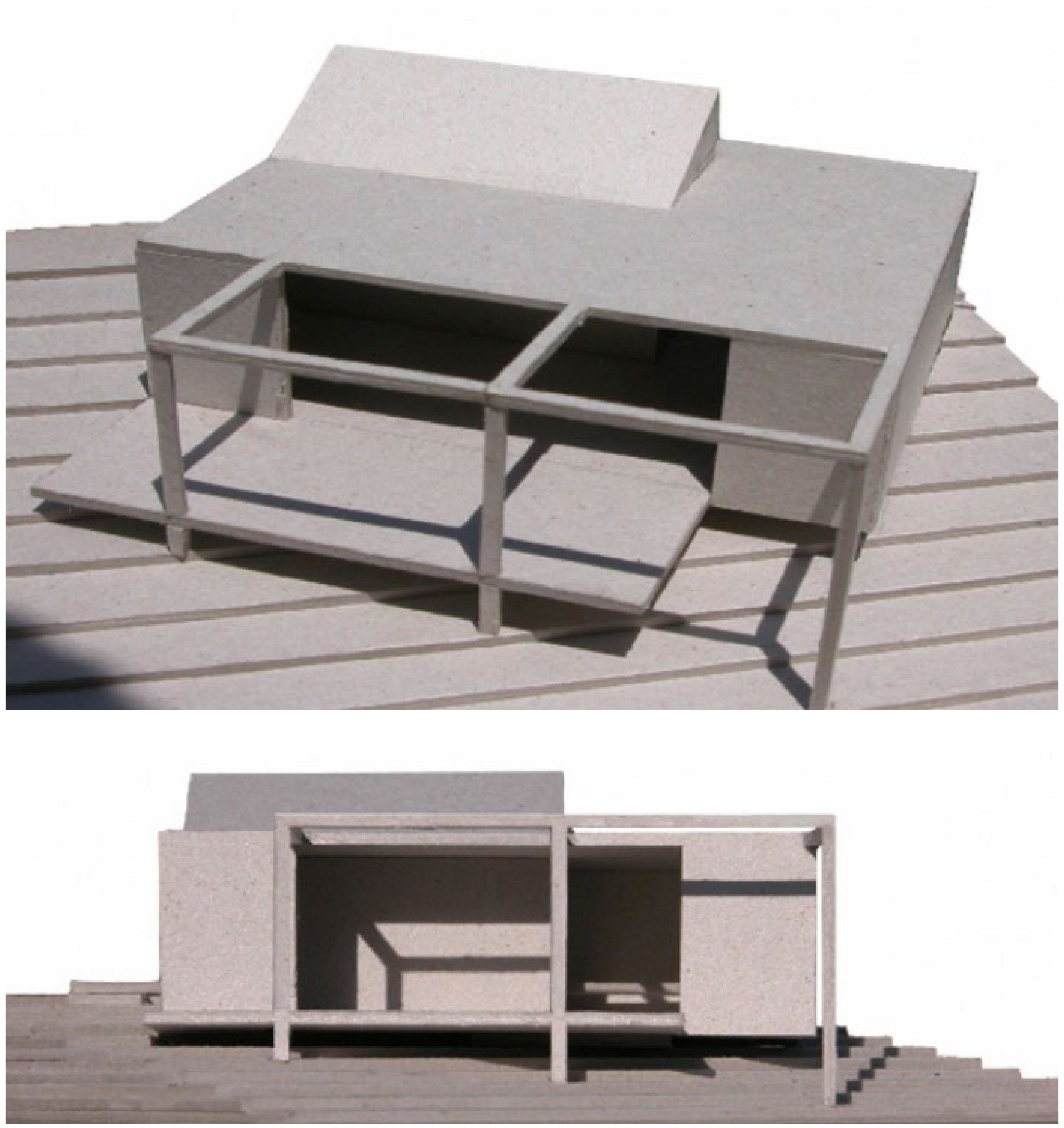
Overlook

Ian Weir Architect

Unbuilt



plan + elevation



model images

Project Information

Built / Unbuilt:	Unbuilt	Onsite Lifting Req:	n/a
Architect / Designer:	Ian Weir Architect	Transport Req:	n/a
Construction Company:	n/a	BAL Rating:	BAL FZ
Manufacture:	n/a	SQM	85sqm (+ deck)
Assembly:	On-site	Cost (per sqm):	n/a
Structure:	Cast in-situ concrete	Construction Time:	n/a
Materials:	Cast in-situ concrete		

Project Summary (from Ian Weir Architect)

