Report for Ballina Shire Council

Housing Resilience Investigation And Options Report

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Important Note:

The Housing Resilience Investigations and Options Analysis Report has been commissioned to provide ideas and information to Council for further consideration. The content of the investigations reporting do not represent Council policy or preference at this time. The material has been prepared to feed into the broader consideration of the future of Ballina through the Ballina Major Regional Centre Strategy Project.

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1. INTRODUCTION

1.1.1 Context

Ballina Shire (BS) is located in the far north of New South Wales and covers an area of 485km^2. BS has a population of approximately 40,000, which is expected to increase to 50,000 by 2025. There are approximately 18,000 private dwellings, 71% of which are separate detached houses (Australian Bureau of Statistics, 2011). Ballina is a growing community and requires more homes for the growing population.

Ballina Shire Council (BSC) is currently preparing the Ballina Major Regional Centre Strategy (BMRCS) and this report is intended to contribute to informing this broader strategy. The BMRCS is seeking to building on the identification of Ballina as a developing major regional centre under the State Government's Far North Coast Regional Strategy. The BMRCS broadly considers existing characteristics, trends and expected outcomes, a vision or preferred future for Ballina and options to achieve the preferred outcomes over the life of the strategy.

Improving community resilience through adaptive measures will support the Ballina community to continue leading a safe and prosperous lifestyle in an environment that is subject to more extreme weather related events. As an emerging regional centre, it is important that Ballina grows into a resilient and secure place for the growing population.

Previous and existing planning and development controls have responded to the flood risk associated with the Ballina residential built environment. Despite this Ballina is still vulnerable to increasingly frequent flood events. It is also becoming disjointed in its style and character; privacy concerns are being raised by neighbours due to overlooking as a result of higher ground floors. Concerns are also being raised that new residential development is becoming cost prohibitive. There is a growing need to address these issues to set development on a pathway for Ballina to achieve the shape, style, amenity and resilience that it requires to be the heart of a prosperous and growing region.

This report focuses on identifying options for construction types that will provide the community and development industry with options in the planning framework to contribute to growing Ballina and creating a "Ballina Style" that is appropriate for Ballina's current and future needs.

This report acknowledges that there are a number of connected Council initiatives or plans that relate to resilience. These include:

- Ballina Floodplain Risk Management Plan (2015) – which states 'The imposition of development controls can be an effective means of managing flood risks associated with future development (including redevelopment)'.
- Ballina Shire Combined DCP 2006, Policy Statement No. 11 - Flood Levels was adopted by Council on 26 August 2010. 'While these controls will manage future flood risk, a more flexible approach to managing future flood risk could be considered' (BMT WBM, 2013).
- Community Strategic Plan 2013-2023 'Our Community, Our Future' – which identified managing the impacts of flooding and climate change as a key challenge faced by the community (Ballina Shire Council, no date).
- Ballina Shire Council Climate Action Strategy 2012-2020 – which identifies 'building design guidelines and development design and construction manual' as part of the action strategy for infrastructure and assets (Ballina Shire Council, 2011).

- The exhibited Draft Ballina Development Control Plan Chapter 2b – Floodplain Management (November 2014) – is based on the premise that building adaption, rather than incremental filling, will be the next adaptive response considering sea level rise and allows for the consideration of performance measures should prescribed and preferred protection measures (fill measures) be unable to be achieved.

- People, Place, Prosperity: A framework for a more sustainable Ballina Shire 2025 (2006) – which includes eight strategies, one of which is to develop 'resilient and adaptable communities'.

BSC has a long history of addressing floodplain risk and this report is part of BSC's ongoing dynamic response; the report aims to build upon and contribute to the ongoing body of work.

Ultimately buildings that are resilient to increased flood events and rising sea levels support local government entities in showing they have acted within their duty of care and limit future legal liability, support maintenance of the amenity of suburbs, provide opportunities for adaptation and retention of housing stock over the longer term and may contribute to insurance affordability.

1.1.2 Report Structure

This project has been conducted in such a way that the project team have been able to learn and understand Ballina as a unique town with a unique set of stakeholders that requires a tailored response to achieve the vision articulated in the BMRCS. The report builds a picture of the current situation and is intended to flow as a narrative towards a set of recommendations, which include specific construction/design options that are appropriate for the growth, and prosperity of Ballina.

We begin by clearly stating the objective and scope of the project; then reiterate the demographics, housing characteristics, flooding and climate related risks, and current controls in the study areas in order to enable an appreciation of the uniqueness of the Ballina situation.

Drawing on research, previous knowledge and experience and engagement with BSC and the local development industry, a set of recommendations have been synthesised and specific construction types are proposed.

Edge Environment understands that this report will be read by councillors as part of a pack of information to inform decisions about Ballina's future planning and development controls, and that it may also be publicly displayed.

2. OBJECTIVE AND SCOPE

BSC have been specific with the objective and scope of this report as follows:

2.1.1 Objective

The objective of this report is to identify options for housing resilience applicable to the circumstances associated with flooding and sea level rise in Ballina, including specific consideration of building design, servicing elements and costs.

2.1.2 Scope

This report provides an investigation of, and recommendations for, the resilience of housing to flooding and sea level rise impacts in four study areas within the Ballina Shire LGA; East Ballina, West Ballina, Ballina Island and North Ballina.

The focus of this report is on practical resilience suggestions that:

- Reflect and align with BSC's overarching vision for Ballina Shire communities.
- Are consistent with a "Ballina Style" cognisant of the areas character.
- Have regard for sustainability including energy efficiency in terms of design and material selection.
- Address service requirements of properties.
- Incorporate houses, dual occupancies and multi dwelling housing.
- Provide background and context.
- Are based on scientific rigour and resilience best practice (leveraging specific case studies and international examples).

The report contains resilience recommendations that take in to account:

- Key planning issues
- Key policy and practice in other jurisdictions
- Housing design solutions will take in to account:
- Cost
- Connection to building services and infrastructure
- Sustainability (energy efficiency)
- Compliance to regulatory standards (i.e. BCA)
- Building aesthetics and neighbourhood amenity
- The potential for protection works
- Foundation stability
- Constraints and barriers to implementation
- Access issues

The project will not include consideration of:

- Impacts of moving water
- Coastal erosion
- Broad Community or stakeholder engagement. Targeted development industry engagement has been conducted to refine assumptions and estimates for the development of case studies)
- Council owned infrastructure (i.e. only looking at dwelling level solutions)
- Emergency response and evacuation capability

2.1.3 Definitions of Key Terms

Resilience is a key term used throughout the report and is a term that is becoming increasingly used for many situations and contexts. It is important that we clearly define what resilience means in the context of this report and in the context of Ballina.

Resilience is gaining interest internationally across many different sectors. In particular it has growing interest when considering the ability of cities and urban areas to respond to climate change and extreme weather. International programs focused on resilience include the United Nations City Resilience Profiling Programme and the Asian Cities Climate Change Resilience Network (ACCCRN).

Resilience refocuses attention from risk reduction to the capacity to respond and recover from hazards. Various definitions of resilience have been developed including:

- *The capacity of individuals, communities, institutions, businesses and systems within a city to survive, adapt, and grow no matter what kinds of chronic stresses and acute shocks they experience (Rockefeller Foundation).*

- *The ability of an urban system to withstand and recover quickly from catastrophic events (United Nations Disaster Risk Reduction Programme).*

- *The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self- organization, and the capacity to adapt to stress and change (*ICLEI*).*

- *Climate change resilience is the capacity of an individual, community, or institution to dynamically and effectively respond to shifting climate impact circumstances while continuing to function and prosper. Simply, it is the ability to survive, recover from, and even thrive in changing climatic conditions (*ACCCRN*).*

The 100 Resilience Cities (funded through the Rockefeller Foundation) is another prominent example of an initiative focused on resilience. The initiative has produced a City Resilience Framework (2014) that has identified seven characteristics of resilient systems. These are:

- Reflective – able to learn
- Resourceful – can easily repurpose resources
- Robust – limits spread of failure
- Flexible – has alternative strategies
- Redundant – has backup capacity
- Inclusive – broad consultation and communication
- Integrated – systems work together

Drawing on the definitions and characteristics above, for the purposes of this report a resilient house is defined as:

> *A residential building and its component parts that can absorb, accommodate and recover from the effects of a given event (in this case flooding and tidal inundation) and has the ability to respond and adapt through re-configuration and flexibility to changes in hazard levels, if and when required.*

Resilient housing allows the house to:

> *"function safely over a range of scenarios, and the investment in additional risk mitigation can be timed to coincide with the increase in hazard, which may occur faster or slower than predicted. It may also allow construction in areas of high risk, where other buildings would fail or become dysfunctional"* (Giles, 2012).

3. BALLINA SHIRE: STUDY AREAS

3.1 Demographics

There are four study areas included in the BMRCS; West Ballina, East Ballina, North Ballina and Ballina Island. As per Table 1 Ballina Island has significantly higher density than the other four areas with North Ballina having the lowest density. Ballina Island has the earliest residences.

Study Area	Population	Land Area (ha)	Density (persons per hectare)
Ballina Island	6855	578	11.86
West Ballina	2901	1064	2.73
East Ballina	5365	778	6.89
North Ballina	1082	1571	0.69

Table 1. Population, land area and population density of the four study areas (Social Atlas (Australian Census)).

Ballina Shire has a median age of 45 years (Social Atlas, 2011) with a predicted 50% increase in the population aged over 65 by 2031 (Ballina Shire Council, no date). The oldest median age in the study areas is within Ballina Island at 52 years old (Social Atlas, 2011). Ballina Island also has the largest percentage of older lone person households at 23.1% households falling in to this category. The other three study areas had 21.3% (North Ballina), 16.1% (West Ballina) and 10.1% (East Ballina) of older lone person households.

There are an average of 2.35 people per dwelling across the Ballina Shire with lower household sizes in the four study areas compared with the Shire average (Census 2011). In the 2001 census the average number of people per household was 2.48, therefore indicating a downward trend. This downward trend is likely to continue as in 2011 the highest growth in age cohorts was in the over 85 year old category; this category are more likely to be living alone. Industry engagement supports this observation as developers respond to market dynamics driven by the baby boomer generation's needs and desires, developing housing solutions that are attractive to elderly clients. This situation is likely to be reinforced by Government policies to enable the elderly to "Age in Place".

Site access for elderly people is clearly an important issue that will be considered when recommending options.

3.2 Housing Characteristics and Trends

In order to make recommendations about alternative options for achieving resilient housing in Ballina, the existing characteristics, trends and expected/desired outcomes need to be understood.

The methodology for achieving this included a desktop survey, via Google Street View, a drive through of the study area during the site visit, ongoing engagement with council and supply of photos of particular relevance.

3.2.1 Increasing Density

Higher density living is a desired trend in the study areas. The desktop survey revealed that the study areas hold a mix of housing and construction types with some noticeable trends in style. The majority of dwellings are single detached dwellings and it was noted that Council is considering enabling subdivision, duplexes or dual occupancies in certain areas as a way to make renewal financially viable. The BMRCS will also identify and conduct economic feasibility studies for potential sites where higher density living could be located. Higher density, such as the multi-storey residential pictured in Figure 1, is mainly concentrated in the central business areas of Ballina Island.

