Flood Resilient Building Guidance for Queensland Homes

Lockyer Valley REGIONAL COUNCIL

Somerset REGIONAL COUNCIL

City of Ipswich

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Queensland Government

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Foreword

Queensland is the most disaster impacted state in Australia, with flooding being the highest risk to the community. We can't stop floods from occurring, but we can take steps to reduce their impact.

Flood resilient design is one of the many ways Queenslanders can build their resilience to floods. It involves adapting the design, construction and materials incorporated into buildings to minimise damage caused by floodwaters.

Incorporating resilient building design can significantly reduce the effort, cost and time to return people to their homes and workplaces following a flood.

This *Flood Resilient Building Guidance for Queensland Homes* (Guidance) provides information about improving the flood resilience of new and existing Queensland homes.

The benefits of flood resilient design are far reaching and support the economic, social and environmental recovery of a community following a flood.

Contents

Introduction to flood resilient homes

Flood Resilient Building Guidance for Queensland Homes

The purpose of this Guidance is to share innovative, practical and affordable solutions for adapting Queensland homes to be flood resilient. The guideline is based on lessons learned through consultation with the building industry, local governments and Queensland Government agencies.

This Guideline provides information about reducing the impact of floods on Queensland homes and families. It is suitable for building industry professionals, state and local authorities, and owners of residential properties in flood prone areas across Queensland. It provides clear guidance on flood resilient design principles, strategies, construction details, materials and the expected benefits and costs of flood resilient design. It is a non-mandatory document, and does not replace the mandatory requirements for building work as set out in the *Building Act 1975*.

This Guidance is one of a suite of flood resilience initiatives developed as part of the Brisbane River Catchment Flood Studies. It responds to the Queensland Floods Commission of Inquiry Final Report (2012), which calls for an appropriate mix of measures including building controls to minimise the impacts of floods and help to reduce the cost of property damage and time taken to restore a building after a flood.[1]

These guidelines provide information on flood resilient design options. They do not consider site specific flood behaviour and characteristics - these must be considered as part of the relevant local planning and building code requirements.

Understanding your flood risk

The first step to making a home flood resilient, is to understand the level of flood risk. It's also important to find out what local government planning considerations apply to your property.

Contact your local government to understand your flood risk, including what impact the Defined Flood Event (DFE) would have on your home and to confirm if there are any specific planning considerations for your home such as building heights.

Return on investment

Flood resilient design and construction can reduce the long-term costs for home owners by reducing expected costs associated with flood damage and insurance premiums.

A cost benefit analysis was undertaken as part of the development of this Guidance to understand the return on investment for flood resilient homes under different circumstances.

[1] Queensland Floods Commission of Inquiry, Queensland Floods Commission of Inquiry Final Report, 2012, pp.210, Available at: www.floodcommission.qld.gov.au/publications/final-report/

Economic benefits of flood resilient homes

Homes in high flood risk areas

Flood resilient homes are a viable option for reducing the impacts of flood events up to a 1% Annual Exceedance Probability (AEP) (1 in 100) flood level.

The average time it takes to recover the initial outlay costs ranges from one to 12 years depending on building type, treatment adopted and likely frequency of flooding.

Homes in lower flood risk areas

As the expected flood frequency decreases, so too do the benefits for investing in flood resilient initiatives for the home.

Impact of climate change

The economic case for investing in flood resilient construction increases when taking into account future predicted climate changes.

The average time it takes to recover the initial outlay costs of implementing flood resilient building measures ranges from one to 14 years depending on building type, treatment adopted and likely frequency of flooding.

Other observations

- The cost of raising a home is generally greater than the cost of a resilient build. However raising the home reduces the likelihood that flood inundation will actually occur.
- There is a direct relationship between flood resilient homes and mitigating internal flood damage.

For further detail refer to **Appendix B - Economic benefits of flood resilient homes**.

Case study

Flood resilient home renovation generates insurance savings

In 2011, a Graceville home was flooded five metres above ground level. Following the flood, the owners renovated their home to increase their flood resilience.

The house was raised approximately three metres above its original height to position the finished floor level above that of a 1% AEP (1 in 100) flood event.

The owners recognised that the lower level of the home remained at risk of smaller, more frequent floods. Flood resilient design principles were incorporated into this lower level including rendered concrete block walls, a polished concrete floor, removable cabinetry and an internal layout that enabled easy cleaning post-flood.

The value of this approach was recently recognised by their insurer, Suncorp, who gave the property significant premium relief. In the years 2012 to 2017, insurance premiums for the property were $5,253.33 per annum.

In 2018, following the renovations that incorporated flood resilient design strategies, Suncorp reduced the premium to $3,133.60 per annum – a saving of 40 per cent.

Alignment with the Queensland Development Code

This non-mandatory guidance may be considered in addition to the mandatory requirements contained in MP3.5 of the Queensland Development Code, which specifically addresses the construction of buildings in flood hazard areas.[2]

Building Assessment Provisions for local governments

All content in this Guidance is non-mandatory.