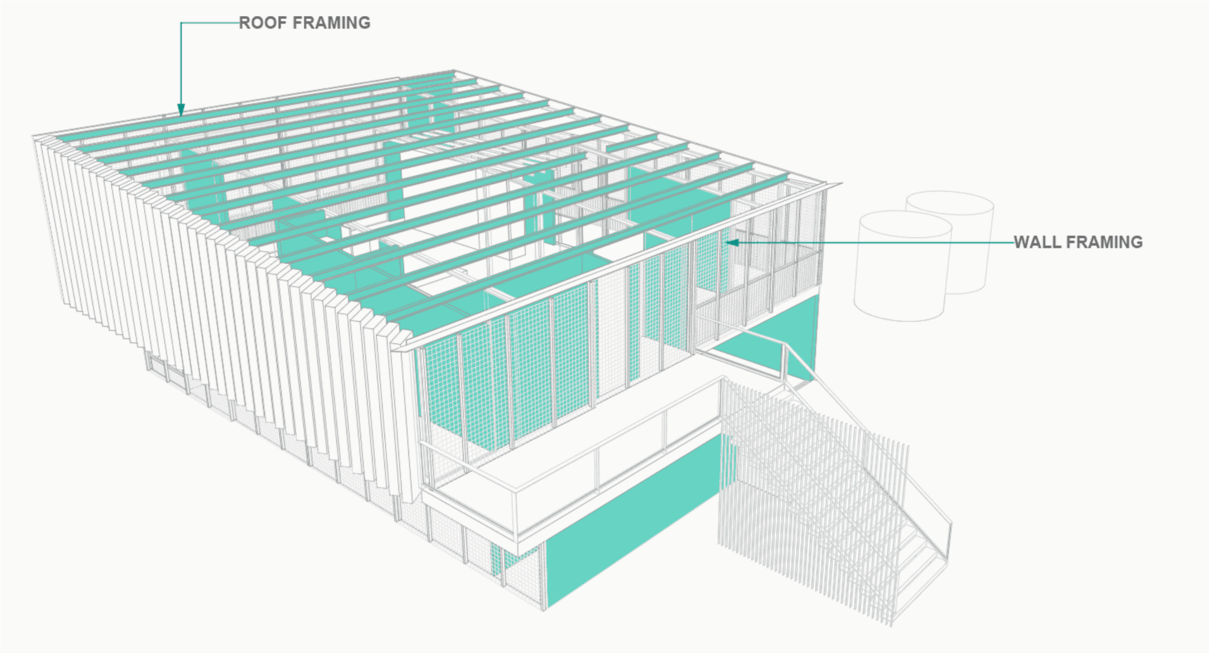
Designed to withstand direct flame contact from bushfire (BAL FZ), the Overlook is a cast in-situ, off form concrete project (unbuilt). At 72m2 enclosed area with an external fireproof suspended concrete deck, the Overlook presents a model for integration of site-specific architecture with biodiverse bushfire-prone landscapes.

Catagory 4: Non-Prefabricated Housing (Bushfire Resistant)

One House

Suncorp / Room 11 Architects

Unbuilt



Project Information

Built / Unbuilt:	Unbuilt (prototype model)	Onsite Lifting Req:	n/a
Architect / Designer:	Room 11 Architects	Transport Req:	n/a
Construction Company:	n/a	BAL Rating:	BAL FZ
Manufacture:	n/a	SQM	unknown
Assembly:	On-site	Cost (per sqm):	unknown
Structure:	Steel frame, concrete block	Construction Time:	n/a
Materials:	Cement sheet cladding, stainless steel roof.		

Project Summary (from One House website)

In collaboration with James Cook University, CSIRO and Room11 architects,One House takes inspiration from the iconic Queenslander, reimagining it into a modern and aspirational home with features specifically selected to help withstand extreme weather such as bushfires, floods and cyclones.

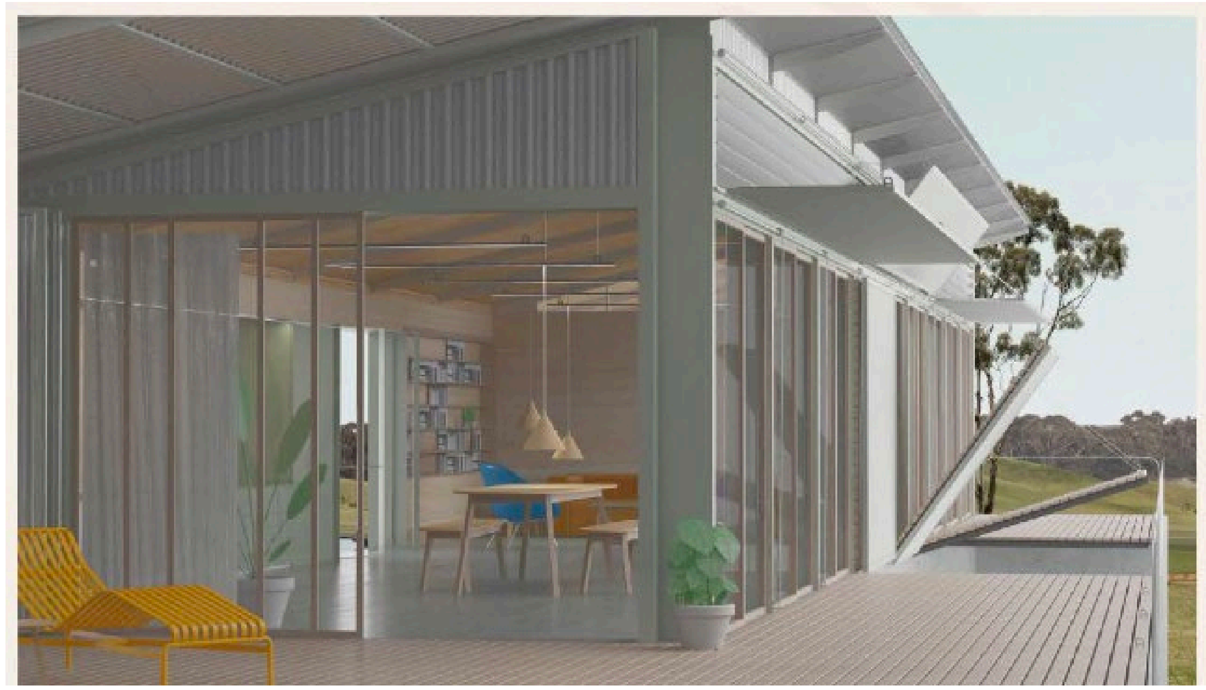
Catagory 4: Non-Prefabricated Housing (Bushfire Resistant)

Decatharoos

UTS

Unbuilt.

plan



project images

Project Information

Built / Unbuilt:	Unbuilt	Onsite Lifting Req:	n/a
Architect / Designer:	UTS	Transport Req:	n/a
Construction Company:	n/a	BAL Rating:	BAL-FZ
Manufacture:	n/a	SQM	100sqm (small) 240sqm (full)
Assembly:	On site	Cost (per sqm):	$1500 per sqm
Structure:	Rammed earth	Construction Time:	n/a
Materials:	Metal roof and screens.		

