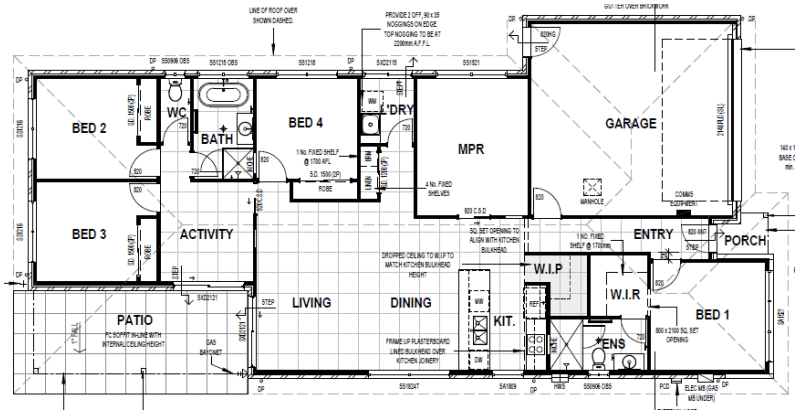
The Floodable Queenslander - Technical Report

Wood Solutions Design Competition - Resilient Timber Homes in Hervey Bay (Brief B)

Designed and Submitted by Michael Croft (Queensland Architect Registration No. 5875) on 23/06/23

1.0 Introduction

For the purposes of this technical report, the below house has been referred to as the 'Benchmark Project' for Brief B – Hervey Bay. The objective of this design competition is to develop a new resilient timber home design by modifying a Benchmark Project that has been designed and built in the recent past by a Developer/Builder selected by the Client (FTMA and OneFortyOne).



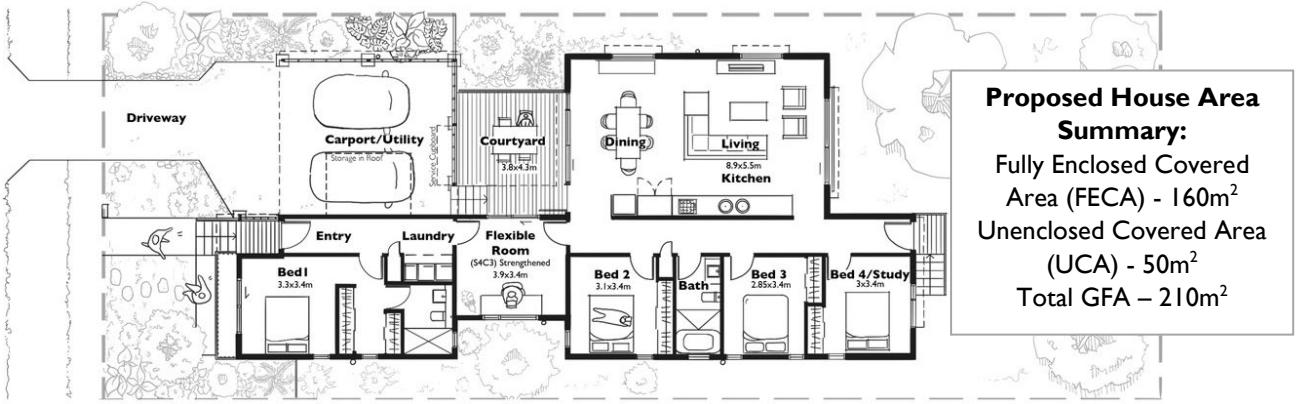
Benchmark Project

Benchmark Project Area Summary:
Fully Enclosed Covered Area (FECA) - 187m^2
Unenclosed Covered Area (UCA) - 23m^2
Total GFA - 210m^2

2.0 Return Brief Summary

The proposed design has been based off modifying the Benchmark Project and attempts to achieve similar functional spaces and good buildability, with an ambition to achieve better resilience against flooding and cyclonic influences, targeting a low carbon footprint and to be economically viable as a domestic development typology.

My understanding of the occupants based in Hervey Bay could range from families, younger or elderly individuals or couples, through to renters in a sharehouse arrangements or AirBnb. The site was assumed to be regionally situated in a sub-tropical, coastal town with potential for Cylonic conditions and riverine flooding. My proposed design aims to match the Benchmark Project quantity of bedrooms, however, to reduce to 3 bedrooms the 'Bed 4' could be simply removed.