The Building Assessment Provisions contained in legislation dictate the mandatory requirements for building work. The relevant Building Assessment Provisions include the *Building Act 1975*, *Building Regulation 2006*, Queensland Development Code Mandatory Part 3.5, the ABCB's Construction of Buildings in Flood Hazard Areas Standard (the Flood Standard) and Handbook (the Flood Handbook) and the National Construction Code.

Section 13 of the *Building Regulation 2006* provides clarity around building matters a planning instrument may address to mitigate the impact of flood. Flood resilient residential building design is not currently included in these matters. As such, in planning instruments, local governments may only refer to this guidance material as an optional matter for consideration in the assessment of building work.

Refer to **Appendix A – Legislative Framework** for more information about the roles, responsibilities, planning schemes and building codes associated with flood resilient building practices.

[2] Queensland Development Code MP 3.5 – Construction of buildings in flood hazard areas, Version 1.2, 2013, Department of Housing and Public Works. Available at: www.hpw.qld.gov.au/construction/BuildingPlumbing/Building/BuildingLawsCodes/QueenslandDevelopmentCode/Pages/QueenslandDevelopmentCodeCurrentParts.aspx

Part 1 - Flood resilient design

Definition of flood resilient design

For the purposes of this Guidance, flood resilient design is defined as:

The use of materials, construction systems and design types that can withstand substantial and multiple inundations by actively mitigating the effects of, and minimising the cost of flooding. Flood resilient design enables occupants to safely store belongings prior to flood and easily clean, repair and quickly move back in with minimal long term disruption to family and finances.

Flood resilient design options

Elevating the finished floor level

Historically, the primary method for reducing flood impacts to Queensland homes has been to elevate the finished floor level of the home above a Defined Flood Event (DFE).

> The Requirements of the Queensland Development Code must be met with respect to elevation of the finished floor level.

Elevating a house above the DFE is an effective method to reduce flood risk. However, elevating a house only reduces flood risk up to a certain flood level and risk still remains if larger floods occur above this level. In addition, the cost to elevate a home can sometimes be prohibitive, and outweigh the costs of other resilient design options. Therefore other flood resilient measures should also be considered.

The flood resilience principles contained in this guidance may be combined with elevation of finished floor level above the DFE for greater flood risk mitigation.

Wet-proofing

Wet-proofing is an appropriate flood design strategy for Queensland homes.

Wet-proofing design can be used to treat the internal and external spaces of an existing or new house, enabling floodwaters to enter and leave quickly and easily without causing significant damage. As a result, occupants often only need to clean and dry the flood impacted materials, before returning to their home.

This is consistent with ABCB's *Construction of Buildings in Flood Hazard Areas Standard* definition of Wet Flood Proofing: includes permanent or contingent measures applied to a building that prevent or provide resistance to damage from flooding while allowing floodwaters to enter and leave the building.

Key attributes of wet-proofing design includes properly anchoring the structure, use of openings or breakaway walls, use of flood resistant materials and protection of mechanical and utility equipment.[3]

Controlled methods are to be used for allowing water entry and exit to the house to maintain equal internal and external water levels and avoid hydrostatic pressure on the walls of the building. The required opening sizes to allow water entry and exit are dependent on the anticipated rate of rise and fall of flood-waters and the size of the house. A registered (RPEQ) Structural Engineer should be consulted for further information on these methods.

[3] U.S. Department of Homeland Security, FEMA, [website], 2018, https://www.fema.gov, (accessed May 2018).

Dry-proofing

Dry-proofing prevents floodwaters from entering a building by using either permanent or temporary flood barriers. However, due to the pressure from flood waters, particularly where water depths are high, the risk of property damage may increase and is therefore not suitable as a flood mitigation measure.[4]

User guide

Water resistant and water-proof materials, systems and construction techniques should be tailored to different building types. The User Guide Flowchart (refer **Figure 1**) sets out a range of criteria for identifying the most suitable flood resilient building methods for different residential types. Steps to navigate this document are outlined below.

STEP 1

Flood resilient design

Select the project category from the following:

- building a new house
- raising an existing house and building underneath
- retrofitting an existing house.

STEP 2

Flood resilient design

Select the building typology:

- lightweight - typically a timber or steel framed construction system
- masonry - typically a brick, block or concrete construction system.

STEP 3

Flood resilient design

Select the construction system required:

- timber or sheet cladding
- concrete block or aerated concrete panels
- brick veneer or double brick (retrofit only).

STEP 4

Flood resilient strategies (page 12)

Select from Sectional Perspective options one to eight and refer to the **Flood resilient strategy table** for further considerations about each strategy.

STEP 5

Flood resilient construction (page 30)

Select the required detail and materials by referring to specific information and relevant associated details and materials contained in this section.