Project Summary (from UTS)

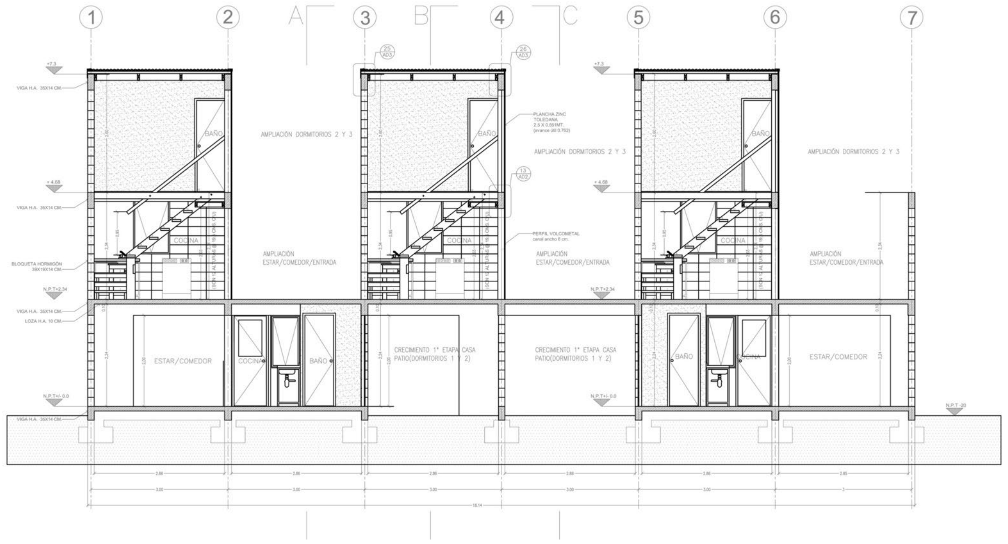
UTS Decatharoos propose a flexible, passive house design for the unique landscape and climatic conditions that exist on the South Coast of New South Wales, Australia. The house is designed to be bushfire resistant and energy and water independent so that it can be deployed on any typical site in the country whether in remote, rural or suburban areas.

The innovative design is flexible in many ways: performance, structural system, integrated services, spatial planning, life cycle, bushfire response, siting, occupant experience, and reponse to nature. Energy independence, bushfire independence, and passive heating and cooling for thermal comfort independence are critical features. We define 'independent living' to mean off the grid but also to mean the occupants can control their environment. The house can grow over time to accommodate people's changing needs in different stages of life.

Category 5: Housing (Half House / Owner Builder / Social Models)

Catagory 5: Housing (Half House / Owner Builder / Social Models)

Quinta Monroy Social Housing
Elemental
Iquique, Chile
2003



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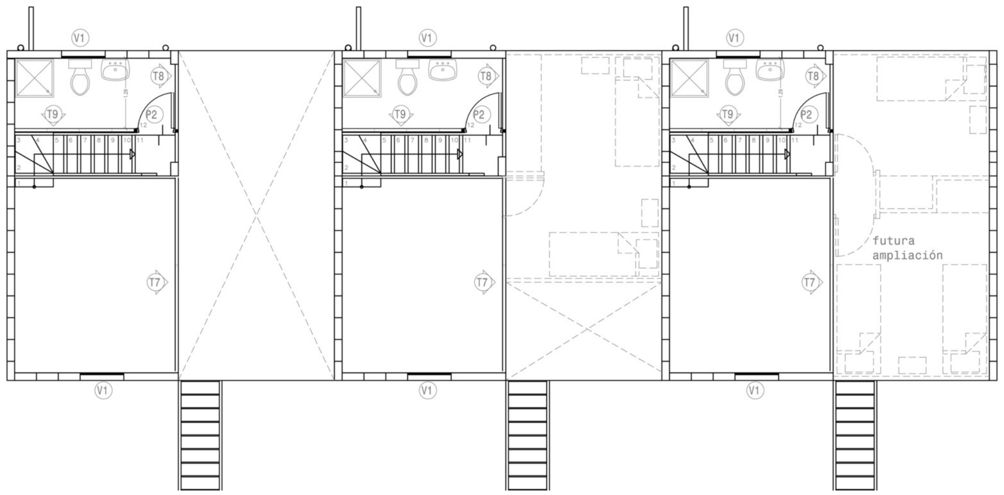


plan

project images

Project Information

Built / Unbuilt:	Built	Onsite Lifting Req:	n/a
Architect / Designer:	Elemental	Transport Req:	n/a
Construction Company:	unknown	BAL Rating:	n/a
Manufacture:	Kit of parts	SQM	72sqm (max 108sqm possible)
Assembly:	On site (staged construction)	Cost (per sqm):	unknown
Structure:	Concrete slab and roof	Construction Time:	unknown
Materials:	Blockwork walls, metal windows		

Project Summary (from Elemental)