Proposed Design Floor Plan

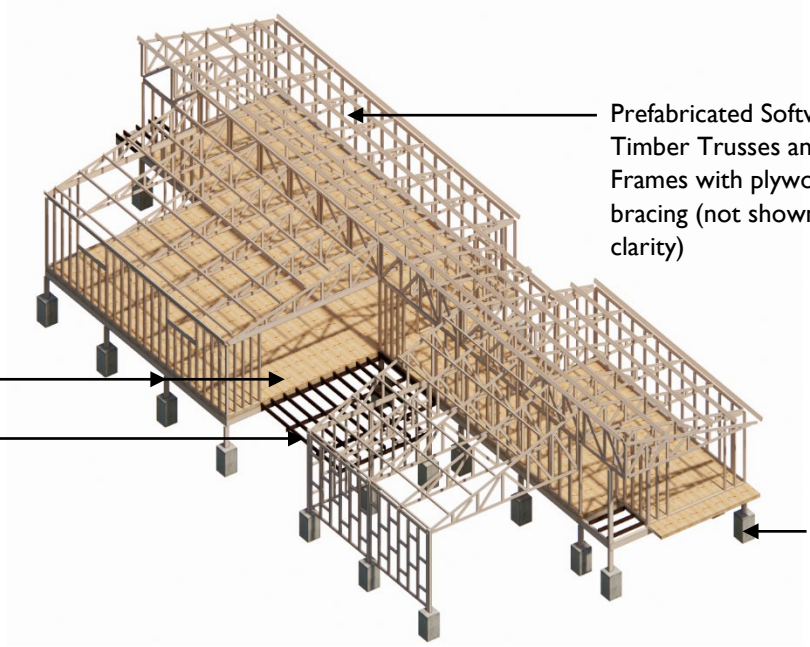
3.0 Design Concept Summary

The key design concepts for The Floodable Queenslander are to create:

1. **An efficient site configuration and form crafted by passive design principles** that maximise opportunities for ideal solar orientation, natural daylight and natural ventilation. A house that also considers successful master planning and works within planning requirements.
2. **A socially and environmentally rooted home in it's local context** that is a 'friendly neighbour' to foster a sense of community and engagement. The elevated structure that touches the ground lightly and landscaping strategy promotes a harmonious relationship with the environment and greater context.
3. **A flexible home which provides a framework for occupants** to adapt the building over time. Utilising building systems which accommodate reconfiguration, additions and longevity - a flexible floor deck, free spanning roof structure and peripheral building envelope.
4. **An innovative timber structure challenge** that combines established prefabricated and conventional timber construction systems to achieve low carbon, efficient outcomes. A house that considers the life cycle assessment of its resources.
5. **A resilient, robust house with moments of delight** that can adapt to the ever-shifting requirements of climatic, social, economic and regulatory requirements. The house has been raised above the flood level but aims to connect with the ground plane.