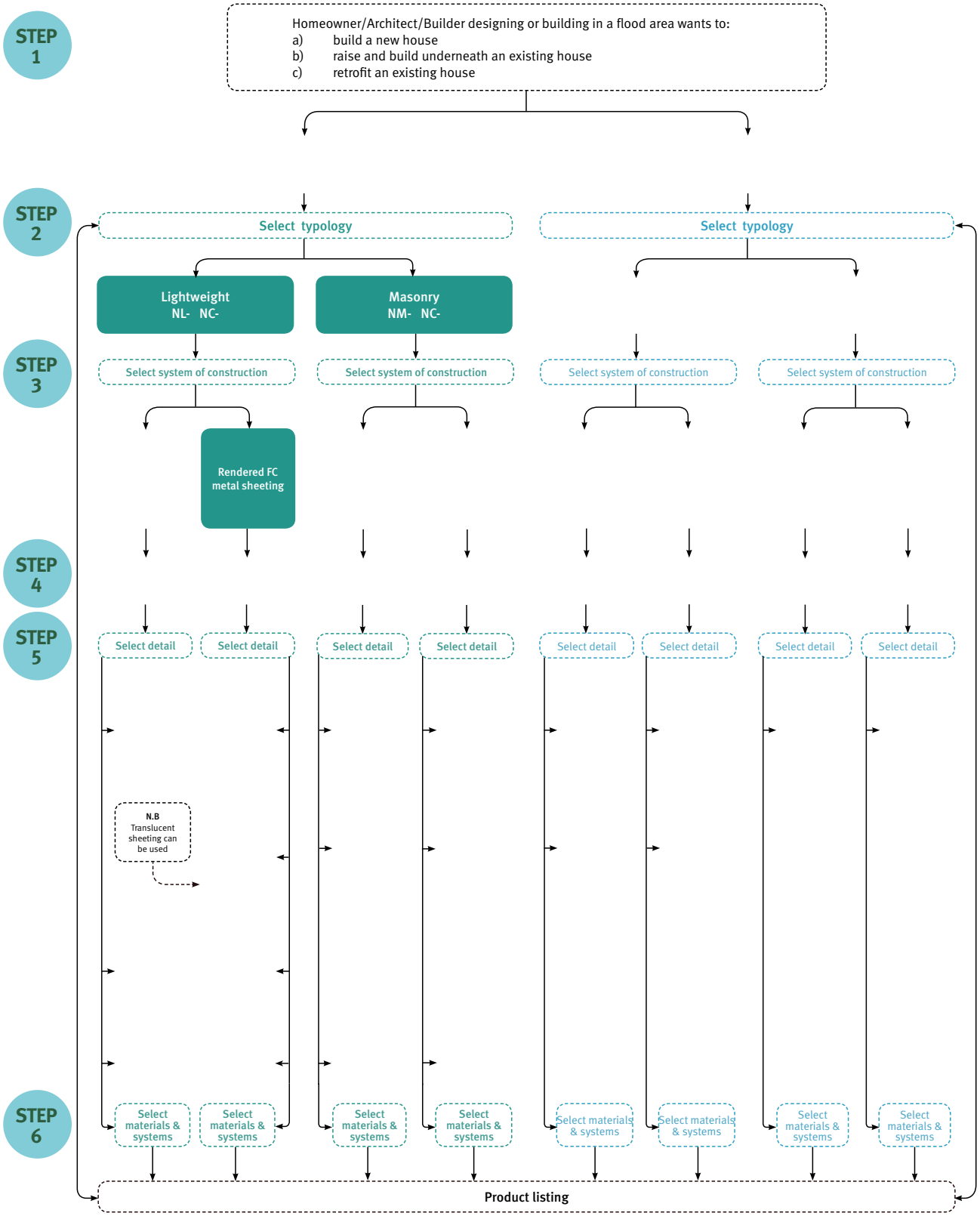
STEP 6

Flood resilient materials and products (pages 70 and 82)

Refer to the **Flood resilient materials table and product listing** for a selection of materials, products and suppliers, and to find material specifications and website details to access further information.

[4] Australian Building Codes Board, Construction of Buildings in Flood Hazard Areas: Handbook Non-Mandatory Document, 2012, pp21, Retrieved from http://www.abcb.gov.au

Figure 1. User guide flowchart



Part 2 - Flood resilient strategies

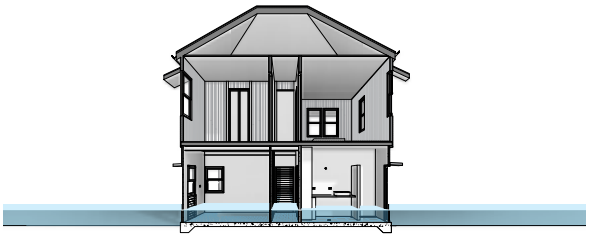
Sectional perspectives

The following sectional perspectives illustrate a variety of different resilience strategies applicable to common building typologies in Queensland, both historic and contemporary. The typologies are classified into New and Retrofit categories. The water levels shown in these diagrams indicate a hypothetical flood event.[5]