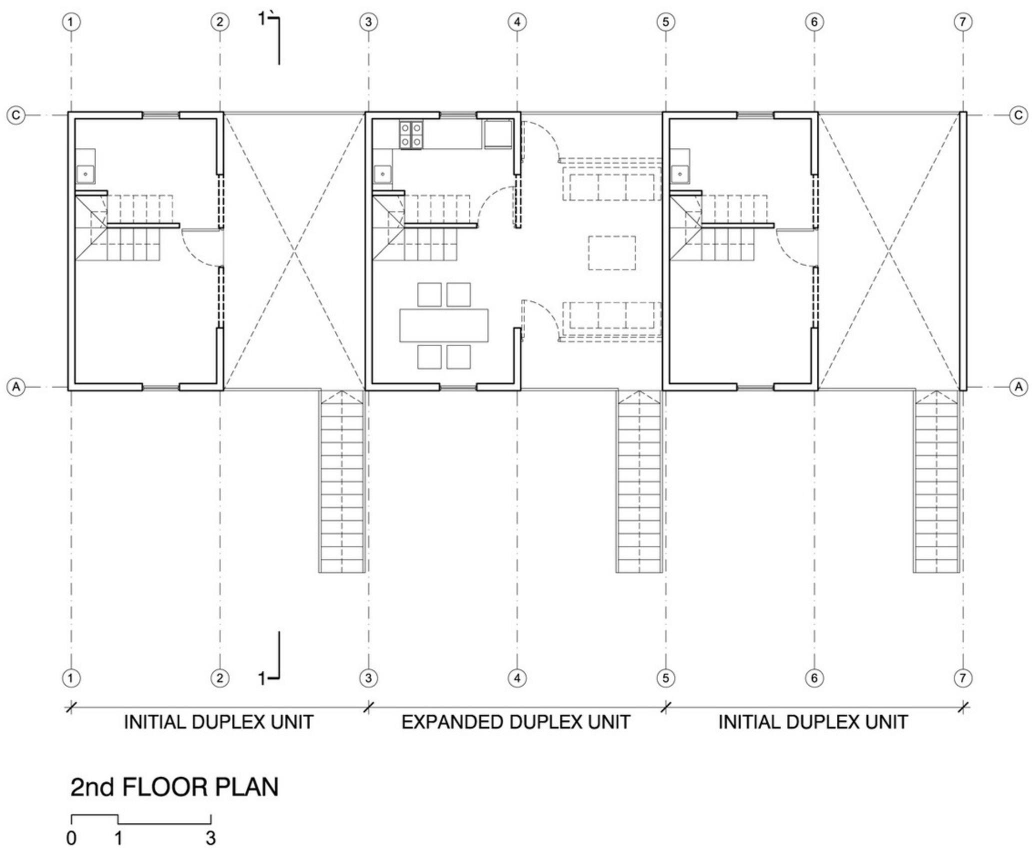
We propose a principle of ‘incrementality’. If you can’t do everything, focus on: A. What is more difficult B. What cannot be done individually C. What will guarantee the common good in the future?

Due to the fact that 50% of each unit’s volume will eventually be self-built, the building had to be porous enough to allow each unit to expand within its structure. The initial building must therefore provide a supporting (rather than a constraining) framework in order to avoid any negative effects of self-construction on the urban environment over time, but also to facilitate the expansion process.

Instead a designing a small house (in 30 sqm everything is small), we provided a middle-income house, out of which we were giving just a small part now. This meant a change in the standard: kitchens, bathrooms, stairs, partition walls and all the difficult parts of the house had to be designed for final scenario of a 72 sqm house.

Catagory 5: Housing (Half House / Owner Builder / Social Models)

Monterrey Social Housing
Elemental
Monterrey, Mexico
2010



plan

project images

Project Information

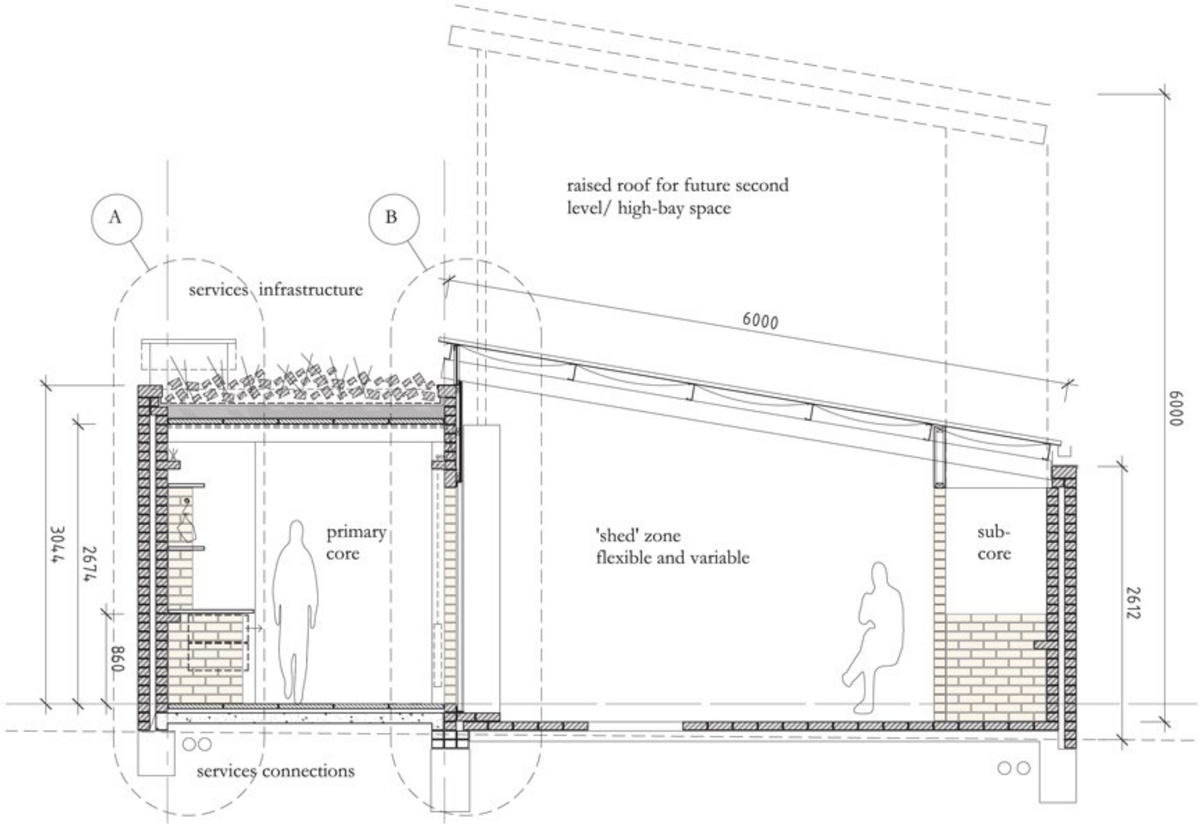
Built / Unbuilt:	Built	Onsite Lifting Req:	n/a
Architect / Designer:	Elemental	Transport Req:	n/a
Construction Company:	unknown	BAL Rating:	n/a
Manufacture:	Kit of parts	SQM	40sqm (max 76sqm possible)
Assembly:	On site (staged construction)	Cost (per sqm):	unknown
Structure:	Concrete slab and roof	Construction Time:	unknown
Materials:	Blockwork walls, metal windowsr.		