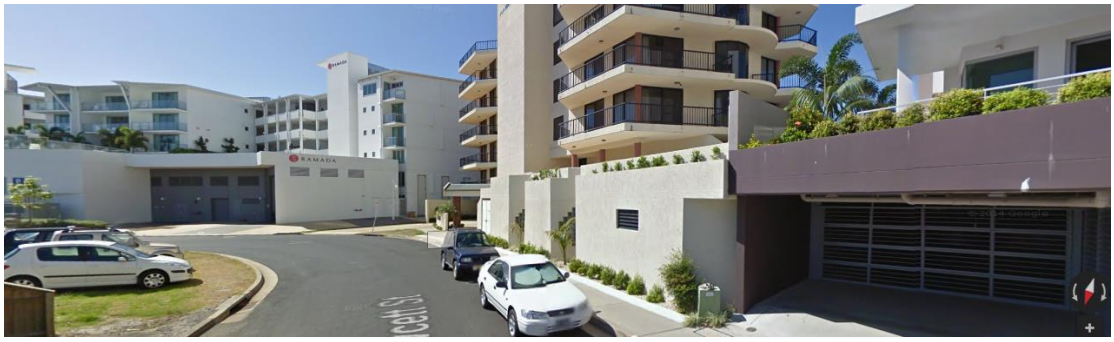

Figure 1. View along Fawcett St, Ballina Island

3.2.2 Disconnection from heritage style

The character of Ballina is changing quickly as new development occurs, and there is little connection between the new and the old; Ballina is becoming disconnected from its heritage style. Figure 2 shows an older house, with heritage value, built on piers with timber bearers and joists, with a lightweight timber construction, which is an example of a typical heritage dwelling.

Figure 2. An older house on Norton Street, Ballina Island (estimated year of build in 1902)

Older housing is more likely to be built from timber with raised floors (see Figure 2) while newer housing stock is almost exclusively slab on ground with brick veneer wall construction (see Figure 3).

Figure 3. Riverside Drive, West Ballina.

There is a risk and commensurate concern from BSC that as Ballina develops, the heritage and character of Ballina today will be lost to a new design vernacular that lacks Ballina character and does not articulate the heritage and history of the region (see Figure 4). With this risk there is an equal opportunity for BSC to balance the need for growth with the retention of heritage and even investment in “Ballina Style” to shape a contemporary and resilient Ballina.

The older housing stock in Ballina articulates a style that may provide a modern Ballina with design leads that can be carried into a set of development controls to guide and nurture a “Ballina Style”.

Figure 4. An illustration of the contrasting styles apparent in Ballina street scapes.

3.2.3 The consequences of “Fill Policy” on housing characteristics

As discussed in section 3.4 Current Controls, Ballina has traditionally mitigated flood risk for housing through fill (Busmanis, Bewsher, Caddis, Chin, & Sharpe, 2013, p. 13). Filling the site raises the ground level so housing developed on the site is raised above the risk of inundation. Fill heights have increased overtime as shown later in Figure 8, from a pre 1997 level of 1.6 metres AHD to a current day level of 2.1 metres AHD. This has resulted in a change from natural ground level as over time lots have been developed to different heights depending on the policy era in which they were developed. The result is streets where houses are built at different floor heights to their neighbours, resulting in issues such as:

- Privacy issues where neighbors overlook one another due to houses being developed in different fill requirement eras;
- A disconnected street where differing lot heights act to disrupt the flow of a typical streetscape.

Figures 5, 6 & 7 illustrate these issues with real examples.

Figure 5 New House built to fill requirement presents different height to neighbours

Figure 6 An example of fill policy contributing to a potential overlooking/privacy issue for neighbours

Figure 7 New "filled" lot interrupting natural levels of ground height

Flooding and sea level rise are hazards that have been forecast to increase, and the incremental change in fill requirements is a policy that is now creating more issues for the community and adversely affecting the character of Ballina residential communities. BSC's policy direction with respect to filling now acknowledges that as climate change and flooding responses information grows, building adaption is the next adaptive response, rather than continuation of incremental filling *(*Reports to the Council's Ordinary Meetings August 2012 and November 2014).

An exclusive fill policy is no longer viable to address the risks of flooding and sea level rise risks, and will not serve BSC well in achieving the desired outcomes for future development.

3.2.4 Desired outcomes creating a "Ballina Style"

BSC may wish to retain a connection to the heritage style of Ballina houses as new development progresses. As shown in Figure 2 the older housing stock in Ballina articulates a style that may provide a modern Ballina with one of the design leads that can be carried into a set of development controls to guide and nurture a "Ballina Style". "Ballina Style" is only one style and if BSC wish to pursue a common style theme, it needs to be well defined and understood by BSC, the community and the development industry so clear guidance can be produced (guidelines), This is an opportunity that BSC may wish to pursue.

We understand that Ballina style:

- Takes a design lead from older heritage houses (Figure 2).
- Ballina style houses are typically built on piers with timber bearer and joists and lightweight construction, eg, newly renovated old house shown in Figure 8.
- Connect to the heritage and history of the region through the use of local

materials and elevated floors.

Figure 8 Renovated house exemplifying Ballina style

Figure 9 A relocated house given a fill exemption due to elevated floor construction. Also illustrates Ballina style.

Figure 10 A renovated house that has elements of Ballina style - elevated floor, long eaves. Although predominantly built out of masonry and heavyweight construction it connects to Ballina style with some design features.

In this section we have only defined the concept of Ballina Style, and there is an opportunity for BSC to take a lead for the community and development industry to clearly define “Ballina Style” as part of shaping a contemporary and resilient Ballina.

A collection of design attributes and picture of houses that have design features that are of Ballina style is at Appendix E. It is recommended that BSC use this Appendix to develop a specification document for Ballina Style with engagement from the Ballina development industry and community. This could then be used as a document to guide and nurture a Ballina Style.

3.3 Flooding and Sea Level Rise Risk

Flooding and sea level rise risk have contributed to the shape and characteristics of Ballina housing as residents and settlers in Ballina have responded to the regional and site specific environment and climate. Elevated timber floors built above the flood line were the traditional design solution to avoid the risk of flooding, which lent itself to light weight construction. Over time fill became the predominant solution to mitigating the risk and has been written into policy in contemporary times. The flood risk is an ongoing fact of life for Ballina communities. Policy responses to mitigate the risk and manage the impacts of flooding will continue to shape the built environment as the likelihood and extremity of flooding increases into the future.

3.3.1 Existing Flooding Risk

Much of Ballina Local Government Area is affected by flood due to its proximity to various rivers and creeks, which include the Richmond River, North Creek, Emigrant Creek and Maguires Creek.

The 2015 Ballina Floodplain Risk Management Plan (BFRMP) identified that there are **three main sources of flooding** in the study area:

- **Richmond River flooding** caused by a widespread storm system (with precipitation typically occurring over multiple days) over the broader Richmond River catchment. These floods rise and fall relatively slowly at Ballina, with flood conditions lasting multiple days.
- **Local catchment flooding** caused by smaller storm systems in the local creek catchments with intense rainfall bursts typically lasting less than 12 hours. Floodwaters rise and fall quickly. This form of flooding presents a high hazard due to short warning times and fast flowing water.
- **Ocean storm surge flooding** caused by low-pressure systems, strong onshore winds and storm wave conditions, which lead to higher than usual ocean levels. This form of flooding is influenced by tides, and will typically occur in combination with one or two high tides.

Localised overland flooding as well as drainage backflow are issues, particularly on Ballina Island (Busmanis, Bewsher, Caddis, Chin, & Sharpe, 2013). According to the BRFMP the majority of inundated dwellings during small floods are located in West Ballina and the majority of inundated dwellings during extreme flooding are located on Ballina Island. There is a large increase (385% to a total of 6419 dwellings) in inundated dwellings between a large and extreme flood.

In order to gauge the significance of the issue and what level of response is required we need to gain an insight into future flood risk. For example if future flood risk is likely to increase, then we can see that the total number of dwellings vulnerable will increase dramatically, and so the magnitude of the problem is greater and requires a more significant response.

3.3.2 Future Flood Risk - Climate Change

The BSC Climate Action Strategy identifies a number of climate change impacts relevant for the North Coast region. In particular sea levels are predicted to rise 0.4m by 2050 and 0.9m by 2100 (based on 1990 levels), rainfall is expected to increase in summer and autumn and decrease in winter and rising sea levels combined with catchment-driven flooding are likely to increase flood frequency. The Strategy also notes an increase in size and depth of run off is likely in summer.

Since publication of this Strategy the NSW Government has completed the NSW/ACT Regional Climate Modelling project (NARCliM) that provides downscaled climate projections for NSW at 10km^2 resolution. These models provide the following details for the North Cost Region in the time range 2060-2079 (NARCLiM, 2014):

- Mean **temperatures** are projected to rise by 2.0 ºC by 2070. There are slightly greater increases in summer, autumn and spring. All models show there are no declines in mean temperatures across the North Coast. Hot days are expected to increase and cold nights are expected to decrease across the

region however there is little change for the coastal region.

- By 2070 **annual rainfall** will increase across the region. Increases are projected across the region during summer, autumn and spring. Winter rains are projected to decrease across the region.

Rainfall intensity will be more important for flooding considerations than average rainfall. On this the BFRMP states that based on the NSW Department of Environment, Climate Change and Water (DECCW) Practical Consideration of Climate Change Guidelines and conversations with the Office of Environment and Heritage, a 10% increase in rainfall intensity has been incorporated in the flood management plan for both 2050 and 2100 climate change horizons.

NARCLiM did not update sea level rise projections. The CSIRO State of the Climate report (2014) confirms that '*sea-level rise around the Australian coastline by 2100 is likely to be similar to the projected global rise of 0.28 to 0.61 metres for low emissions and 0.52 to 0.98 metres for high emissions, relative to 1986–2005*.' This is broadly consistent with previous government advice.

The BFRMP notes that climate change may greatly increase flood risk so that a small flood has the same impact in 2100 as a large flood in the current year. Residential property damage makes up the vast majority of flood damage costs.

We can draw the conclusion that flooding in the study area is likely to increase in frequency and intensity and therefore more properties will be exposed and damaged leading to a greater cost, unless appropriate policy responses are implemented.

3.4 Current Controls

BSC has been dynamic in its response to the flood risk and ongoing development needs as the community has evolved. This section outlines how BSC's policies have adapted appropriately over the years and demonstrates how BSC have come to consider alternative adaptive responses to manage the continuing healthy growth of Ballina communities.

3.4.1 Responsible entities

Local Councils have the primary responsibility for the management of floodplain risks. The NSW government provides technical, financial and policy assistance to councils including through the *Floodplain Development Manual* (2005) that incorporates the NSW Flood Prone Land Policy.

3.4.2 Chronology of BSC Controls

Ballina has traditionally mitigated flood risk for housing through fill (Busmanis, Bewsher, Caddis, Chin, & Sharpe, 2013, p. 13). Minimum fill heights have increased overtime as shown in Figure 11.

Year	Ballina Island (AHD)	Based on
Pre 1997	1.64	Historical flood levels
1997	1.8	1D flood model

2008	2.0-2.2	2D flood model
2010	2.0-2.2 and 2.5-2.7 (2100)	2D and SLR
2012	2.1-2.4 (2050) and 2.5-2.7 (2100)	SLR

Figure 11. Flood control height requirement changes from pre-1997 to 2012 (Busmanis, Bewsher, Caddis, Chin, & Sharpe, 2013).

BSC has invested significant resources over the previous decade developing flood information:

- 2004: Award of project for completion of dimensional (2D) flood model for the lower Richmond River at Ballina including aerial photography and river bathymetry.
- 2008: Completion of Ballina Flood Study Update (BFSU, 2008) and subsequent amendment to Combined DCP, Policy Statement No. 11 - Flood Levels.
- 2009: Award of project for preparation of the Floodplain Risk Management Study and Plan. This also comprised the additional data collection of property floor level surveys which was undertaken in late 2009.
- 2010: DCP amendment made to incorporate NSW State Government's 2009 sea level rise (SLR) projects in to Policy Statement No.11-Flood Levels. The ongoing Floodplain Risk Management Study and Plan process was recommended to further assess Council's DCP with respect to infill development.
- 2012: Council confirms, that until local SLR benchmarks are determined, Council will continue to apply the benchmarks established by the former NSW Government 2009 SLR Policy in its plans and strategies.
- 2012: Public exhibition of the draft Floodplain Risk Management Study and draft Flood Risk Management Development Control Plan. Adoption of the Floodplain Risk Management Study.
- 2012-2014: Preparation of further flood mapping and modeling, finalised preparation of the Draft Ballina Floodplain Risk Management Plan (BFRMP) and update to the draft Flood Risk Management Development Control Plan (DCP)

As of March 2015 the BFRMP and the draft DCP have been exhibited but have not yet been adopted by Council. However, according to the Ordinary Meeting of BSC dated 27th November 2014 the policy direction as it applies to infill development is in summary:

- *"Proposes to continue to fill, adopting 2050 year 1:100 year ARI. This accommodates SLR of 0.4m by the year 2050, which exceeds 1:100 year ARI protection up to 2050, and allows for further climate change assessment into the future.*
- *The adoption of the 2050 year 1:100 year ARI for minimum fill levels across Ballina island also provides property protection for SLR without flooding, and allows for positive drainage. The minimum fill heights across Ballina island for the draft DCP range from 2.1m AHD to 2.4m AHD and predictions for king tides at 2100 are 1.8m AHD (ie without flooding).*
- *Provides for reduced freeboard for commercial and industrial premises, rather then blanket 0.5m freeboard for all floor heights. This is relevant, in particular for the CBD and retail areas.*
- *Allow for consideration "performance measures" which may be considered if*

the prescribed and preferred protection measures are unable to be achieved.