Sectional perspective 1

New home

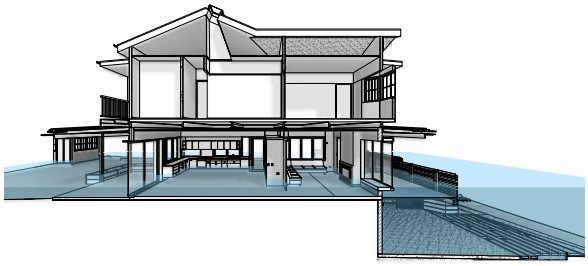
Lightweight | VJ Board



Sectional perspective 2

New home

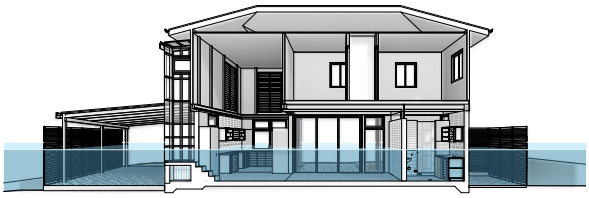
Lightweight | Rendered FC



Sectional perspective 3

New home

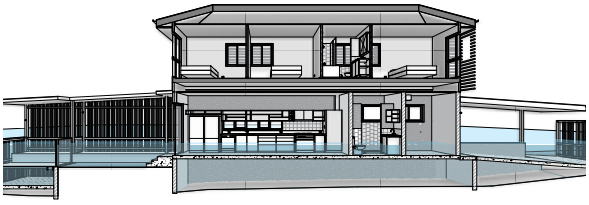
Masonry | Rendered Concrete Block



Sectional perspective 4

New home

Masonry | Rendered AAC Block



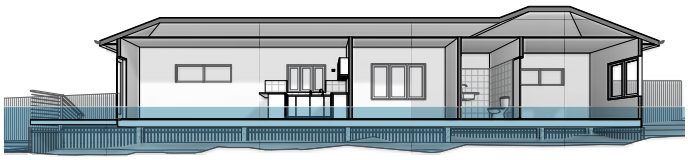
[5] The Requirements of the Queensland Development Code must be met with respect to elevation of the finished floor level.

If a home is likely to experience prolonged periods of flood inundation, waterproof measures are recommended rather than water resistant measures.