Project Summary (from Elemental)

ELEMENTAL Monterrey consists of a three-storey continuous building that in sections superimposes a home (first floor) with a two-storey apartment above (2nd and 3rd storey). Both units are designed to technically and economically facilitate the final middle class standard of which we will hand over the “first half” (40 m2). In this sense, the difficult parts of the house (bathrooms, kitchen, stairs, and dividing walls) are designed for the expanded scenario, that is, for a home of more than 58 m2 approx. and an apartment of approximately 76 m2. Secondly, given that almost 50% of the m2 of the complex will be self-built, this building is porous so that the growth can occur within the structure. On one hand we want to frame and give rhythm (more than control) to the spontaneous construction so as to avoid deterioration of the urban environment over time, and also make the process of expansions for each family easier. The proposed continuous roof above the volumes and voids protects the expansion zones from rain and ensures a definitive profile of the building toward the public space.

Catagory 5: Housing (Half House / Owner Builder / Social Models)

Core House
NMBW Architects
Moonee Ponds, Victoria
2010



section

project images

Project Information

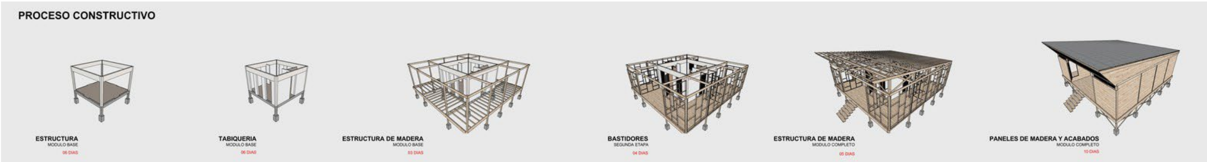
Built / Unbuilt:	Unbuilt	Onsite Lifting Req:	n/a
Architect / Designer:	NMBW	Transport Req:	n/a
Construction Company:	n/a	BAL Rating:	unknown
Manufacture:	Kit of parts	SQM	42sqm core
Assembly:	On site (Staged construction)	Cost (per sqm):	n/a
Structure:	Concrete slab, brick.	Construction Time:	n/a
Materials:	Brick, timber frame, cladding, doors.		

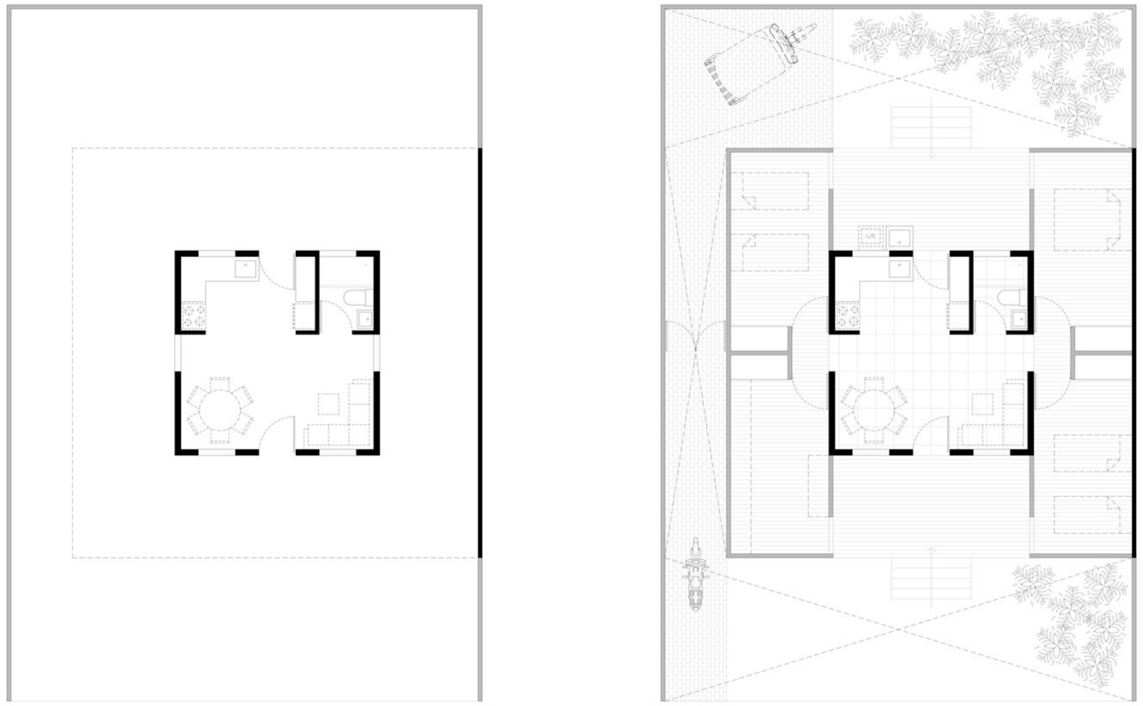
Project Summary

An experimental housing model with a primary core containing services, a secondary core and then a potential series of 'shed' zones that are flexible and variable and can be constructued over a staged timeframe.