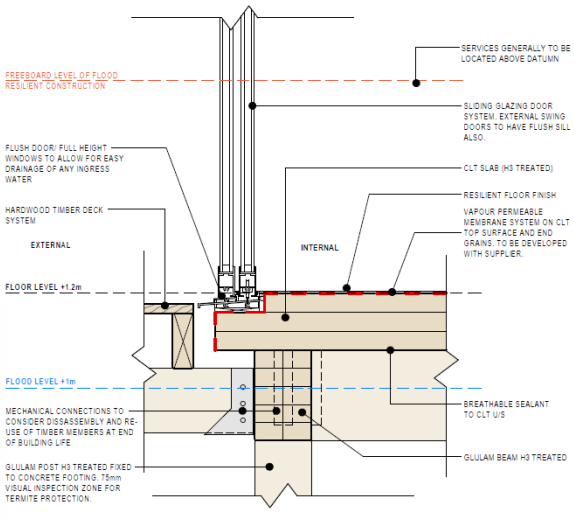
4.0 Tectonic System Summary

Structure

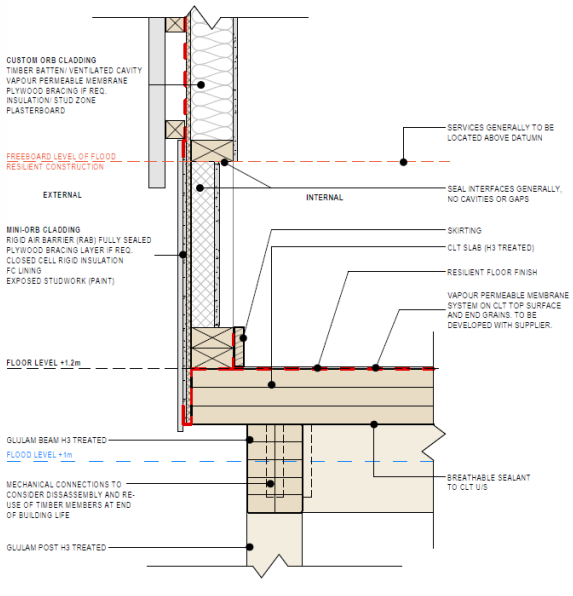


The proposed house structure is a raised above the 1m flood level, with a floor level set at 1.2m above ground (approximately 200mm above the flood level). This level was chosen to balance physical connection to the ground plane while acknowledging that inundation during a flood event should be avoided from an asset and safety risk.

A Mass Engineered timber elevated floor system using Cross Laminated Timber floor slabs and Glue Laminated posts and beams has been chosen as a suitable material. This system has potential to achieve speedy, prefabricated construction outcomes to replace slower wet trades, offer more control over the design process and result in quality outcomes of coordination and implementation of services and structure, while being robust against possible inundation or moisture. Above the floor deck, prefabricated softwood timber wall and roof truss systems, with plywood bracing, are proposed as an efficient, lightweight solution which can be erected swiftly and are known affordable and conventional construction systems. For all timber components, attention will be given to the detailing to enable the wood to dry out post flood event. The underside of the CLT Slab is intended to remain open to the air to assist this drying process. Further research and development would be required around the moisture control of the mass timber elements, particularly around membrane type, locations and treatment of the timber.



DETAIL 2 - GLAZED SLIDING DOOR/ COURTYARD DECK



DETAIL 3 - TYPICAL EXTERNAL WALL DETAIL

Enclosure & Interiors

A 450mm freeboard datum (above the floor level) of flood resistant building wall systems are proposed for severe flood events and offer long-term tolerance against climate change if the 1m flood level is exceeded. Walls and floors will be cavity free and water will drain through flush doors and window sills. This datum will be expressed as a feature internally.

Robust and durable materials have been selected for this climate, such as metal cladding (custom orb) externally, fibre cement sheeting and plasterboard internally, hardwood decking and screening systems, aluminium framed window systems and polycarbonate sheeting for low maintenance and longevity while achieving an architectural quality that supports the design concept framework.

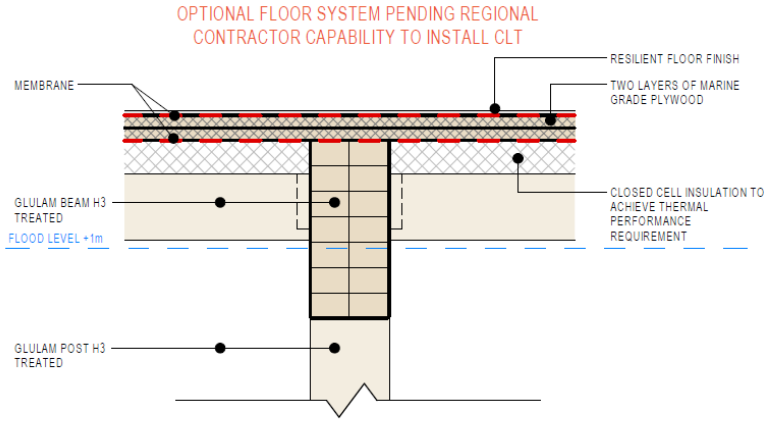
Another feature of the home is the proposal of the roof thermal line to occur completely within the purlin zone, not the ceiling cavity, to promote easier reconfiguration of internal partitions and maximise the volume between trusses. The CLT slab is nominally 120mm, which would provide thermal insulation for the underside of the house (to be confirmed in an energy report).