Overall the outcomes of the draft DCP respond to the immediate requirements to consider Sea Level Rise and flooding for infill development with current climate change knowledge. As further information or knowledge grows with respect to climate change and flooding it is considered that responses through building adaption would be the next adaptive response, rather than continuation of incremental filling."

The above sets the direction for consideration of resilient housing options in Ballina, and recognizes that there is a need to explore alternatives to the fill policy as the policy may have reached its threshold due to a combination of issues. The current controls and flood maps which illustrate the extent of the 100 year ARI flood levels are appended in Appendix C.

3.4.3 Fill vs. Adaptive Building Responses

As the dominant policy of managing flood risk has been through the use of fill it is worthwhile noting the relative advantages and challenges with this strategy as recognised in the literature and policy documentation.

- From a paper submitted to the Floodplain Management Conference in 2013 and authored by BSC, Bewsher Consulting, BMT WBM and NSW Office of Environment and Heritage: '*There are practical issues associated with small blocks and high fill and vehicle and person access, notwithstanding the use of fill resource. The current fill height appears to be reaching practical limits in tight situations'* (Busmanis, Bewsher, Caddis, Chin, & Sharpe, 2013).
- The Australian Building Codes Board notes in C2.5.5 Use of Fill: 'Whether the use of fill is permitted in flood hazard areas needs to be checked with the authority having jurisdiction. Fill can reduce the capacity of the floodplain, exacerbate the flood risk or cause a nuisance for neighbouring property. Where the use of fill is permitted to elevate the house above the DFL or reduce potential inundation, care needs to taken to ensure the fill remains stable and is not adversely affected by erosion and scour' (Australian Building Codes Board, 2012).
- The State Government Land Use Guidelines notes that filling of flood prone land need to consider the degree to which it 'impacts on flood behaviour, the environment, biodiversity and the ability of the proposed development itself to manage that flooding' (Hawkesbury-Nepean Floodplain Management Steering Committee., 2006).

The residential lots in the study area average round 600m^2 and the fill option to deal with the flood risk has likely reached a threshold level that is no longer practicable.

The BFRMP and Draft Ballina Flood Risk Management Development Control Plan have recently been exhibited and recognise that it is not practicable to fill to 1/100 ARI Flood levels plus SLR forecast for 2100.

In addition, there are growing reports from the Ballina community of experiences and situations as described in the points above. Some of these issues are described and evidenced in the next section by engagement with the development industry.

The typical life of a house in Australia has been estimated to be between 50 and 75 years based on various estimation methods. The Green Building Council uses a

typical average life of 60 years in its Green Star suite of Rating Tools. Therefore houses built now need to be able to be resilient to conditions up to 2075. This report recognises that the current fill policy has reached a threshold limit that can no longer meet the needs of a growing Ballina and an alternative adaptive response is required.

4. BALLINA DEVELOPMENT INDUSTRY CONSIDERATIONS

We are now aware of the characteristics of the current housing stock, the demographics, the changing risk profile, the aspirations for the future and that the current development policy can not meet the needs for the desired future. There is a case building through this study that an alternative adaptive response is required; Ballina development industry are a key stakeholder in enabling the change required and as such were engaged early in the project to make a contribution.

4.1 Introduction

The professionals in the development industry, including the architects, engineers, builders, real estate agents and owner builders have established a body of knowledge and experience from working with and responding to BSC's development control plans. This knowledge and capacity is critical in considering alternative options for resilient housing in Ballina.

The local professionals were engaged through a series of structured telephone interviews to could contribute ideas and professional advice on ways dwellings could be constructed to manage or respond to predicted climate change impacts including higher rainfall intensity, more frequent flooding and SLR. The responses also describe experiences and situations that corroborate the need to explore alternatives to the fill policy.

4.2 Methodology

It has been established that a likely alternative to fill as an option to mitigate flood risk would be elevated floor construction in the flood prone areas. In this way a structured interview was designed to provide questions and topics to guide the discussion with individual professionals towards how the development industry would respond to an elevated floor policy in flood affected areas and test elevated floors as alternative solution to fill policy.

The following themes were chosen to guide the discussions:

- **Cost** of elevated floor construction type relative to fill option
- Types of **construction materials** that local development community would likely select and their availability locally
- **Energy Efficiency** – Would it be an issue achieving compliance?
- **Services and Liveability** – What would be the advantages/disadvantages relating to an elevated floor policy?
- **General** – Comments and ideas to contribute to the development of an alternative to fill.

The intent of the structured interview was to enable a framework for consideration of each theme, and be investigative in discussion. The interview was not leading, rather exploratory and aimed to encourage and provoke creative thoughts, responses and advice.

A list of local professionals was made in consultation with BSC, and 20 – 60 minute telephone interviews were conducted. In total 12 professionals were contacted between December 2014 and end January 2015. The details of each are provided in Appendix A with their full interview responses.

Once all the responses had been collected the responses were synthesised into a "consensus summary". In general the 12 professionals interviewed shared the same perspectives and there was good alignment of ideas and advice as to how an elevated floor DCP would be received and responded to.

4.3 Interview responses

The following tables describe the themes, indicative questions and summary responses. Individual's responses can be seen in Appendix B.

4.3.1 Cost

What is the relative cost (per m^2 /or % uplift) for construction of this type (elevated floors)? (Ideally a figure or a range). What is the biggest contributor to the cost?
• The cheapest form of construction is slab on ground. Fill and retaining walls are expensive. If the fill requirement was removed, timber bearer and joist construction is perceived as the cheapest construction method.

4.3.2 Construction Materials

What type of elevated floor construction would you choose? What are the key construction materials required for this building type?
• The most discussed options for achieving elevated floors were: 1. Hardwood Timber Bearer and Joist 2. Engineered Wood Product Bearer and Joist 3. Strip Footings with Infill 4. Steel Bearers and joists 5. Concrete elevated floors • There is certainly a preference for hardwood bearers and joists over engineered timber products; the reason is that hardwood is available in the area, this is what the trades are used to, and there is the perception that hardwood fairs better than engineered timber in wet conditions.
Are they easy to access in the Ballina area and what, if any, particular constructions skills or trades are required for this building type?
• All materials and all trades are readily available to achieve any type of construction.

4.3.3 Energy Efficiency

Do you see any advantages or challenges for this type of construction compared with other options for energy efficiency in the Ballina climate?
• The industry will always find a way to achieve energy efficiency compliance. • Concrete slab on ground is the preferred solution for thermal comfort as thermal coupling is the best passive method for regulating temperature in homes. This can't be achieved with an elevated slab – but may be achieved with Brick infill.

4.3.4 Services and Liveability

Do you see any advantages or challenges for this type of construction compared with other options for connection to services and livability in the Ballina area?
• Flat sites for the ageing population is a key issue in terms of livability; fill does achieve this. Bearer and joist construction results in steps that are unfavorable for elderly. • With an elevated floor there is still the issue of the garage being down at flood level; this would have to be addressed too, maybe with a requirement to achieve a minimum floor height for the garage. • The roads in the area create a matrix of barriers for floodwaters stopping overland flow. The drainage needs addressing and will remain a problem even with elevated floors – pooling on sites. • There needs to be careful consideration of the piers and piling for sites in flood affected areas – the engineering detail should be clearly understood.

4.3.5 General

Are there any other barriers or enablers for this construction type in the Ballina area?
• Typically it comes down to personal preference and cost. Usually cost is the main driver, • Real Estate Agents are also key stakeholders that should be engaged as well as the local Chamber of Commerce. • Raising the site is making the viability of development too high.
• Would go timber before steel due to corrosion issues by coast.
• Good idea to start thinking about how to address this issue now.
• It is excellent that council is finally considering this issue; I am available to support further and would like to see a copy of the report when

complete. Will there be a public hearing?
• May be an issue that you may have a wet block all the time if the sea level rises, although I am skeptical.
• The physical and scouring of floodwaters – Concrete provides that excellent robustness.
• The policy and the open space requirements for more than 80m square • Ballina is a very tough development proposition – got to deal with the floor height fill requirement. • Developed 60 units on the Ballina island based on what is required. Retail price at Lennox is much higher. • Ballina style. • Anything that can be done to get a product to market at a reasonable price is going to help the market.
• There needs to be an overland flow path created to drain off the grid pattern – don't realise it until the flooding occurs – creates a water trap – pipework needs renewing. Whatever need to address the overland flow issue. • Good that someone is making enquiries • Process must be further amplified in West Ballina.
• It is all lot specific – difficult to find a policy that will fit for all.
• It would be really nice if we could elevate everything; obviously can't afford to; maybe sort out drainage though. • Either accept the status quo or raise the land area and hope that in the future that's enough. • I think raising the land is a good long term solution. • Already have roads that are underwater at high tide, saving money for developers may be a short-term fix, but we need to consider the long term sustainability of the community. • The solution we come up with has to address all the issues that will come up over the 50 years.
• Drainage is a problem; its good Its about time council considered alternatives

4.4 Conclusions from the development industry

Based on the interviews conducted the Ballina development industry appears to be supportive of change to the fill requirement. The consensus is that current requirements are stifling development and that they are creating problems that are exacerbating flooding issues and creating new issues for housing in the community; something has to change so that industry can deliver a product to meet the needs of

a future Ballina. There is a general consensus that elevated timber floors would be a good alternative solution to mitigating flood risk, and other options were also discussed. An inherent drainage issue was recognised that will always need consideration so land can drain and recover quickly from flooding.

Garages and elderly access have been singled out as key issues that an alternative adaptive response would have to consider.

The development industry as a whole was very willing and cooperative during a holiday period, and the consultant team would like to thank them for their contribution.

These conclusions are carried forward into the recommendations for resilience responses.

Note* Following the initial consultation detailed above, an additional industry consultation was conducted to test and validate the assumptions made in the report. A discussion paper was prepared which included the assumptions and costing case studies detailed in section 7. See section 7.

5. BACKGROUND TO RESILIENCE OPTIONS

5.1 Introduction

This section reviews different categories of flood protection including: avoid, retreat, protect and accommodate. Important documents that inform the development of the resilience options are then presented including the Building Code of Australia voluntary Flood Standard and the Lake Macquarie City Council *Report on Development Guidelines for Resilient Housing for Lake Macquarie.*

The purpose of reviewing and understanding these documents is to identify attributes and components that may be useful to the Ballina situation. However, the Ballina situation is quite unique and there is no other policy that can be replicated, rather a tailored approach is required that can be informed by precedent and lessons learned in other jurisdictions.

5.2 Forms of Flood Protection

There are several approaches that councils can use to mitigate the risk of flooding and sea level rise. These approaches fall in to a number of categories:

- **Avoid**: using planning and zoning, particularly for green-field sites, that restrict development in hazardous areas.
- **Retreat**: when the level of risk or the costs of managing risk become prohibitive, abandoning hazardous areas. While this is a potentially contentious it can be effectively implemented through suitable trigger thresholds such as:
    - *Time limited development consent*: development consent can be granted for a limited time depending on the estimated time the asset will comply with risk thresholds

- *Biophysical thresholds*: this requires a change in the development when, for example, water levels reach a certain height
- *Critical decision points*: adaptive changes are made at the time a building is being re-developed, when changes are made on neighboring properties or when critical infrastructure is being upgraded or renewed.