Catagory 5: Housing (Half House / Owner Builder / Social Models)

120 Incremental Homes
Rafael Arana Parodi, Carlos Suasnabar Martínez, Amed Aguilar Chunga, Santiago Nieto Valladares
City of Iquitos, Peru
2017





plan - stages

Project Information

Built / Unbuilt:	Unbuilt	Onsite Lifting Req:	None
Architect / Designer:	Rafael Arana Parodi and others	Transport Req:	Small tray truck
Construction Company:	n/a	BAL Rating:	n/a
Manufacture:	Modular / Kit of parts	SQM	various
Assembly:	Mix	Cost (per sqm):	unknown
Structure:	Structural steel frame	Construction Time:	n/a
Materials:	Timber and cement sheet cladding		

project images - stages

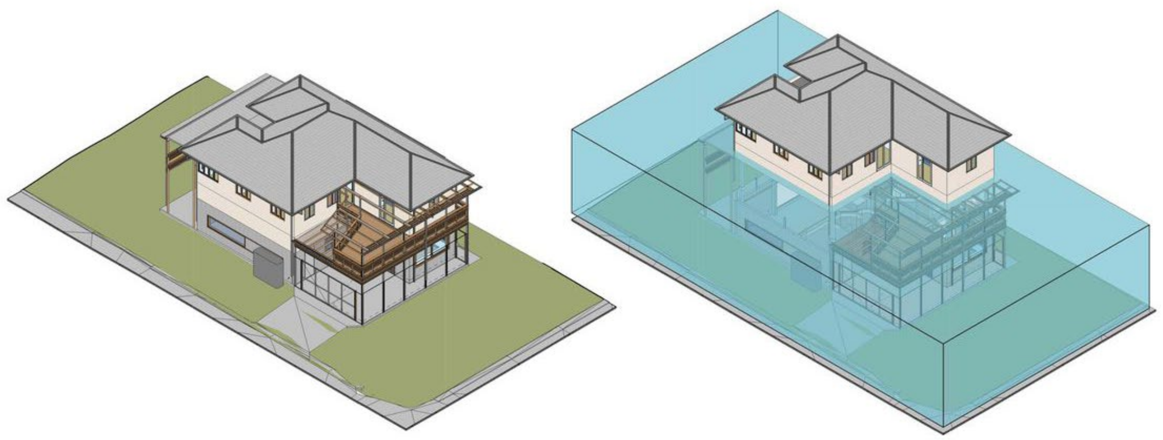
Project Summary (from the Architects)

The concept of the housing module is based on providing a nucleus of noble material with basic services, which is complemented by a wooden structure that will eventually contain the rest of the rooms. The nucleus contains the social area of the house, the kitchen, and the bathroom, which are the only parts of the house that accommodate the water and drainage networks, and the main electrical network. The nucleus has a cross circulation that allows the house to grow on its 4 sides. The progressive stages are modular and flexible and permit the owner to choose their use and the type of material for the finish. The proposed design makes the progressive growth of the house always orderly since it is limited by the roof, creating a consolidated urban image. The one-floor module was proposed as a single-family home; and the two floor model as a single, or multi-family detached house.

Category 6: Other

Catagory 6: Other

Graceville Flood Housing
James Davidson Architects
Brisbane, Queensland
2012



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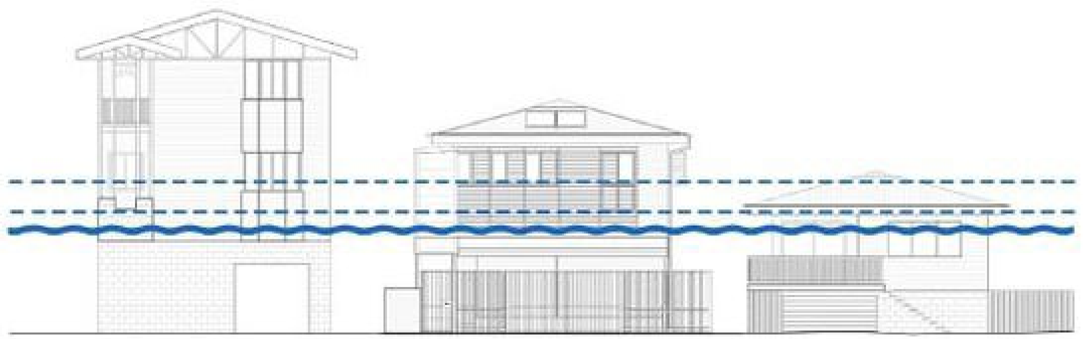


section

project images

Project Information

Built / Unbuilt:	Built	Onsite Lifting Req:	n/a
Architect / Designer:	James Davidson Architects	Transport Req:	n/a
Construction Company:	unknown	BAL Rating:	n/a
Manufacture:	n/a	SQM	unknown
Assembly:	On site	Cost (per sqm):	unknown
Structure:	Concrete blocks	Construction Time:	unknown
Materials:	Hardwood timber, waterproof joinery		

Project Summary (from James Davidson Architects)

Located a few hundred metres from the Brisbane River, this house was completely destroyed in the 2011 floods. The clients were forced to raise their (new) house over three metres to comply with new temporary planning instruments that required habitable floor levels to exist above the flood line. In addition to elevating the house, the lower level of the building is designed to be completely inundated. By using large openings and permeable screens, we ensured that water could flow through the house without creating structural damage. Our design also allows for an easy clean of the spaces after future flood waters recede. Flood-proof joinery was installed on the ground level. Hardwood timber was used for screens and the staircase, ensuring these areas are also more resistant to future flood water.