Services

Services such as electrical infrastructure will be above the flood datum in the carport roof void, which can be safely accessed off the courtyard deck location. Ceiling fans are proposed to be included in the living spaces and bedrooms to support the passive design features of the house. The house is also able to accommodate ducted air conditioning as an option.

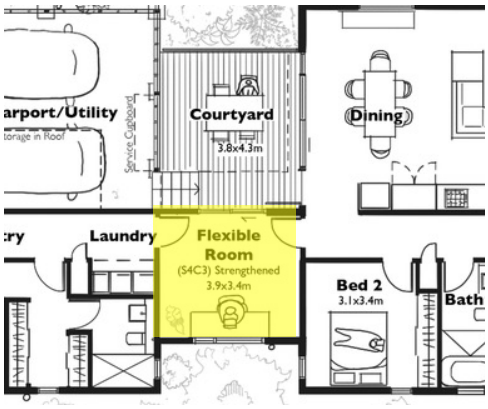
Alternative Option

An alternative floor build-up which uses a double plywood deck in lieu of the CLT has been provided pending capability of regional construction to accommodate. This alternative build-up will require separate insulation to be installed and would not be as efficient to construct as the CLT.



ALTERNATIVE FLOOR SYSTEM DETAIL

5.0 Code + Functional Performance



S4C3 Strengthened Room:

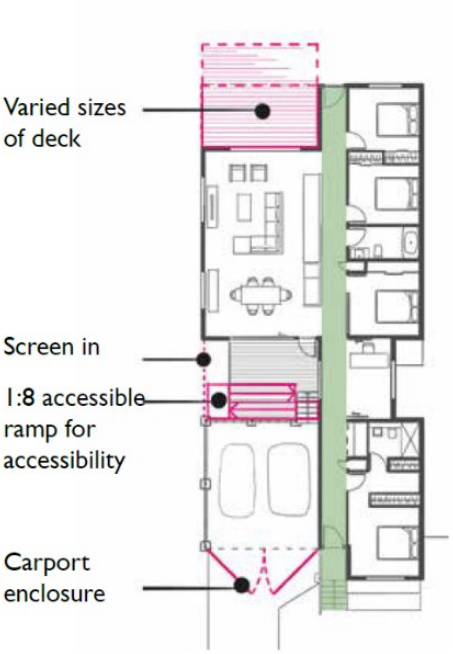
The 'Flexible Room' located in the centre of the house will be the designated 'S4C3 Strengthened Area' during cyclonic conditions and will be designed to comply with the area requirements for the house population, reinforcement to the perimeter walls and enclosure protection against debris while retaining the domestic and delightful design quality of the rest of the house.

Accessibility and Liveable Housing Guidelines

In the NCC 2022 there are revised requirements based on the 'Liveable Housing Guidelines' being introduced. This will present an interesting paradox for flood resilient housing. The floor level has been set at 1.2m which presents access issues under the revised NCC access requirements.

This issue of access would need to be agreed with a Certifier early in a project to agree on the provision of access to the house. The proposed design allows a zone in the courtyard for a possible ramp (1:8 only possible) which may be a concession for this requirement.

The proposed design includes set downs for flush access to wet areas, a requirement in the NCC 2022. This would be routed out of the CLT floor zone.



Future options for house owners

Flood Resilience

Flood resilience is a complex topic and brings a variety of challenges. Options range from raising the house completely above the flood zone to building on ground and allowing a building to be submerged during a flood event. Local Governments may reject habitable space being under a flood level as well as major occupant asset loss and slow recovery from a flood event being prohibitive. Alternatively, significantly elevated homes present accessibility and urban design quality issues. This project aims to mediate these tensions and acknowledge the limitations and opportunities of building in a flood zone.