- **Protect**: the implementation of measures that prevent floodwater from entering a site including barriers, protection works and use of fill.
- **Accommodate**: the design or modification of landscapes, buildings or infrastructure to accommodate the flow of water.

Resilient residential dwellings fall in to the final category: accommodate. Resilient housing that is based on adaptability and flexibility allows for buildings to respond to changing uses and hazards over time. The concepts of flexibility and responsiveness are well ingrained internationally with research projects focusing on new ways to live with water and cost-effective ways to build with the end in mind – whether that is deconstruction, disassembly or relocation. Key features of resilient housing that are recurring in international literature include:

- Appropriate site design and landscaping.
- The ability to adapt the building over time including raising floor heights and designing for relocation (including modularity).
- The ability to minimise damage through inbuilt redundancy (such as resilient ground level construction in two storey homes).

While this report is focused on options that fit in to the category of accommodating flood water it is acknowledged that a complete approach to managing flood risk should incorporate measures across the other categories.

5.3 Building Code of Australia and the Flood Standard

The BCA is a national document providing the technical building requirements produced by the Australian Building Codes Board. It must be complied with under the NSW Environmental Planning and Assessment Act (1979). The BCA does not currently include any durability or resilience requirements, but a Flood Standard provides "*additional requirements in flood hazard areas consistent with the objectives of the BCA which primarily aim to protect the lives of occupants in buildings in events up to and including the defined flood event*" (Australian Building Code Board, 2012).

Section 2 of the Flood Standard contains basic design requirements, including a fundamental Performance Requirement that describes the level of performance required for the construction of buildings in flood hazard areas. The Flood Standard does not specify particular materials or a design solution but relies on professional judgement to develop designs intended to comply with the Performance Requirement (Australian Building Code Board, 2012).

The Flood Standard includes requirements to satisfy:

- Flood actions
- Elevation requirements
- Foundation requirements

- Requirements for enclosures below the defined flood level
- Structural connections
- Material requirements
- Flood-proofing
- Requirements for utilities
- Requirements for egress
- Impacts to other structures and properties.

Key requirements in the Flood Standard that will also apply to any building being developed under the Adaptable Building Guidelines (Australian Building Code Board, 2012) include:

- Foundation requirements: must provide the required support to prevent flotation, collapse or permanent movement resulting from flood actions (geotechnical considerations, depth, walls, piers, posts and piles, use of fill, use of slab-on-grade).
- Structure and connections: erosion control structures must not be connected to the foundation or superstructure of the building. Decks, patios, stairways, ramps and the like below the flood hazard level that are attached to the building must be structurally adequate and not reduce the structural capacity of the building during the defined flood event (DFE).
- Material requirements: materials used for structural purposes and located below the flood hazard level must be capable of resisting damage, deterioration, corrosion or decay due to direct and prolonged contact with floodwater. Materials used for structural purposes include load-bearing columns, bracing members, structural connections, fasteners, wall framing members and the like.
- Utilities: must not be below flood hazard level unless designed to cope with inundation, electrical meters and switches must be placed above FHL, backflow protection on drains and plumbing below flood hazard level.
- Egress: evacuation must be possible at Defined Flood Event (DFE) flood height

The NSW Department of Planning and Infrastructure suggests that the Flood Standard should be referred to and used as a minimum level of requirements for buildings designed to be adaptable to sea level rise and flooding (NSW DPI, pers. comm., 2013).

5.4 Lake Macquarie City Council (LMCC) Resilient Housing Guideline

LMCC area is a similar geography to Ballina and is at increasing risk from flood and tidal inundation. Development trends are also similar with density increasing, particularly around the lake. LMCC decided on a flexible approach to manage the tidal inundation and sea level rise risk using a variety of measures. One measure was to provide guidance to developers and homebuilders on how to deliver resilient homes in flood prone areas. Resilient housing that is based on adaptability and flexibility allows for buildings to respond to changing uses and hazards over time.

The concepts of flexibility and responsiveness are well ingrained internationally with research projects focusing on new ways to live with water and cost-effective ways to build with the end in mind – whether that be deconstruction or disassembly or relocation. Key features of resilient housing include:

- Appropriate site design and protection works.
- The ability to raise floor heights and floatable foundations.
- Inbuilt redundancy (such as two-storey homes).
- Modularity.
- The ability to deconstruct the building.

Based on stakeholder engagement and local and international literature review the following principles for Resilient Housing in Lake Macquarie were developed:

1. Site analysis and design
2. Relocation
3. Raising of floor height
4. Redundancy

These principles, along with a set of performance criteria and suggested acceptable solutions, are designed to guide the industry, homeowners and LMCC staff on how best to plan for the future and develop resilient housing.

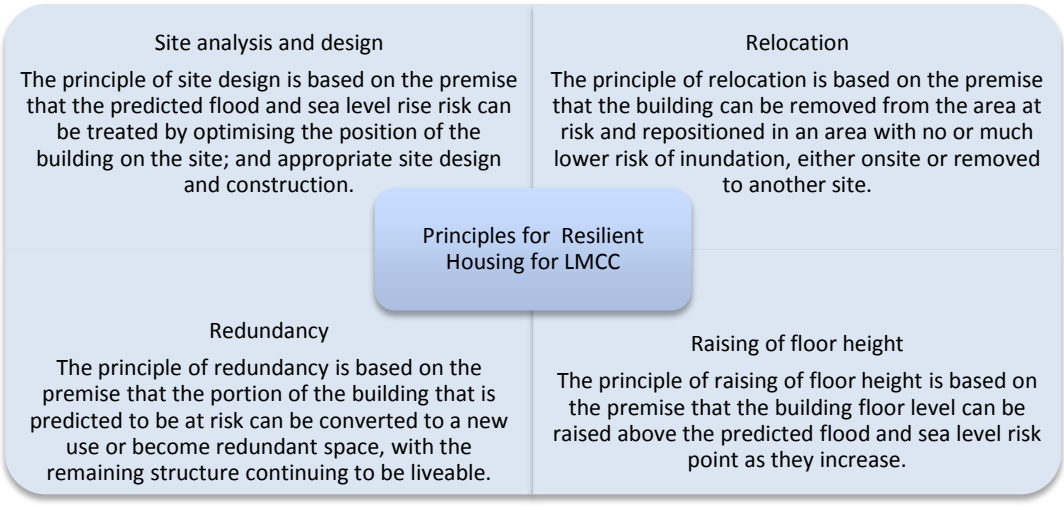

Figure 12 LMCC Principles for Flood Resilient Housing

5.5 Conclusions

Ballina Council has adopted an “accommodate” policy path by continually increasing fill requirement height to change the landscape over time. The accommodate category of policy and principle could be extended to the design of the buildings; other councils have successfully implemented this policy approach.

The Australian Building Code Board's Flood Standard does not specify particular materials or a design solution but relies on professional judgement to develop designs intended to comply with the Performance Requirement. This approach allows for innovation and development of alternative solutions.

Triggers and thresholds are a means of integrating the precautionary approach into policy development, and has allowed LMCC to accommodate development in potentially risky areas.

There are some principles such as, Site Analysis and Design that can be carried forward in Ballina policy.

6. SYNTHESIS OF CONSTRUCTION OPTIONS FOR RESILIENT HOUSING IN BALLINA

6.1 Introduction

Throughout this report a case is building for making a significant change to BSC development policy to allow for continued development and growth of resilient communities in the study areas, up to and beyond 2050 due to a series of factors including:

- the economics of development in the study areas being unfavorable;
- the implications of the fill policy creating a disconnected streetscape;
- local stormwater displacement issues onto remaining unfilled lots; and
  a recognition by BSC that there is a need to explore alternatives to the fill policy as the policy may have reached its threshold due to a combination of issues.

In this section we pull together the key issues that an alternative adaptive response for housing in Ballina must address, and then work towards recommendations for performance measures for resilient homes in Ballina.

Through review of BSC documents, consultations with council, a site visit, engagement with the Ballina development industry, and research and analysis of relevant policy during the course of the project, a set of key criteria for Ballina Resilient Buildings have been identified. It is recommended that future development control plans should be developed to consider and address these criteria.

At this stage, it is important to acknowledge this work has been led towards the consideration of single detached homes as the predominant type of housing in the study areas. Dual occupancy and multi-residential is included in the scope of the project, and many of the aspects covered can translate across to dual occupancy and multi-residential homes; however it is recommended that this report should narrow the scope to focus on the majority of the market today in order to take the first step towards an adaptive building policy. It is suggested that this will then build momentum. Attempting to consider multiple building types at this stage will become complex and may dissipate efforts to make an initial first step.

6.2 Criteria for Resilient Housing in Ballina

It is proposed that the criteria be split into "requisite" criteria and "desirable". The desirable criteria are inessential to achieving the aim.. This approach is

recommended as there are ten criteria that have been identified and it is suggested that no one solution could wholly address all.

6.2.1 Requisite criteria

There are three requisite criteria. They have been distinguished as "requisite" as they relate directly to the objective of the project:

"*to identify options for housing resilience applicable to the circumstances associated with flooding and sea level rise in Ballina, including specific consideration of building design, servicing elements and costs*."

To meet the objective, these requisite criteria must be met.

1. **Flood resilient**: A house that is resilient to flood. The definition agreed in the project is:

   > *"A residential building and its component parts that can absorb, accommodate and recover from the effects of a given event (in this case flooding and tidal inundation) and has the ability to respond and adapt through re-configuration and flexibility to changes in hazard levels, if and when required".*

2. **Future proofing and adaptability**: The ability to adapt to changing hazards over time. For flood and sea level rise hazards this can include the ability to raise the building or relocate it to a less hazardous area if required.
3. **Affordability/Costs**: For the purposes of the report a construction system is deemed to meet the affordability criteria if it can be constructed at less cost than the current typical building solution of Raft Concrete Slab on Ground with Fill. High costs have been reported to be stifling development in the study areas. In order to catalyse change and establish favourable market conditions any adaptive response should not add cost.

   Cost information has been taken from discussions with local builders and developers and a cost comparison has been done between the current Raft Concrete Slab on Ground with Fill and Elevated Timber Floor using Cordell Housing Cost Guide (2013) and Rawlinsons Construction Cost Guide 2015.

6.2.2 Desirable criteria

The following five criteria have been designated as desirable. This recognises that it would be very difficult to wholly address all issues in Ballina, but they all need considering and may be achieved to some degree with a thoughtful and considered adaptive policy response.

4. **Amenity for an ageing population**: An ageing population in the Ballina study areas has led to a reported increasing preference for blocks with level access. A design solution that accommodates ease of access for an ageing population would be optimal, particularly between the garage and the house.
5. **An elevated garage**: The current fill option enables a garage at increased height removed from flood hazard. Consideration of garage floor height needs to be included in a DCP that selects for elevated floors in order to resolve the issue of a low lying garage and subsequent damage to property and contamination of flood waters.
6. **Street Continuity maintained**: The continuity of the street refers to the connection of the design vernacular; the way the street character presents and connects as a group of houses. The current fill policy has been

disconnecting the street by selecting for varying levels as development occurs.

7. **Privacy/overlooking of neighbours**: Different floor heights has resulted in some properties being overlooked by neighbours and resulted in privacy of lower neighbours being compromised.
8. **No exacerbation of flood issues** (reduction in flood volume): Fill reduces the total flood volume and exacerbates the flood hazard for lower lying houses.

6.2.3 Compliance Criteria

The following two criteria are addressed in the Australian Building Code and NSW legislation, and are therefore statutory requirements. They have not been included in the matrix as it is mandatory that all options will meet the required standard.