Sectional perspective 5

Retrofit

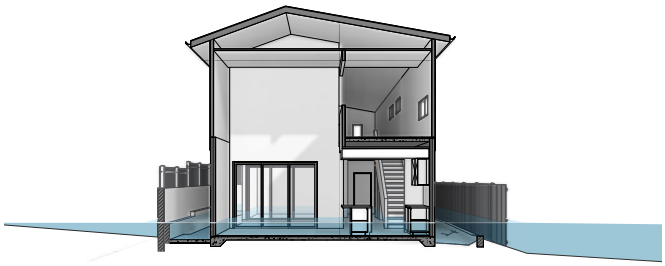
Lightweight | Weatherboard



Sectional perspective 6

Retrofit

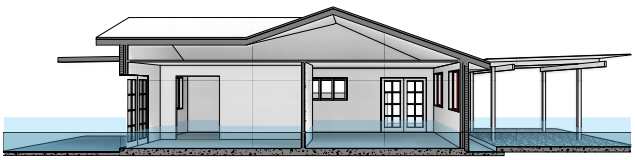
Lightweight | Rendered FC



Sectional perspective 7

Retrofit

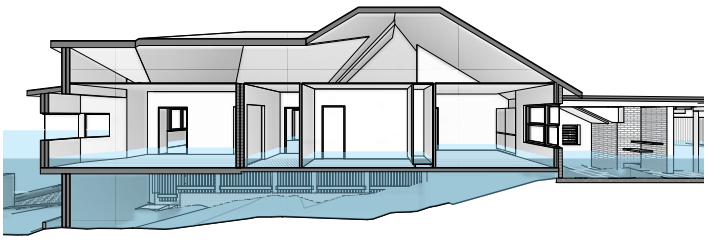
Lightweight | Brick Veneer



Sectional perspective 8

Retrofit

Lightweight | Double Brick

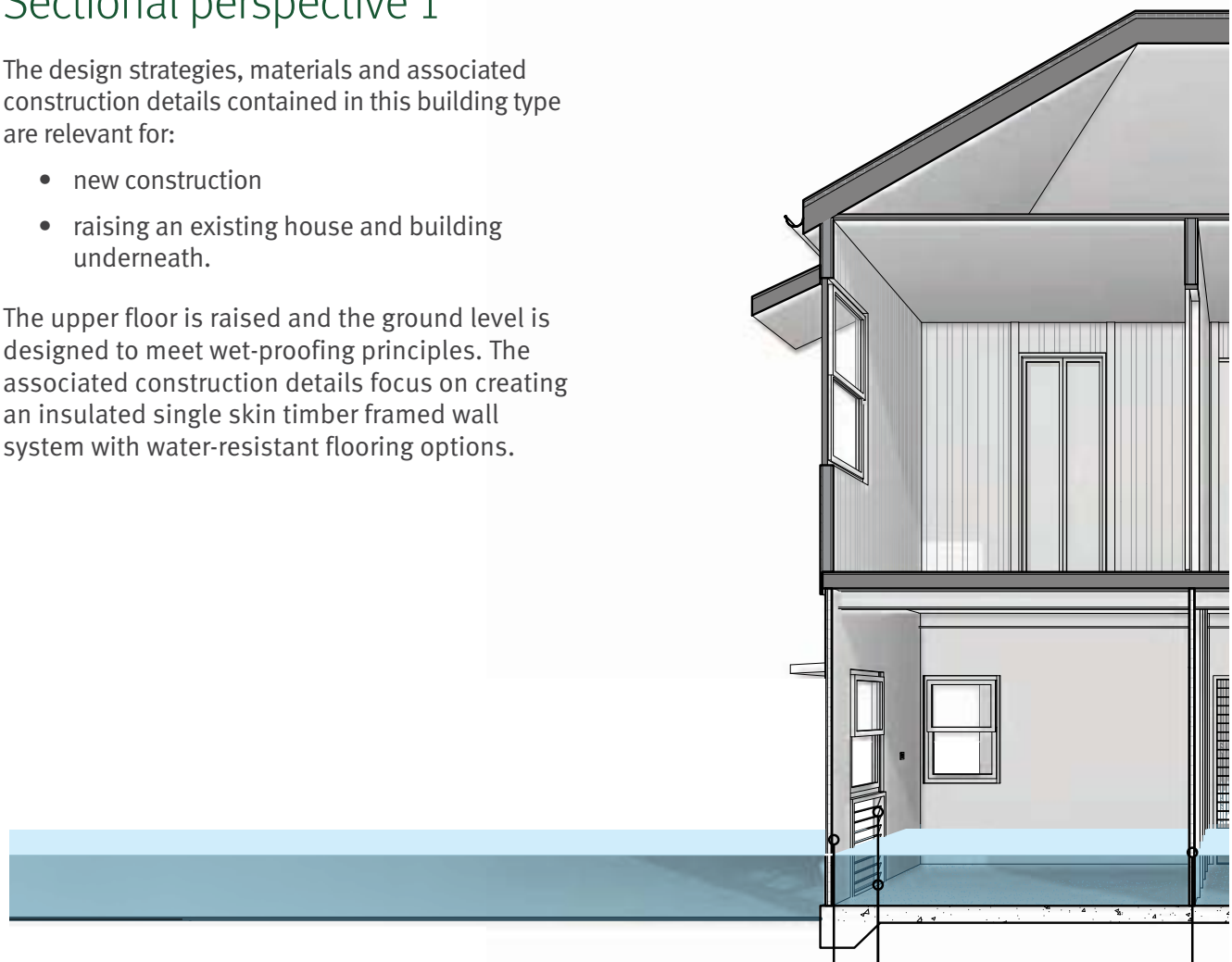


Sectional perspective 1

The design strategies, materials and associated construction details contained in this building type are relevant for:

- new construction
- raising an existing house and building underneath.

The upper floor is raised and the ground level is designed to meet wet-proofing principles. The associated construction details focus on creating an insulated single skin timber framed wall system with water-resistant flooring options.



Detail NL-101

External wall with exposed hardwood framing.