6.0 Carbon Footprint Calculation

This calculation was based of Greenstar Upfront Carbon Calculator, Modules A1-A3 for the house Superstructure and Substructure. For consistency of the calculation for materials, are based off the University of Melbourne, Melbourne School of Design Life Cycle Assessment EPiC Database 2019 tool referenced by the Greenstar Upfront Carbon Calculator. All quantities and engineering of Superstructure and Substructure are approximations only and Specialist Consultants were not involved for the calculations for the Upfront Carbon.

Proposed Building – Timber Construction

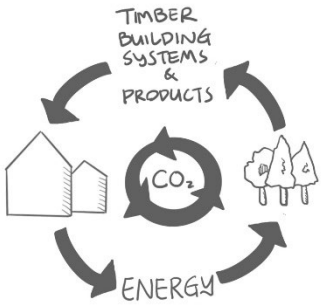
Building Element	Material	Total Material Volume (m^3)	Carbon Footprint per kg/m^3	Material Carbon Footprint A1-A3	Sequestered Carbon Potential of Material	Overall Carbon Footprint *
Foundations						
Concrete Piles 900 x 600 dia nominal	Concrete 25mPa	5.2m^3	361 kg/m^3	1,877 kg/m^3	Nil	1,877 kg/m^3
Floor Structure						
Cross Laminated Timber 120mm	Radiata Pine (550kg/m^3)	19m^3	645 kg/m^3	12,284kg/m^3	19,204 kg/m^3	No additional CO^2
Timber Glulaminated Timber Bearer 230 x 120mm	Radiata Pine (550kg/m^3)	3.4m^3	1,605 kg/m^3	5,466 kg/m^3	3,434 kg/m^3	2,032 kg/m^3
Hardwood Joist Timber 150 x 80mm	Spotted Gum (980kg/m^3)	0.3m^3	1,178 kg/m^3	379 kg/m^3	579 kg/m^3	No additional CO^2
Column/ Wall Structure						
Columns/ Stumps – External Glulaminated Timber 120 x 80mm	Radiata Pine (550kg/m^3)	0.6m^3	1,605 kg/m^3	960 kg/m^3	603 kg/m^3	357 kg/m^3
Stud Framing – Pine Timber 90 x 45mm	Radiata Pine (550kg/m^3)	2.4m^3	583 kg/m^3	1,441 kg/m^3	2,492 kg/m^3	No additional CO^2
Roof Structure						
Truss Framing – Timber 90 x 45mm	Radiata Pine (550kg/m^3)	2.7m^3	583 kg/m^3	1,570 kg/m^3	2,716 kg/m^3	No additional CO^2
Timber Purlins – 145 x 45mm Nominal	Radiata Pine (550kg/m^3)	1.8m^3	583 kg/m^3	1,045 kg/m^3	1,045 kg/m^3	No additional CO^2
Total Carbon Footprint				**25,022 kg/m^3**	**20,756 kg/m^3**	**4,266 kg/m^3**
Per m^2 GFA						**20.3 $CO2e/m^2$**

**Note: Refer Green Star Guidance for 'Stored Carbon'.*

Reference Model Building – Steel and Concrete Construction

Building Element	Material	Total Material	Carbon Footprint per Unit	Material Carbon Footprint A1-A3	Sequestered Carbon Potential of Material	Overall Carbon Footprint *
Foundations						
Concrete Piles 900 x 600 dia nominal	Concrete 25mPa	5.2m³	361 kg/m³	1,877 kg/m³	Nil	1,877 kg/m³
Floor Structure						
Precast Concrete Planks 150mm Thick	Concrete 25mPa	23m³	645 kg/m³	8.628.78kg/m³	Nil	8.628.78kg/m³
PFC Steel Bearers 125mm	Hot Steel	1,555.71kg	1,605 kg	5,466 kg/m³	Nil	5,466 kg/m³
Column/ Wall Structure						
Columns/ Posts – SHS 75	Hot Steel	464.6 kg	1,605 kg	960 kg/m³	Nil	960 kg/m³
Stud Framing – Lightweight Steel 92mm	Cold Steel	802.53 kg	583 kg	1,441 kg/m³	Nil	1,441 kg/m³
Roof Structure						
Truss Framing – Lightweight Steel 92mm Framing	Cold Steel	875.91 kg	583 kg	1,570 kg/m³	Nil	1,570 kg/m³
Steel Purlins – 150 C Purlins	Cold Steel	853.36 kg	583 kg	1,045 kg/m³	Nil	1,045 kg/m³
Total Carbon Footprint						**26,572 kg/m³**
Per m² GFA						**126.53 CO2e/m²**