9. **Energy Efficiency**: Each construction option can achieve the energy efficiency standards required by the Australian Building Code and NSW Building Sustainability Index (BASIX) legislation. After consultation with the development professionals the consensus was that as energy efficiency is a compliance standard it becomes neutralised as a consideration; all houses will be built to meet the standard.
10. **Floor height requirements** – The finished floor height must be 500mm above the 1:100 year ARI level

6.3 Construction Systems for Housing

There are many different ways to design and construct houses, and the housing industry is constantly evolving new methods of construction, materials, products and designs to respond to an ever-changing market. In this way the housing industry is dynamic, and has always responded to the challenge of delivering an optimal product within the regulatory and policy frameworks that it operates. The Building Code of Australia (BCA) provides the technical requirements to achieve healthy, safe, amenable and sustainable housing in Australia and also includes a Flood Standard providing "*additional requirements in flood hazard areas consistent with the objectives of the BCA which primarily aim to protect the lives of occupants in buildings in events up to and including the defined flood event*" (Australian Building Code Board, 2012).

In concert with the specific DCP's provided by BSC the industry delivers housing to the market. Given clear direction the house building industry will respond to achieve performance measures.

The combinations of materials used to build the main elements of our homes — roof, walls and floor — are referred to as construction systems. They are many and varied, and each has advantages and disadvantages depending on climate, distance from source of supply, budget, maintenance requirements and desired style or appearance (Your Home, Australian Government, 2013). There are two predominant types of construction systems in Australia:

1. **High mass systems** – typically require slab on ground construction and include the use of bricks and masonry for cladding. In terms of climate they are most appropriate where there is a high variation in temperature ranges. High mass systems are difficult to adapt as they are difficult to move due to their weight. The predominant option in Ballina is for high mass systems.

Raft concrete slabs are laid on compacted fill. In Figure 15 we consider and compare the following construction options:

- Raft concrete slab on ground (built on lots where ground height allows within limits of current floor height requirements);
- Raft concrete slab on ground with fill;
- Raft concrete slab on strip foundations with brick infill (Brick Infill);

against lightweight construction system alternatives.

2. **Lightweight construction systems** – Lightweight construction systems are typically built on piers with lightweight materials for bearers and joists (steel or timber sub floors). They require lightweight frames and cladding and are best suited to temperate and hot climates. Lightweight systems enable elevated floors. There are several ways to achieve elevated floors and platforms for building lightweight systems and in Figure 15 we consider the following construction options:
    a. Elevated Timber floors
        i. Hardwood timber bearers and joists
        ii. Engineered timber bearer and joists
    b. Elevated Concrete slabs
    c. Elevated Steel subfloors (with particle board flooring)

Figure 4 illustrates the two types of construction system side by side and the difference between the two.

6.4 Optimal Resilient Construction Systems for Ballina

To determine the optimal construction system for resilient building design for Ballina's future housing, the key development criteria were considered against the set of construction options. The criteria were plotted against the construction options in a matrix, Figure 9 below. The requisite criteria are in bold and the desirable are to the right in lighter shading.

Criteria / Construction Options	Flood Resilience (Current)	Future proof / adaptable	Affordability/Costs	Site access for elderly	Garage elevated	Street amenity maintained	No Impact Privacy of neighbours	No exacerbation of nearby drainage issues
Raft concrete slab on ground	Met	Not Met	Met	Met	Not Met	Met	Met	Met
Raft concrete slab on ground (with fill)	Met	Not Met	Not Met	Met	Met	Not Met	Not Met	Not Met
Elevated Timber Floor - Hardwood	Met	Met	Met	Not Met	Not Met	Met	Not Met	Met
Elevated Floor - Concrete	Met	Not Met	Not Met	Not Met	Not Met	Met	Not Met	Met
Elevated Floor - Brick Infill	Met	Not Met	Met	Not Met	Not Met	Met	Not Met	Met
Elevated Timber Floor - Engineered	Not Met	Met	Met	Not Met	Not Met	Met	Not Met	Met
Elevated Steel Subfloor	Not Met	Met	Met	Not Met	Not Met	Met	Not Met	Met

Figure 13 Decision making matrix for determining resilient housing options for Ballina

6.5 Considering each construction option

In this section we describe why each construction option has "Met" or "Not Met" each requisite criteria. Elevated Timber Floor – Hardwood is the only option that meets all three of the requisite criteria. For this option, the report will go on to discuss the desirable criteria performance and means of achieving these with a recommended design solution.

Criteria / Construction Options	Flood Resilience (Current)	Future proof / adaptable	Affordability	Site access for elderly	Garage elevated	Street amenity maintained	No Impact Privacy of neighbours	No exacerbation of nearby drainage issues

6.5.1 Performance of each construction option

Raft concrete slab on ground	Met	Not Met	Met	Met	Not Met	Met	Met	Met

Raft concrete slab on has been discounted as an option as it does not meet the criteria for being future proof/adaptable. A raft concrete slab is very difficult to adapt (raise) if flood levels increase and floor height requirements increase. Raft concrete slab is the cheapest and most efficient way to build homes, and is the preferred solution by the typical volume homebuilder. It has been discounted due to extreme difficulty of raising.

Raft concrete slab on ground (with fill)	Met	Not Met	Not Met	Met	Met	Not Met	Not Met	Not Met

Raft concrete slab on ground with fill is the current preferred option for new homes in Ballina. The report has demonstrated that it will not achieve the objective of delivering flood resilient homes beyond 2050. The “affordability” criteria is not due to the high cost of fill and feedback from the development industry. Raft concrete slab is discounted, but will be costed as the business as usual case and used as a comparison.

Elevated Timber Floor - Hardwood	Met	Met	Met	Not Met	Not Met	Met	Not Met	Met

Elevated timber floor – hardwood is the only option that meets all three. In this way it will be examined as a case study and options for meeting the desirable criteria will be examined.

Elevated Floor - Concrete	Met	Not Met	Not Met	Not Met	Not Met	Met	Not Met	Met

Elevated concrete floors will be difficult to raise in the future due to their high mass. However it may become economically viable into the future. They are also perceived to be expensive and do not meet the affordability criteria.

Elevated Floor - Brick Infill	Met	Not Met	Met	Not Met	Not Met	Met	Not Met	Met

Elevated Floor – Brick infill has been discounted as it is perceived as difficult to adapt if required in the future.

Elevated Timber Floor - Engineered	Not Met	Met	Met	Not Met	Not Met	Met	Not Met	Met

Engineered timber floors have been discounted due to the perception that engineered timbers are not resilient to wetting and will fail given continuous wetting and drying.

Elevated Floor - Steel	Not Met	Met	Met	Not Met	Not Met	Met	Not Met	Met

Elevated steel floors have been discounted due to the coastal environment in Ballina and the perception that steel will corrode.

6.6 Conclusions

Elevated Timber Floor Hardwood is the only option that meets all three of the requisite criteria, and therefore seems to present the best option to carry forward to a case study.

The project team acknowledges that this is an initial scoping of potential adaptive measures and that it is limited to basic principles as allowed by the resources and time available to the project. Some of the options have been discounted based on perceptions and comments from the Ballina construction industry rather than rigorous assessments. We therefore recommend that although this report indicates that Elevated Timber Flood Hardwood is the best option, that any policy response allow for innovation and performance measures from alternative solutions.

In addition it is recommended that this report be recognised for its purpose, as an investigation into alternative responses and as a means to progress towards adaptive building responses; therefore an important step is to engage the wider building industry and investigate market responses to achieving Ballina's requirements.

7. CASE STUDY

7.1 Introduction

In this section we will examine the construction system Elevated Timber Floor Hardwood in more detail by assessing how it performs against all of the criteria and considering options for how it might perform as an adaptive building response for flood resilient housing in Ballina.

We will then go on to cost a typical house using elevated hardwood timber floors as a construction system and compare it against the current typical response of fill and retaining walls.

7.2 Full Consideration of Elevated Timber Floor – Hardwood as an option for adaptive building response for flood resilient housing

How the Elevated Timber Floor – Harwood meets/does not meet the desirable and inessential criteria is now analysed to assess if there are any options that may be carried forward into a holistic adaptive building DCP. The matrix is used again to methodically assess performance.

Criteria / Construction Options	Flood Resilience (Current)	Future proof / adaptable	Affordability	Site access for elderly	Garage elevated	Street amenity maintained	No Impact Privacy of neighbours	No exacerbation of nearby drainage issues
Elevated Timber Floor - Hardwood	Met	Met	Met	Not Met	Not Met	Met	Not Met	Met

Elevated Timber Floor – Hardwood is the only option that meets all three requisite criteria. We will examine how it compares to a benchmark for affordability in a later section, but for now we will discuss the desirable criteria in order to use it as a vehicle for considering how it might present a holistic solution as an adaptive response.

Figure 14 Elevated Timber Floor construction with ramp for access.

Figure 14 above shows an elevated timber floor used on a house with heritage values in Ballina.

7.2.1 Floor height requirement

Elevated timber floors can meet the floor height requirement by being raised by piers or piles to the required height. However, due consideration must be given to the bearer and joist materials being exposed to flood waters as timber will expand and contract when wet and there may be corrosion of connectors. It is suggested that the height requirement consider a freeboard requirement for bearers and joists to be kept out of water. Bearer and joist dimensions will vary depending on material type, but a typical range of dimensions for a hardwood bearer is between 150 – 300mm

depending on span and material type. A range of dimensions for joists is between 70 – 150mm, again, depending on span and material.

Figure 15 A typical Queenslander illustrating elevated timber floor and stairs that may create issues for elderly access.

In terms of meeting the floor height requirements for any future increase in height there are pier and piling systems that will allow for raising in the future. Such systems include telescopic piers where the steel pier is telescopic and the initial height is set with bolts, which may be adjusted for greater height in the future.

It is recommended that more work be conducted to identify options for raising homes with this type of construction system for future floor height requirements if needed.

7.2.2 Site access for elderly

This option does not immediately meet the needs of elderly residents due to the likely requirement for steps or ramps. Site works and optimising natural topography can be used to reduce the slope where possible. There is a potential option of connection a garage structure with a walkway between them to allow people to drive up to an elevated garage and then walk across a level walkway to the house which may provide an adaptive solution.

7.2.3 Garage elevated

The elevated timber floor does not meet the requirement of a raised garage and an additional measure may be required. As identified above, a potential solution to achieve a raised garage may be the brick infill option or a raised concrete slab. This could provide the required strength of floor to support the weight of a car and also connect to the house at floor level to provide level access.

7.2.4 Street amenity maintained

Street amenity is maintained with an Elevated floor.

7.2.5 No impact on privacy of neighbours

Whilst there are homes that were originally constructed at low floor heights there will always be the potential to impact on the privacy of neighbours. This is an unfortunate consequence of floor height requirements. It is recommended that BSC might explore screening requirements and explore the use of native vegetation and/or screens where possible.

7.2.6 No exacerbation of nearby drainage issues

An elevated timber floor does not exacerbate flooding for neighbours as it allows for overland flow. However it does create a space under the house, which must have well considered drainage to allow waters to drain from the site post flood. It is recommended that an elevated timber floor DCP include consideration of site preparatory works and drainage issues.

The house in Figure 16 below is a concept house commissioned by the Queensland state government in 2011 to encourage homebuilders to build flood resilient homes. It is an excellent example of an elevated timber floor home that would not exacerbate flood issues on its neighbours, and an example of a contemporary “Queenslander”.

Figure 16 The Queenslander of the future, Queensland Gov 2011.

7.3 Introduction to Costing

It has been determined by engagement with the development professionals in the Ballina area that the cost of development is a major influencing factor contributing to making development in the Ballina study areas prohibitive given the current fill requirements contained within the DCP.

In this way Edge Environment have been working to develop case studies that can be used to give indicative costs of construction for elevated floors versus the typical construction method currently used: fill and raft ground slab. It is hoped that these case studies can be used to engage with the broader development community and inform the development of a new DCP that selects for elevated floors.