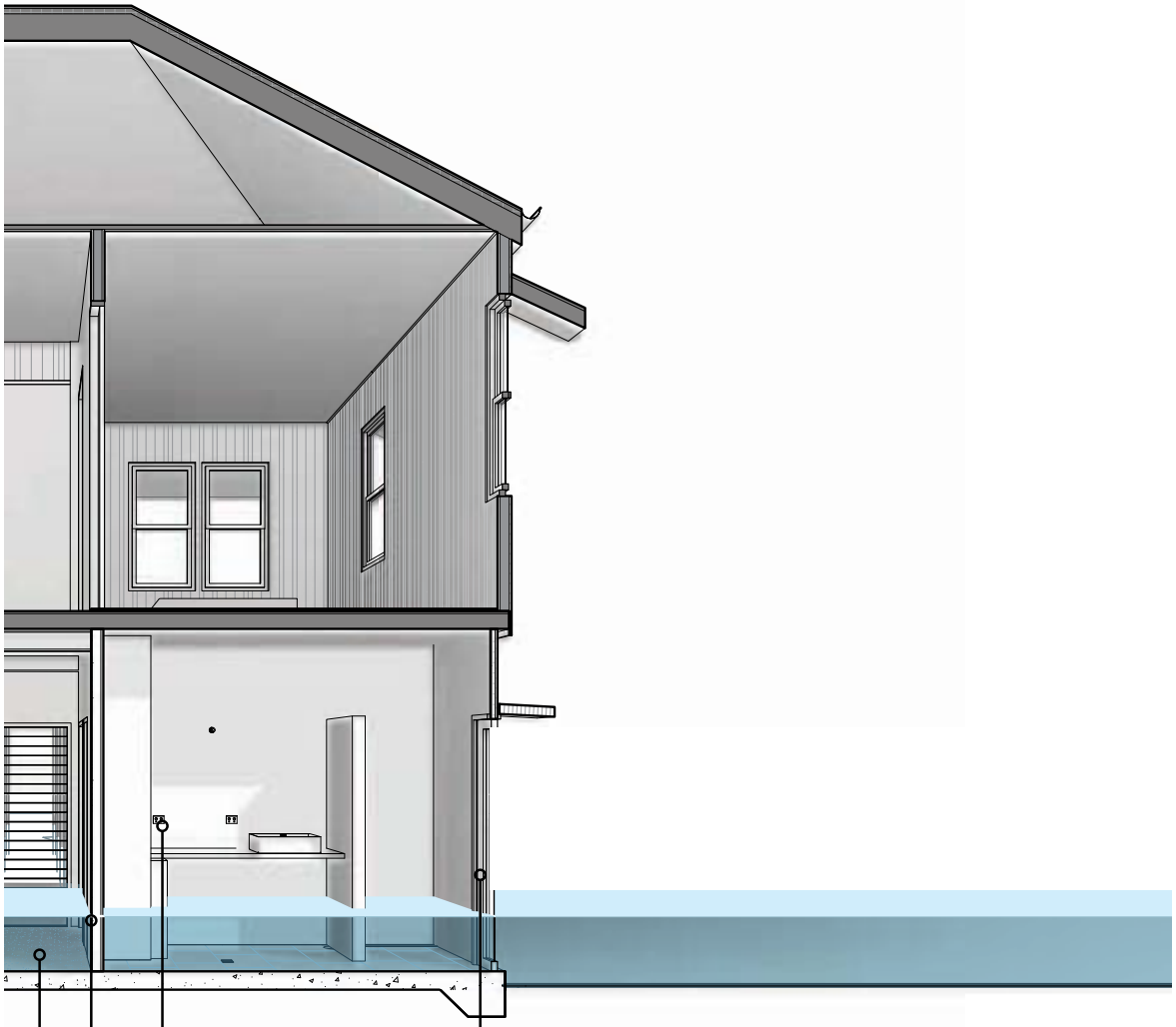
Strategy 13.2 - 13.3

Threshold Detail NT-104

Louver windows and flush thresholds.

Detail NL-401

Lightweight exposed stud internal wall.



Strategy 14.1

Elevated powerpoints and datapoints.

Detail NM-402

Rendered AAC block internal wall.

Strategy 9.1

Polished and sealed concrete slab.

Detail NL-103

External wall with tiled and waterproofed internal face and externally exposed hardwood framing.