Catagory 6: Other

Shack 14

Ken Latona

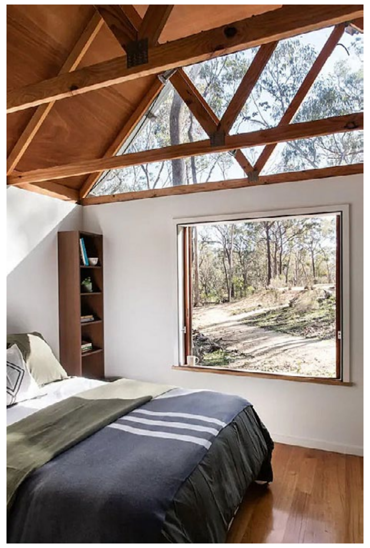
Chewton, Victoria (and other locations)

2017

project images

Project Information

Built / Unbuilt:	Built (multiple)	Onsite Lifting Req:	unknown
Architect / Designer:	Ken Latona	Transport Req:	unknown
Construction Company:	Smartshax	BAL Rating:	BAL 29 (shown exampe)
Manufacture:	Flatpack / Modular options	SQM	63sqm (+ 18sqmm deck)
Assembly:	Mix	Cost (per sqm):	$195,000 (off-grid)
Structure:	Timber truss and frame	Construction Time:	6 - 8 weeks
Materials:	Metal roof, cement sheet cladding		



project images

Project Summary (from Smartshax)

The Concept

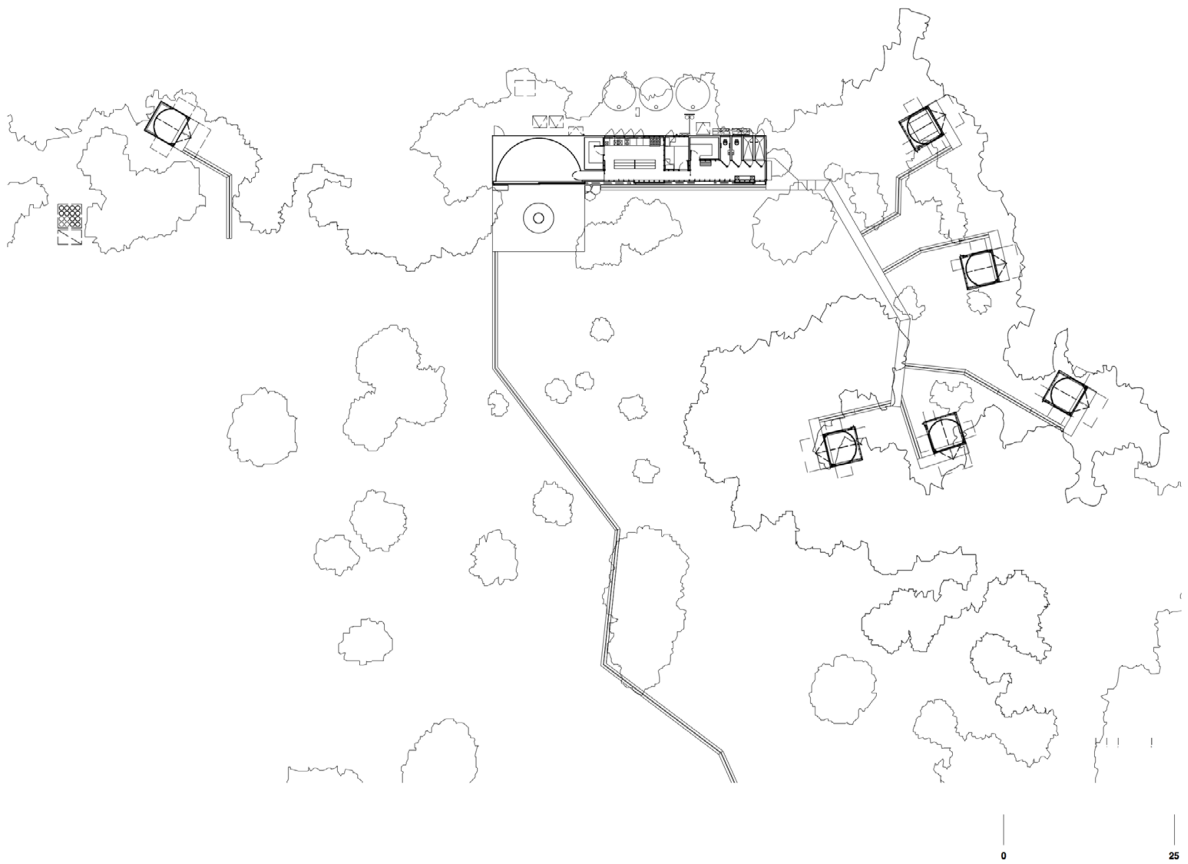
This lightweight, environmentally sustainable dwelling was designed by award-winning architect Ken Latona with Australian coastal climate in mind. “Basic amenity plus maximum connection to the environment. It’s camping with doors.”