Ranges of cost have been developed to account for the many variables, options and differences in cost information that can affect estimates of the cost of a house.

7.4 Selection of case studies

The case studies include, “the benchmark option” of Raft Concrete Slab with Fill construction type, compared against the Elevated Timber Floor - Hardwood construction type.

7.5 Assumptions

In order to make the comparison between Raft Concrete Slab with Fill construction type, compared against the Elevated Timber Floor - Hardwood reasonable, some assumptions have to be made in order to create a valid comparison. An initial set of assumptions was made and an initial set of costings derived. These assumptions and costings were then tested and validated with industry at a workshop held on the 22nd April 2015.

7.5.1 General Assumptions for both construction types

- **Typical lot size in Ballina Council area** - The typical lot size has been derived from consideration of the Ballina Housing Precincts report that recorded average lot sizes in each of ten study areas and discussed median values, and discussion with council. After discussion with council and consideration of the lot sizes in our study areas council agreed that 600m^2 is the most typical and best lot area to be used. We have further assumed that the lot dimensions are 20m x 30m (with a street frontage of 20m.
- **Average home size** – The average home size taken from the latest Australian Bureau of Statistics data (2012-13) as 241m^2. However for the purposes of comparisons within the Rawlinson’s 2015 Construction Cost Guide we are assuming a 190m^2 house.
- **Cost of materials** – Costs of materials have been taken from Cordells and complemented with local market knowledge where available. Local market knowledge has been derived through the development professional interview process and subsequent personal communications with individuals and an industry engagement workshop on the 22nd April 2015.
- **Ground Height (AHD)** – The ground height has been derived from the Ballina Home Survey and consultation with BSC. A range of heights has been agreed between 1.2m AHD and 1.8m AHD. This is used to calculate the amount of fill required to achieve a ground height of 2.1m AHD, and therefore a range of 900mm to 300mm will be required. For the purposes of the costing exercise we will calculate both.
- **Ground works and drainage** – are the same for each site and are included in the per metre rates for housing.
- **Site preparation –** Prior to the start of any construction the site must be prepared. This includes clearing of any rubbish, vegetation or small structures. On advice from industry this cost is typically $6.67 per sqm.
- **Professional fees –** Each case study will incur additional professional fees amounting to $6000. Engineering and surveying would be typical professional fees incorporated in this amount. This is included on the advice of the local development industry provided during the engagement process.

7.5.2 Assumptions specific to Raft Ground Slab with fill

- **Retaining Walls** – There are several construction methods for retaining. This report has been informed by BSC that the most typical construction method in the study areas is "Blockwork", plain faced hollow concrete block, 400 x 200 x 200mm thick, including bar filling and bar reinforcement with a 400mm x 600mm concrete strip footing. On the advice of industry the total cost of retaining is calculated per sq metre of wall. This includes:
    - Footings 400mm x 600mm deep @ cum $445 (Rawlinsons, 2015)
    - Retaining Wall cost used is $226 per sqm (Rawlinsons, 2015)
- **Drainage for retained fill** – Assumes retaining wall has drainage incorporated with a reinforced concrete footing; excavation; 100mm PVC slotted flexible coil pipe sub soil drain @ $18.50 per metre.
- **Spoon Drains** – Are assumed to be equivalent to: Extruded in situ concrete kerb 150 x 350mm high, 150mm in ground @ $37.10 per lineal m (Rawinsons Construction Cost Guide 2015). It is assumed that Spoon Drains have been laid around 3 sides of the house =) 80m.
- **Fill** – On the advice of industry stakeholders fill is available and can be delivered to site and compacted for $50 per m^3.
    - For a fill of 300mm the site will require $600m^2$ x 0.3m = $180m^3$ of fill at a cost of $9,000.
    - For a fill of 900mm the site will require $600m^2$ x 0.9m = $540m^3$ of fill at a cost of $27,000.
- **Contingency and profit for retained ground height** – A contingency and profit factor is added to achieve the retained ground height. This is 25% of costs.
- **Additional substructure concrete –** For the 900mm filled site it is assumed that there is an additional requirement for substructure on the concrete slab. It has been assumed that there will be 38 metres (2 x 19m beams) of concrete foundation beams – 20MPa concrete in foundation beam including reinforcement (75kg/cum), formwork, excavation of equal depth, planking and strutting, 450mm wide x 600mm deep @ $253 per m =) $9,614.
- **Geotechnical Engineer fees** – A geotechnical engineer is required to be on site to supervise filling as per AS 3798, 2007 at a typical cost of $3500.
- **Type of House** – Is a "Project House" – tiled roof and built on a flat site: medium standard finish, brick veneer as specified in the Rawlinson's 2015 Construction Cost Guide.

7.5.3 Assumptions specific to Elevated Timber Floor house

- **Cost per metre square for $190m^2$** – Direct comparisons between our two construction types are being made for $190m^2$ houses. The elevated timber floor house has been taken to be the "Individual House" as specified in the Rawlinson's 2015 Construction Cost Guide.

7.5.4 Costing for Raft ground slab home built on filled site 1.8m AHD with 300mm fill.

Construction Element	Calculations	Cost (ex GST)
Site Preparation	600m^2 x $6.67	$4,002
Footings for retaining Wall	80m x (400mm x 600mm)= 19.2m^3 x $445	$8,544
Retaining walls for 300mm fill	$226 per m^2 x 0.3m x 80m	$5,424
Drainage	$18.50 x 60m	$1,110
Fill	180m^3 x $50/m^3	$9,000
Spoon Drains	80m x $37.10	$2,968
Subtotal for Fill Construction Elements		**$31,048**
Other Fill Related Cost Items		
Contingency and Profit on Fill Construction Elements	25%	$7,762
Geotechnical Engineer Fee	$3,500	$3,500
Professional Fees (Including Engineering and Surveying)	$6,000	$6,000
Subtotal for Other Building on Fill Related Cost Items		**$17,262**
Cost of 190m^2 House	190m^2 x $1170 to $1260 per m^2	($222,300 + $239,400)/2 = $230,850
Total	**$31,048+ $17,262+$230,850**	**$279,160**

7.5.5 Costing for Raft ground slab home built on filled site 1.2m AHD with 900mm fill.

Construction Element	Calculations	Cost (ex GST)
Site Preparation	600m^2 x $6.67	$4,002
Footings for retaining Wall	80m x (400mm x 600mm)= 19.2m^3 x $445	$8,544
Retaining walls for 900mm fill	$226 per m^2 x 0.9m x 80m	$16,272
Drainage	$18.50 x 60m	$1,110
Fill	540m^3	$27,000
Spoon Drains	80m x $37.10	$2,968
Subtotal for Fill Construction Elements		**$59,896**
Other Fill related Cost Items		
Contingency and Profit on Fill Construction Elements	25%	$14,974
Geotechnical Engineer Fee	$3,500	$3,500
Professional Fees (Including Engineering and Surveying)	$6,000	$6,000
Additional Substructure concrete	2 x beams running length of 19 x 10m slab	$9,614
Subtotal for Other Building on Fill Related Cost Items		**$34,088**
Cost of 190m^2 House (Project House)	190m^2 x $1,170 – $1,260 per m^2	($222,300 – $239,400)/2 = $230,850
Total	**$59,896 + $34,088 + $230,850**	**$324,834**

7.5.6 Costing for Elevated Timber floor house – Hardwood

Construction Element	Calculations	Cost (ex GST)
Professional Fees (Including Engineering and Surveying)	$6,000	$6,000
Retaining walls	Not required	$0
Fill	Not required	$0
Drainage	Not required	$0
Spoon Drains	Not Required	$0
Subtotal for Fill requirement	N/A	$0
Cost of 190m^2 House	190m^2 x $1,400 - $1,510 per m^2	($266,000 - $286,900)/2 = $276,450
Total	**$276,450 + $6,000**	**$282,450**

7.5.7 Conclusions

The cost of a “Raft Ground Slab house, built on filled sites ranging between 300mm - 900mm fill are $279,160 - $324,834

The cost of an “Elevated Timber Floor – Hardwood” house is estimated to be – $282,450.

It costs approximately the same amount (1% difference) to build an elevated timber floor house on a site as it does to fill a site and build a slab on ground home.

It is 13% less costly to build an elevated timber floor house on a site rather than build a raft ground slab home on a site that requires 900mm of fill or more.

On sites where required fill is less than 900mm there is additional long term value in building houses with elevated timber floors. These houses are significantly more resilient to predicted rising sea and flood level impacts.

Additional benefits associated with timber homes also include their cooling properties, character and their ability to build to the specific design requirements of the owner.

8. CONCLUSIONS AND RECOMMENDATIONS

8.1 Introduction

The objective of this report is to identify options for housing resilience applicable to the circumstances associated with flooding and sea level rise in Ballina, including specific consideration of building design, servicing elements and costs.

A resilient house is defined as:

> *A residential building and its component parts that can absorb, accommodate and recover from the effects of a given event (in this case flooding and tidal inundation) and has the ability to respond and adapt through re-configuration and flexibility to changes in hazard levels, if and when required.*

Resilient housing allows the house to:

> *"function safely over a range of scenarios, and the investment in additional risk mitigation can be timed to coincide with the increase in hazard, which may occur faster or slower than predicted. It may also allow construction in areas of high risk, where other buildings would fail or become dysfunctional"* (Giles, 2012).

8.2 Conclusions

The project has considered all aspects identified in the original scope and draws the following conclusions:

- There is a need to explore alternatives to the fill policy as the policy may have reached its threshold due to a combination of issues. Houses being built now need to be resilient to conditions up to 2075. The current fill policy can no longer meet the needs of a growing Ballina and an alternative adaptive response is required.
- The Ballina development industry (from the interviews conducted) appears to be supportive of changes to the fill requirement. The consensus is that current requirements are stifling development and are creating problems that are exacerbating flooding issues and creating new issues for housing in the community.
- There is a general consensus that elevated floors would be a good alternative solution to the fill policy for mitigating flood risk.
- There is an inherent drainage issue that will always need consideration so that land can drain quickly and recover quickly from the effects of flooding.
- The Elevated Timber Floor – Hardwood construction type presents the best option for an adaptive response as an alternative to the fill policy.
- The population in the study areas are ageing and the people per dwelling is trending downwards. Site access for elderly people is clearly an important issue that will be considered when considering adaptive building responses.
- The cost of a Raft Ground Slab house, built on filled sites ranging between 300mm - 900mm fill are $279,160 - $324,834. The cost of an Elevated Timber Floor – Hardwood house is estimated to be $282,450. It costs approximately the same to build an elevated timber floor home on a site as it does to fill a site with 300mm of fill and build a slab on ground.

8.3 Recommendations

Edge Environment recommends that:

1. BSC develop an adaptive building response to mitigating the risk of increasing flood risk and develop a policy that enables the development industry to develop elevated timber floor homes;

2. BSC maintain engagement with the development industry to stimulate and progress the development of elevated floors in the Ballina area as the next step in exploring pathways to an adaptive building response;
3. BSC use the “Ballina Style” information contained in this report to develop a specification document for Ballina style with engagement from the Ballina development industry and community. This could then be used as a document to guide and nurture a Ballina style and be included in development guidelines.
4. BSC use this report as a starting point to further investigate higher density building options, such as multi-residential.

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APPENDIX A – STRUCTURED INTERVIEW RESPONSES FROM LOCAL PROPERTY PROFESSIONALS

A set of professionals from the Ballina property development industry including architects, building designers, engineers, surveyors and real estate agents were asked about elevated floor construction for achieving 2.6M AHD floor height as an alternative to the current fill policy. The interview was structured around a set of themes as titled below. The answers have been synthesised into a summary which articulates the consensus from the group.