Select detail

Select materials & systems

New

Lightweight | VJ Board

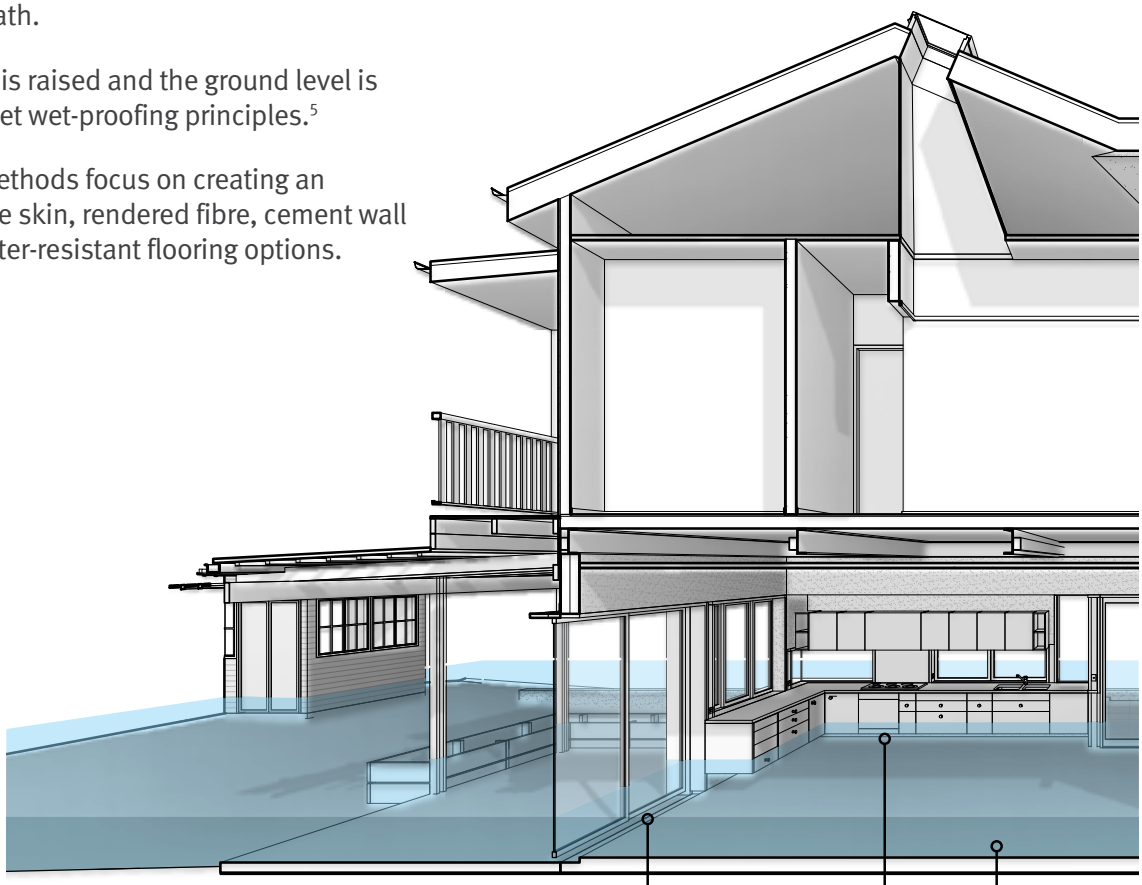
Sectional perspective 2

The design strategies, materials and associated construction details contained in this building type are relevant for:

- new construction
- raising an existing house and building underneath.

The upper floor is raised and the ground level is designed to meet wet-proofing principles.[5]

Construction methods focus on creating an insulated, single skin, rendered fibre, cement wall system with water-resistant flooring options.



Strategy 13.2 - 13.3

Threshold Detail NT-102

Flush threshold recessed into concrete floor.

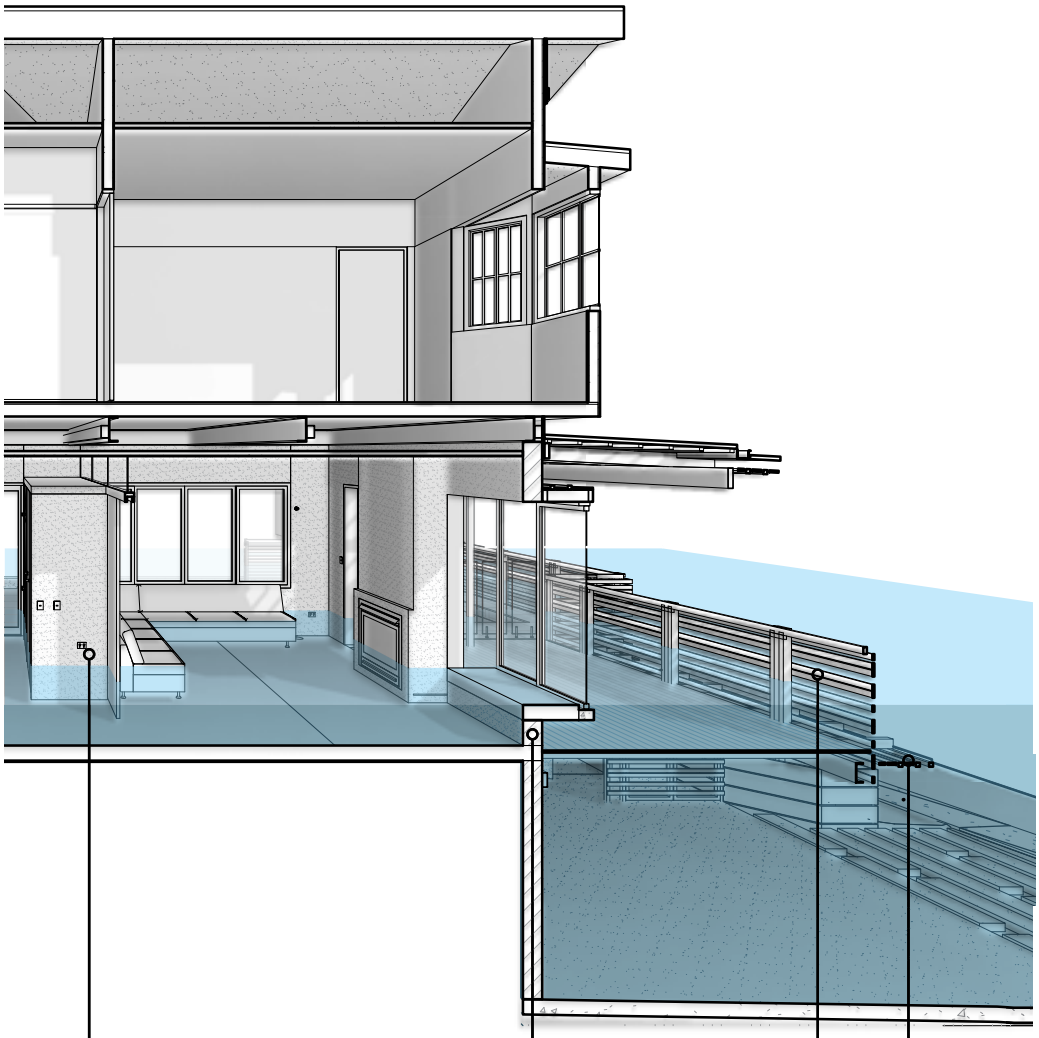
Strategy 15.1

Elevated water-resistant cabinetry.[6]

Strategy 9.1

Polished and sealed concrete slab.