Circular Economy and Life Cycle Assessment Opportunity



As seen in the comparison above, timber structure has a significantly lower carbon footprint at approximately 16% of the steel structure option when factoring in carbon sequestration. It is therefore crucial to consider the sustainable management of absorption and release of carbon dioxide when contemplating timber construction. The whole of life of wood products needs to be considered to authentically claim 'low carbon' construction.

As part of this project, an 'End of Life Plan' could be considered where the life cycle of the timber structure and products are examined to consider options for the responsible procurement (such as FSC), specifying and management through its manufacture, use, disposal or returning of material back into the cycle and subsequent life.

Research could include design of mechanical connections for assembly and disassembly, reduction of glues and adhesives, treatment of wood products for re-use or energy production after use and how these buildings can be effectively managed and maintained by the occupants over the building life. It is crucial for the construction industry to enable sustainable forest practices, maximize wood reuse and recycling, and explore alternative waste management options to minimize the release of CO2 into the atmosphere.

7.0 Cost Estimate Comparison

A cost estimate for the Benchmark Project was supplied by the Woodsolutions as a reference to compare against when assessing the cost premium of the Proposed Design. The excel document – *"RTH-DC Brief A&B - Cost Estimates"* – contained a "High Level Cost Estimate" for Resilient Timber Homes Design Competition, Brief B prepared by Laurence Ritchie (WoodSolutions Advisor) on 14/05/2023. This document outlined the cost for the reference design sourced from Rawlinsons Cost Guide 2023 (Pages 43-65) for 'Brisbane' region. Refer '*Table 1 – Benchmark Project High Level Cost Estimate*' for provided estimate. The inclusions and exclusions of the estimate result in the categories listed in the tables below.

'Table 2 – Proposed Design High Level Opinion of Cost Estimate' shows an opinion cost for the proposed design based on the same format as the Benchmark Project. Note that the 'Opinion of Cost Estimate' was prepared without input from a Quantity Surveyor or Specialist Consultants and is only to be used as a holistic mechanism to compare differences between the Benchmark and Proposed schemes. Rates for the Cross Laminated Timber and Glue Laminated Timber were sourced from XLAM, an Australian Timber Product Supplier, since it was the predominant deviation from the Benchmark Project. Other rates for other building elements were extrapolated from the Benchmark Project rates as a starting point.

Table 1 – Benchmark Project High Level Cost Estimate
(Extracted from *RTH-DC Brief A&B - Cost Estimates)*

Building Element	Cost
Ground Slab	$20,400.08
Patio slabs	$2,105.36
Brick Veneer	$37,587.36
Internal wall timber framing	$20,892.10
External wall timber framing	$21,243.74
Internal Swing Doors	$6,765.00
External Swing Doors	$2,180.00
Roller Door	$3,533.62
Windows	$6,971.04
Sliding Doors	$7,741.44
Roof	$54,703.28
Eave Soffits	$6,569.64
Ceiling lining	$7,949.33
Posts	$600.00
Subtotal	**$199,241.98**
Preliminaries (11%)	**$21,916.62**
Contingency	**$0.00**
Margin	**$0.00**
Total ex tax	**$221,158.59**

Table 2 – Proposed Design High Level Opinion of Cost Estimate

Building Element	Cost
Cross Laminated Timber	$51,129
Hardwood Timber Deck	$2,850
Glulam Beams	$23,800
Metal Cladding	$5,450
Internal Stud Walls	$21,750
External Stud Walls	$34,880
Timber Columns	$2,800
Internal Doors	$5,400
External Timber Swing Doors	$3,000
Louvres & Fixed Windows & Sliding Doors	$20,400
Roof	$52,500
Awnings	$2,000
Soffits	$3,600
Ceilings	$3,735
Balustrades	$2,500
Timber Screening	$3,600
Subtotal	**$239,394.00**
Preliminaries (11%)	**$26,333.34**
Contingency	**$0.00**
Margin	**$0.00**
Total ex tax	**$265,727.34**
Difference from Benchmark project	**+16.77%**

Cost Premiums and Value Offsets:

Based on the cost comparison, the approximate cost premium of the Proposed Project is 16.77%. This estimate excludes portions of the building project which, when factored in, could reduce the difference between the two schemes.