Cost

What is the relative cost (per m^2 /or 5 uplift) for construction of this type? (Ideally a figure or a range). What is the biggest contributor to the cost?
• Cheaper to build slab on ground; the problem is bringing the floor height, and the site height up to 2.1 AHD. End up with retaining wall 2 – 3 feet high and a steep driveway. Floor level has to be 500mm above ground level. • Problem for architects is that the clients want amenity of a flat site and accessible home, but have to comply with fill requirement. • Ballina is a retiree area, raised house and therefore ramps going up top front door results in an impracticality. • Council haven't allowed just building floor level at new flood height. • In Tamar Street – at high tide (spring tide) comes over the street at 1.8 – 1.9 metres through stormwater drains.
• Yes – there is a higher cost – built two townhouses – slab on ground construction – retaining wall – 500 – 600mm for fill. Cut strip footings. Definitely more expensive than building elevated floor with bearer and joist. • Hassle with neighbours assuming that water runs off onto their place – stormwater management plan mitigates risk of run-off. 300mm pipe in rear drain. • The problem with bearers and joists in the 2.6 floor level – 1.6 m site level meant 500mm of fill. Was part of the site consent and was costly. • Anecdotally additional cost $25,000 additional cost for fill. 5.5% uplift.
• Need to be consistent – inconsistency in decisions/policy is leading to a mixed built environment, and mixed level homes in Ballina. • Council need to set a policy that they can stick to. • We do a lot of timber floors because we develop on hillsides; project home companies will struggle – issues that come up are outdoor spaces

being raised – can be a problem for disabled/elderly access. • Can't see a problem with timber floors. • 2 things that are very noticeable are that the heights are going up – all inconsistent with heights – end up with drains everywhere. If we have a consistent policy then we will future proof Ballina. We are currently locked into a vicious circle of changing fill heights and it is exacerbating the problem. • Should have looked at Mitigation strategies 20 years ago – from now on we'll mitigate – (Levies, dams….)
• The concrete alternative is a post and beam construction. • The flooring system would be formed in place concrete or a re-cast concrete • Several systems available: 1. In situ concrete slab 2. Pre-formed 3. Pre-stressed (manufacture hollow ducts in slab) technique mostly used in commercial construction.
• Depends on size of site very much – gut reaction is that it would be cheaper to do bearer and joist. • The only negative would be pooling of water under the house – would have to do a high point/pyramid type of structure to drain water away. This would require some prelim ground works which would have a cost associated with it.
• Creating a major problem in Ballina – Council came up with an idea – creating a major furore because of various problems, including with the drainage channels that the policy creates between boundary and retaining wall, overlooking and inconsistency of design. • It works out cheaper to do strip footings and fill. • There is a cost of retaining the fill – the cheapest way is to go fill inside strip footings on a strip footing – brick infill. • If clients want to build on the island and fill within the strip footings. Steps creating a major problem for the older population. • A cheap way out is bearers and joists, using a veranda type design to minimise steps. Design out the steps – Good design can deliver.
• Very lot specific – it depends on the size of the lot – 1000 metres square will be very different to 400 metres square with a small fill requirement. • Filling the whole site ultimately disadvantages someone else. • Decreasing the flood volume – pushing the water somewhere else • Brick infill

• Bearer and joist would be much cheaper vs fill compacting, concrete and retaining walls. • B&J construction would be well received at the right price • Plenty of old houses of this style around • It depends on the style – still have a beach style – no brick and tile with timber
• Incidental costs fall in when you have slab on ground. For instance if you are the first, you have to control all waters that come onto your boundary. The construction cost becomes incidentally larger – fill $30 - $35 per cubic metre. Have to take existing topsoil off and bring level back to 150mm below 2.6 Ground level ranges from 1.2 – 3 metres. Could be taking up to $35K of cost of fill even before slab. • In saying that there needs to be some shaping of site to achieve - there are still ground works for bearer and construction but much lower to stop ponding • Civil works $25 – $30K
• Elevated timber floor is more expensive than a slab on ground floor on a standard site; not allowing for any ground works. • If you saved all the costs of retaining and filling it would a bigger saving than the ground works required. • The only thing that needs considering is the garage access. Would the garage have to be raised?
• It would save money • Same in Tweed Shire • I've been working on it in 25 years • When you can fill directly to the boundary then the adjoining property has the opportunity to fill to the boundary too. • Without question it will be cheaper, but I don't think that an alternative is necessarily better • On a king tide, the road around the hospitals 0.8m AHD and is underwater. • Where we have very low roads we have very low properties. If we did have an alternative to filling the site, would that also include some requirement for fill. • Riverside road went underwater and site see-ers created waves with there cars and the resulting waves were running into peoples homes.
• Firstly ridiculous, secondly cost prohibitive • Not always easy to understand where the water tracks • Alluvial soil over marine clays

• 30-40 years are all fill
• The cheapest form of construction is slab on ground; with the fill requirement timber bearer and joist construction is perceived as the cheapest

Construction Materials

What type of elevated floor construction would you choose? What are the key construction materials required for this building type?
• There was a turn towards steel frame construction, however the majority of builders round Ballina tend to be carpentry based. Steel not great in longer term. Timber framed. 6 – 10 per year – predominantly timber framed.
• slab on ground. • Controlled Fill – compacting as they go • A lot of project home builders are using waffle pod • Screw piles in Lennox in a basement carpark – 3 storey commercial building
• Will use everything, use most appropriate material for the design and site conditions. Mostly timber.
• Timber is possible the cheapest – Kiln dried – we have a white ant problem here • Concrete is still the best method of flooring to combat white ant activity
• Hardwood bearers and joists. Most people might go engineered timber. • Suspended concrete on piers would be far more expensive • Steel – wouldn't do steel due to corrosion impacts
• Concrete, steel reinforcement • Insulation adhered to bottom of slab, or could do a • Ultrafloor have a manufacturing facility on North Coast.
• Developers will probably go with the concrete piers – they sell well, but that's what the market has had. In the right style timber floors – will come down to cost
• Because it's a salt environment it is likely that steel understorey would be expose – timber solution; • Would be pushing for Hardwood bearers and joists as is an older type of profession • The market place that we deal with is an aged and local population. The prefer hardwood rather than
• Depends on the design of the house. If it required

• Light weight construction – timber bearer and joist on adjustable piers – still have the issue of the car parking • Kiln dried hardwoods with tongue and groove • Industry is concerned about bounce in the floors.
• Concrete, bricks and fill. – Brick infill construction.
• Masonry construction up to 2.1 metre level. Then everything below would be waterproofed. • Masonry/concrete substructure – brick perimeter wall. • Once out of 1/100 year flood level all timber would stay dry • Would be choosing whatever is cost efficient • The day will come when we won't be able to continually lift all our infrastructure
• A decent percentage would go for timber
• The most discussed options for achieving elevated floors were: 6. Hardwood Timber Bearer and Joist 7. Engineered Wood Product Bearer and Joist 8. Strip Footings with Infill 9. Steel Bearers and joists 10. Concrete elevated floors • There is certainly a preference for hardwood bearers and joists over engineered timber products; the reason is that hardwood is available in the area, this is what the trades are used to, and there is the perception that hardwood fairs better than engineered timber in wet conditions.
Are they easy to access in the Ballina area? **What, if any, particular constructions skills or trades are required for this building type?**
• Only two hours from Brisbane, all trades available –
• Would go straight for timber rather than steel. • JH Williams can supply all relevant materials.
• Used to use Hyne, have some very good timber merchants, Hurfords
• Hardwood is procurable but not common. Treated pine sections would be most common. • Skills and trades are available.
• There is no shortage of the required materials or skills to build bearer

and joist, or any type f construction in this area.
• Not an issue
• No issues
• All available – limited by section sizes
• All materials and all trades are readily available to achieve any type of construction.

Energy Efficiency

Do you see any advantages or challenges for this type of construction compared with other options for energy efficiency in the Ballina climate?
• No not really – just need to insulate the floor.
• With Timber framed floor do have to insulate floor • Timber floor would be colder in winter – would have to insulate with bubble wrap stuff… • Easier to run services in.
• Residentially they like to see thermal mass. Use Styrofoam/closed cell insulation
• Hard to go past slab for protection against slab. We do a double floor, yellow tongue 19mm with a timber floor over top – good rating – without any floor insulation
• No
• Life of structure is 100 years plus • Concrete can provide for thermal efficient envelope if you insulate it correctly. You can design a passive solar house using an elevated concrete floor appropriately.
• Buyers are always interested in Energy Efficiency – not going to stop a sale. • The population is 65+ is 29% of the population state average is 19%. • Got to encourage single level housing; open space requirements are very onerous
• General feel is that as much as people feel is that it's a secondary consideration – the market will comply with regulations – Not an issue – cost is the primary issue
• There are always issues to consider, but always solutions.
• We will always build to code and find the most cost effective method of achieving compliance.

• If you can go back to a slab on ground construction you benefit from the thermal coupling. • Slabs on ground work very well. • Elevated slabs still have the thermal mass opportunity, but not the thermal coupling
• The industry will always find a way to achieve energy efficiency compliance • Concrete slab on ground is preferred solution for thermal comfort as thermal coupling is best passive method of regulating temperature in homes. This can't be achieved with an elevated slab – but may be achieved with Brick infill.

Services and Liveability

Do you see any advantages or challenges for this type of construction compared with other options for connection to services and liveability in the Ballina area?
• Yes the older people in the area are attracted to the flat site and the location • Privacy – Transitional state
• The garage would be an issue. 300mm step to the concrete garage floor to the building. If you go bearers and joists and don't fill the site
• No problem – easier to renovate with
• If the sites are elevated with retaining walls than water diversion during a flood can cause major contention as the non-elevated house is subjected to greater flows. • Council are asking for a 300mm dish drains, which become attractive for vermin and also create difficult spaces between retaining wall and boundary. It also adds to the contention of boundary issues.
• Understand the merit in keeping consistency in the streets. I like the idea of not creating dam walls in different blocks around town
• Requires a little more forward planning – need to pre-plan and place PVC pipe into slab
• The older generation want single storey flat blocks for amenity; they also want to live in Ballina island.
• Certainly extension and modifying is much easier if you want to add – easier with sub floor access, more economic with sub floor access. • If you could flag West Ballina the floor height goes to 3.6M – the visual intrusion/perception (pimple on a pumpkin) looks odd an uncomfortable perception

• Need to consider a pad area for vehicles
• People like level services, particularly the older population • Engineers might need to consider the solidity of the piers, the depth of the holes for piers. Geotechnical engineering.
• Issue with garage drive gradient •
• The issue of living on flat ground • Car out of water if you raise site • How we do this hybrid solution – how do we keep stuff outside of house dry.
• At Flood level • There are some areas where existing drainage, kerb and gutter or swail is too high – relief for water caught in these areas; need to demonstrate to council that you have addressed the drainage issues; you would need to survey considerable areas outside the blocks; drainage patterns change – a short term impact – constantly changing drainage flows. • Ballina island doesn't have drainage • A consolidated drainage plan may not be achievable
• Flat sites for the ageing population is a key issue in terms of livability; fill does achieve this. Bearer and joist construction results in steps that are unfavourable for elderly. • With an elevated floor there is still the issue of the garage being down at flood level; this would have to be addressed too, maybe with a requirement to achieve a floor height of x for the garage. • The roads in the area create a matrix of barriers for flood waters stopping overland flow. The drainage needs addressing and will remain a problem even with elevated floors – pooling on sites. • There needs to be careful consideration of the piers and piling for sites in flood affected areas – the engineering detail should be clearly understood.

General

Are there any other barriers or enablers for this construction type in the Ballina area?
• Typically it comes down to personal preference and cost. Usually cost is the main driver; • Peter Carmont at the Professionals Real Estate Agent in Ballina – Also Chamber of commerce. • Raising the site is making the viability of development too high.