The Shacks

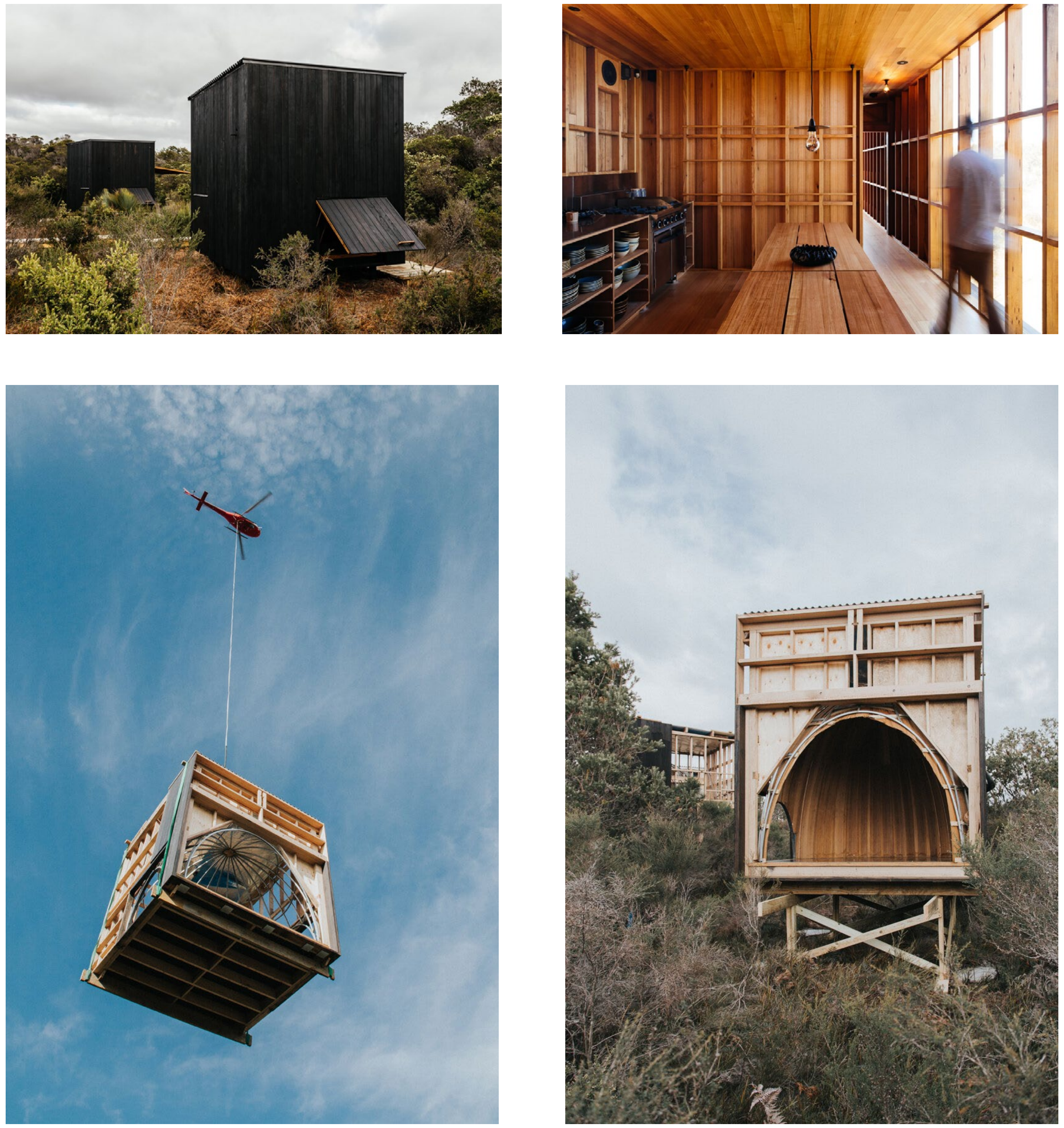
The timber design allows the building to rest lightly in its environment upon galvanized steel stirrups. This makes the building particularly suitable for remote, isolated or difficult blocks where traditional buildings would be uneconomic or an environmental insult. The materials selected have low embodied energy, are renewable and reusable.

Catagory 6: Other

Krakani Lumi
Taylor Hinds Architects
Mount William National Park, Tasmania
2017



site plan



project images

Project Information

Built / Unbuilt:	Built (1)	Onsite Lifting Req:	Helicopter
Architect / Designer:	Taylor Hinds Architects	Transport Req:	Helicopter
Construction Company:	AJR Construct	BAL Rating:	unknown
Manufacture:	Modular	SQM	150sqm
Assembly:	Mix	Cost (per sqm):	unknown
Structure:	Hardwood timbr frame	Construction Time:	unknown
Materials:	Hardwood timbr lining and cladding		

Project Summary (from Taylor Hinds Architects)

Krakani-lumi - 'resting place' - is a standing camp within the wukalina/Mt William National Park for a cultural walk that is guided and operated by the Aboriginal Land Council of Tasmania. The project has been designed over a number of years in close consultation with the Land Council, and the broader Tasmanian Aboriginal community.The project is strongly informed by the siting, materials and traditional half-domed forms of ancient Tasmanian Aboriginal shelter. These traditional interiors are held by a robustly detailed charred timber clad exterior. When not in use, the exterior conceals and protects the experience of the rich timber interior and becomes a shadow against the coastal banksia that surrounds the site.

"the infrastructure be durable but removable, luxurious but economical, simply constructed yet robust enough to be airlifted in by helicopter. Rainwater had to be harvested, toilets composted and the entire site configured to be off-grid, powered by a solar array with a generator back-up." (David Neustein)

CRC AMGC #35

Prefab Housing Solutions for Bushfire and Disaster Relief

Design research