My opinion of cost suggests the overall house price could be in order of $650,000 to $840,000 (exc GST) based off a square metre rate of $3000m^2 to $4000 m^2 (more likely for a regional, innovative and resilient home), an approximate cost rate for residential construction. A Quantity Surveyor would be required to validate these figures.

The following points identifies cost premiums and value offsets associated with the proposed scheme:

- Masterplanning:
    - Firstly, masterplanning is a key stage in the formulation of the economics of the housing model. The design could be influenced at the masterplanning phase of a project to better understand key ingredients such as lot size, development density, landscaping strategy and community amenity. This could impact the metrics and allocation of costs in a development to achieve a high quality, desirable development typology.
- General Building Summary:
    - The overall GFA of the Proposed Scheme is 210m^2, the same as the Benchmark Project, however, the internal area of the proposed scheme is approximately 27m^2 smaller to offset the cost premium of the additional constraints resilient design includes.
    - A significant part of the proposal was to 'strip back' the house design to essential spaces required for the owner to comfortably live in initially. For example, the carport was not enclosed and there is no rear verandah. The house has been designed to allow the occupant to retrofit additional components over time, in turn adding value and potential for the house to appreciate significantly over the ownership of the house.
    - Due to the site location in Hervey Bay, there could be an additional premium for reinforcement of structure and building envelope for the wind region and cyclonic conditions. Being located near the coastline will also require a level of corrosion resistance in products specified. The use of timber structure is a suitable material to provide resistance against salt air and could have longer service life than comparable steel structure. Durable, low maintenance cladding and window systems will be proposed that can achieve lengthy warrantees and long-term maintenance costs (such as painting every 10 years). The long term savings possible with these systems will accumulate over time.
- Flood and Cyclone Resilience:
    - The house level was raised to 1.2m to be above the 1m riverine flood level and to keep engineered timber to be above inundation for any length of time. This required elevating the floor structure at a small cost premium. Other associated costs with this design move include stairs to elevated spaces. A freeboard datumn of flood resilient wall and floor construction is proposed to allow for tolerance with climate change over time. The cost benefit of these features would be obvious during flooding events by reducing damage and loss to the property.
    - It is unlikely that insurance would cover the house in event of flood however it is recommended the client discusses the project and strategies with a prospective Insurer.
- Low Carbon, Life Cycle Assessment and Prefabricated Systems:
    - Prefabricated technologies, such as CLT or GLT, often have an upfront capital premium for fabrication. There may be opportunities to work with suppliers during the design phase can look to value manage the design to create a more cost effective building. Successful prefabricated construction can reduce material waste, site labour and construction programs which could offset cost.
    - Consideration of connections and timber treatments to enable re-use at the end of life may incur an additional premium. However, this offset by identifying the house as an accumulation of resources that can be sold or reused at the end of life, a radical circular economic principle in the current market, however, potentially a mainstream concept in the not-too-distant future.

- Social and Environmental:
    - The introduction of a courtyard has passive design benefits while forming the heart of the home. This courtyard introduces more surface area compared to the Benchmark Project. However, successful passive design would reduce operational energy costs for mechanical ventilation and lighting, and give the house resilience when without power. The social benefit of natural ventilation and daylight cannot be understated as important for keeping occupants satisfied with their property. longevity of occupation. surface area offset by delight of living in house is offset by reduced reliance on mechanical ventilation systems and artificial lighting.
    - The aesthetic appearance and social engagement of a house with the street is important for a successful building and local community. The allowance for a generous green space on site was also thought to foster this. The cost premium of the front timber screening and verandah, transparent polycarbonate sheeting to the carport and landscaping would be offset by owners being willing to pay more for a desirable residential development.