• Would go timber before steel due to corrosion issues by coast.
• Good idea to start thinking about how to address this issue now.
• It is excellent that council are considering this issue finally; I am available to support further and would like to see a copy of the report when complete. Will there be a public hearing?
• May be an issue that you may have a wet block all the time if the sea level rises, although I am skeptical.
• The physical and scouring of floodwaters – Concrete provides that excellent robustness.
• The policy and the open space requirements for more than 80m square • Balina is very tough – got to deal with the floor height • Developed 60 units on the Ballina island based on what is required. Retail price at Lennox is much higher. • Ballina style – • Anything that can be done to get a product to market at a reasonable price is going to help the market.
• There needs to be an overland flow path created to drain off the grid pattern – don't realise it until the flooding occurs – creates a water trap – pipework needs renewing. Whatever need to address the overland flow issue. • Good that someone is making enquiries • Process must be further amplified in West Ballina3
• No more comments
• It is all lot specific – difficult to find a policy that will fit for all.
• It would be really nice if we could elevate everything; obviously can't afford to; maybe sort out drainage though • Either accept the status quo or raise the land area and hope that in the future that's enough. • I think raising the land is a good long term solution • Already have roads that are underwater at high tide, saving money for developers may be a short term fix, but we need to consider the long term sustainability of the community. • The solution we come up with has to address all the issues that will come up over the 50 years.
• Drainage is a problem; its good Its about time council considered alternatives

APPENDIX B – STUDY AREAS

Figure 17. Ballina Island

Figure 18. West Ballina

Figure 19. North Ballina

Figure 20. East Ballina

APPENDIX C – CURRENT MINIMUM FILL LEVEL REQUIREMENTS AND FLOOD MAPS

Table 2 - Minimum Fill Level Required		
Column 1 **Land**	**Column 2** **Minimum Fill Height**	**Column 3** **Minimum Floor Level**
Land within the Ballina Floodplain as illustrated on Maps 1 and 2	100 year ARI (mAHD) as indicated on the applicable flood planning map*	Height determined by Column 2 plus 0.5m AHD
Rural Land - Farm Sheds	1 in 50 year flood level	1 in 50 year flood level
Secondary Dwellings - Detached	Refer to Clause 3.4C	100 year ARI (mAHD) as indicated on the applicable flood planning map* plus 0.5m AHD
Flood Prone Areas in the Remainder of the Shire (Not illustrated on Maps 1 and 2)	300mm above highest recorded or known flood level.	800mm above highest recorded or known flood level.
*Note: Clause 3.2 identifies the applicable flood planning map to be used.		

Table 2. Adjusted from the Minimum Fill Level Required as per Ballina Shire Development Control Plan 2012 Chapter 2b – Floodplain Management (p6).

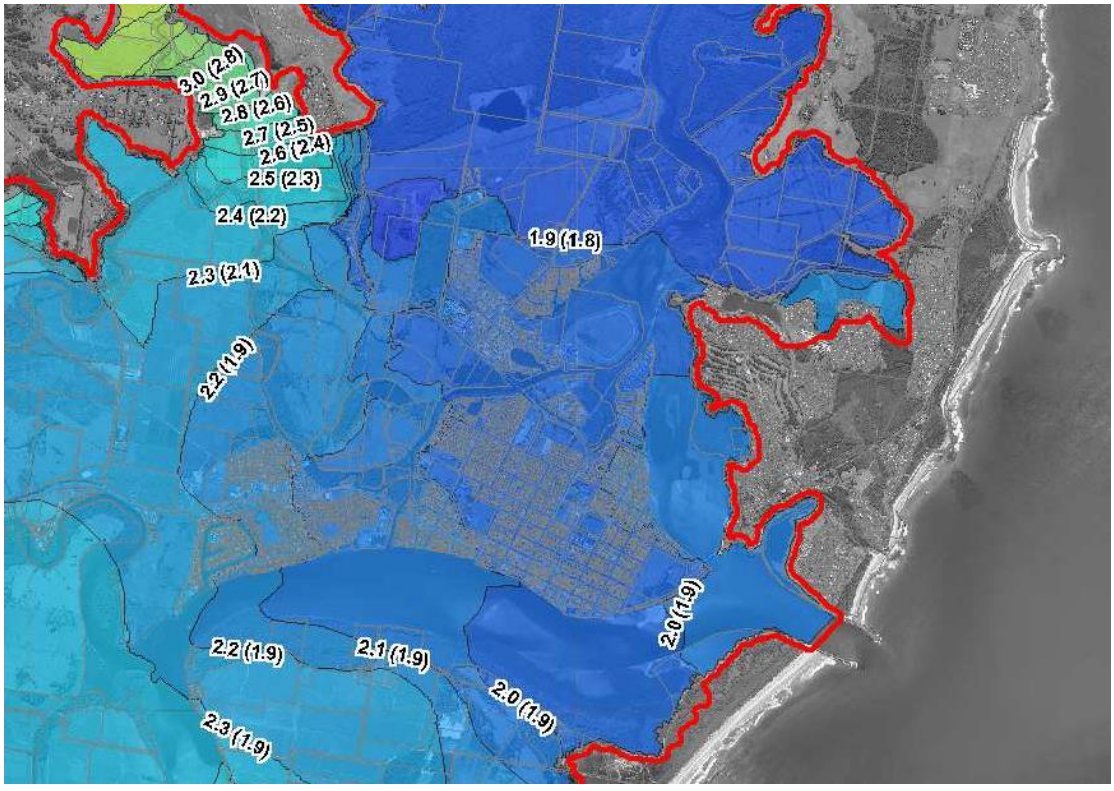

Figure 21. Minimum Fill Policy (m AHD) 100 Year ARI Flood Levels taken from Map 1a Identification Number DCP2012_FP_1A_20130204 (Development Control Plan 2012).

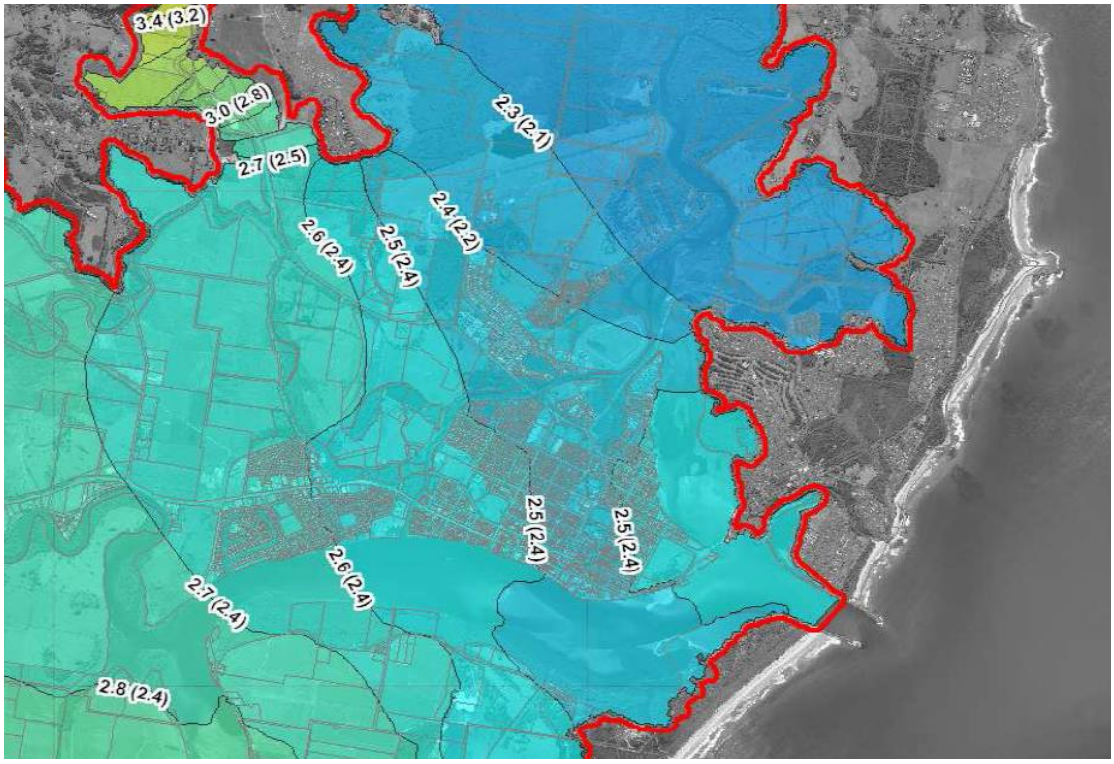

Figure 22. Minimum Fill Policy (m AHD) 2100 Climate Change Scenario 100 Year ARI Flood Levels taken from Map 2a Identification Number DCP2012_FP_2A_20130204 (Development Control Plan 2012).

APPENDIX D – RESILIENCE RESEARCH

WAGGONER AND BALL ARCHITECTS

Our Homes in New Orleans | June 28, 2012

Waggoner and Ball Architects are located in New Orleans and designed this home. From the Make it Right project: http://makeitright.org/see/new-orleans/

MAKE IT RIGHT HOME

Our Homes in New Orleans | May 11, 2012. From the Make it Right project: http://makeitright.org/see/new-orleans/

APPENDIX E – "BALLINA STYLE"

Ballina Style has been referred to as a concept throughout the report.

This Appendix collects together some aspects of Ballina style; it is designed to aggregate the thoughts, ideas and concepts that may be built on to more clearly articulate Ballina style.

We understand that Ballina style:

- Takes a design lead from older heritage houses (Figure 2).
- Houses that are of Ballina style are typically built on piers with timber bearer and joists and lightweight construction, eg, newly renovated old house shown in Figure 8.
- Connect to the heritage and history of the region through the use of local materials and elevated floors.

A summary of suggested Ballina Style elements includes:

1. Lightweight materials roof and walls. Assists with cooling and facilitates ability to raise building if and when required.
2. Internal design that facilities cross through ventilation of habitable rooms.
3. Minimisation of window size along western elevation.
4. For two storey developments minimise habitable rooms on ground floor and incorporate external stairs as replacement for, or additional to, internal stairs.
5. Use of verandas under main roof elements with minimal cantilevered sections. Reason – decreases maintenance costs and increases year round useability.
6. Use of pier and beam foundations not slab on ground.
7. Suggest a light colour palette.
8. Maximum roof pitch of 35 degrees.
9. Design should create a sense of vibrancy. Have architectural merit and still be affordable.

Other design components that may have merit include:

- Dwelling jacking points.
- Storm shutters particularly along southern most elevations.
- Oversize gutters
- Roof fixings appropriate for cyclone zone.

Ballina Shire DCP 2012 – Chapter 4 Residential and Tourist Development contains the applicable development controls for residential development within Ballina Shire that requires development consent.

Photos – Examples of buildings which contain Ballina Style elements or elements not of the style.

Photo shows renovated dwelling with typical Ballina style elements consisting of pier and beam foundations, front veranda, and lightweight cladding – walls and roof.

Photo shows new multi dwelling housing which has incorporated lightweight construction on first floor. Floor is slab on ground which is not a Ballina style design element. First floor veranda should be under main roof not cantilevered to qualify as being part of the Ballina style. Additionally window to western elevation should be minimised or smaller which is not the case in this development.

Photo shows typical older style dwelling which is able to be raised through use of lightweight materials and pier and beam foundations. These building typically require restumping at certain intervals – 50 – 75 years. During the restumping exercise dwellings can readily be raised due to accessible foundation area.

Photo shows new multi dwelling development, which contains the following elements of the Ballina Style – lightweight external walls on first floor, modern skillion roof design.

Duplex in this photo depicts modern roof lines. First floor veranda covered by roof not partly proud of roof as in previous photo.

Renovated dwelling. Ballina style elements displayed non-habitable areas on ground floor, external stairs to first floor habitable areas, general light colour palette.

Renovated dwelling. Ballina style elements contained within this development include -mainly non habitable areas on ground floor, use of light weight construction for first floor, north-east facing veranda contained under main roof, light colour palette.

Ballina style foundation elements. This photo shows foundations contained within a building originally built as a dwelling house now used for commercial purposes. Services are readily accessible, in this case stormwater, which facilitates easy disconnection should need to raise building arise.

Photo – Example of Ballina style features within this dwelling (internet photo) include striking modern skillion roof design, lightweight materials for walls and roof, dwelling on piers not slab on ground. Ground floor deck should be covered to qualify as a Ballina style component.