[6] If disconnection and reconnection of plumbing is required, this must be undertaken by a licensed professional.



Rendered FC metal sheeting

Select detail

N.B
Translucent sheeting can be used

Select materials & systems

Detail NL-201

External rendered fibre cement wall.

Strategy 1.2

Permeable hardwood screening.

Strategy 1.6

Hardwood decking and structure.

Strategy 14.1

Elevate powerpoints and datapoints.

New

Lightweight | Rendered FC

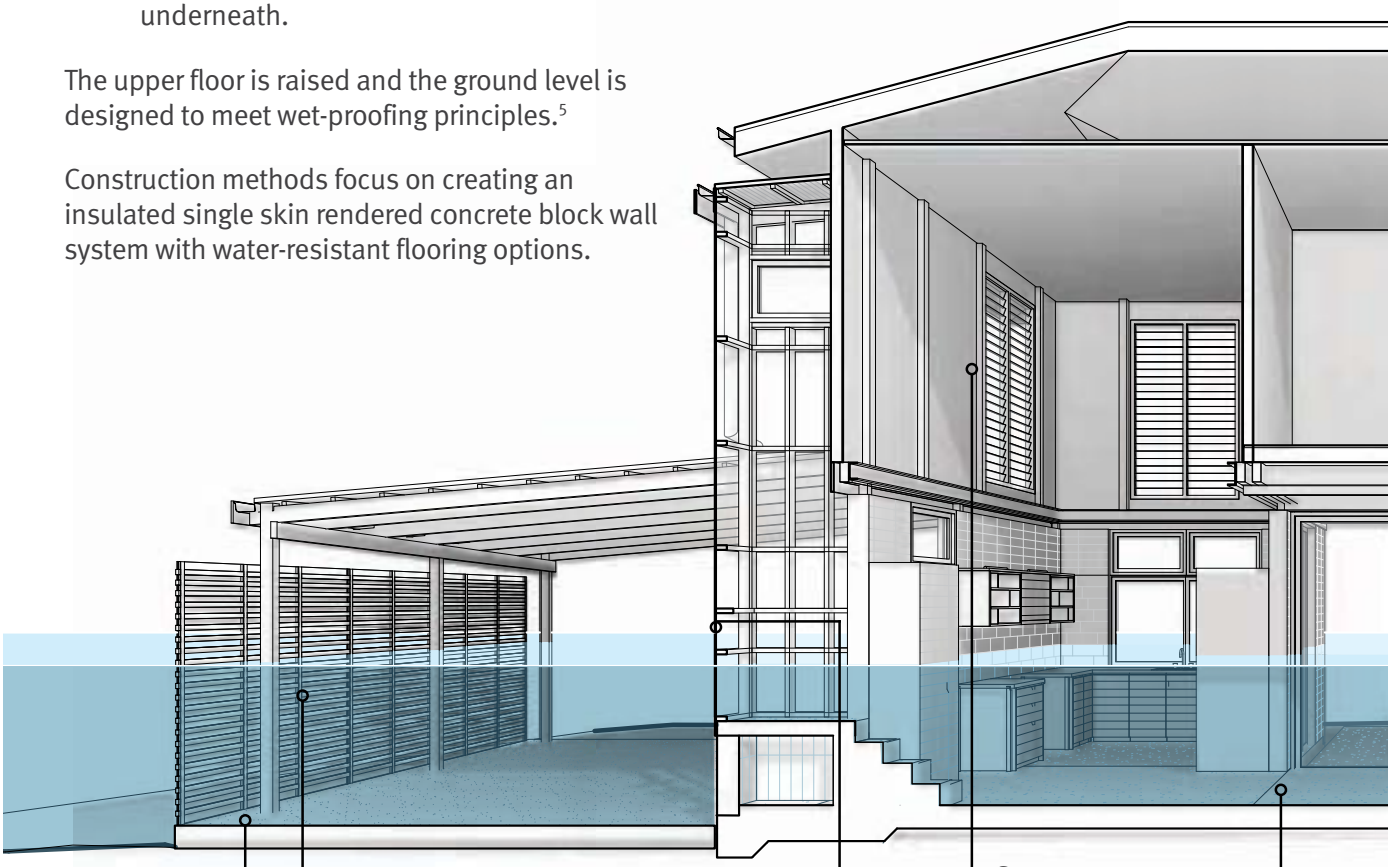
Sectional perspective 3

The design strategies, materials and associated construction details contained in this building type are relevant for:

- new construction
- raising an existing house and building underneath.

The upper floor is raised and the ground level is designed to meet wet-proofing principles.[5]

Construction methods focus on creating an insulated single skin rendered concrete block wall system with water-resistant flooring options.



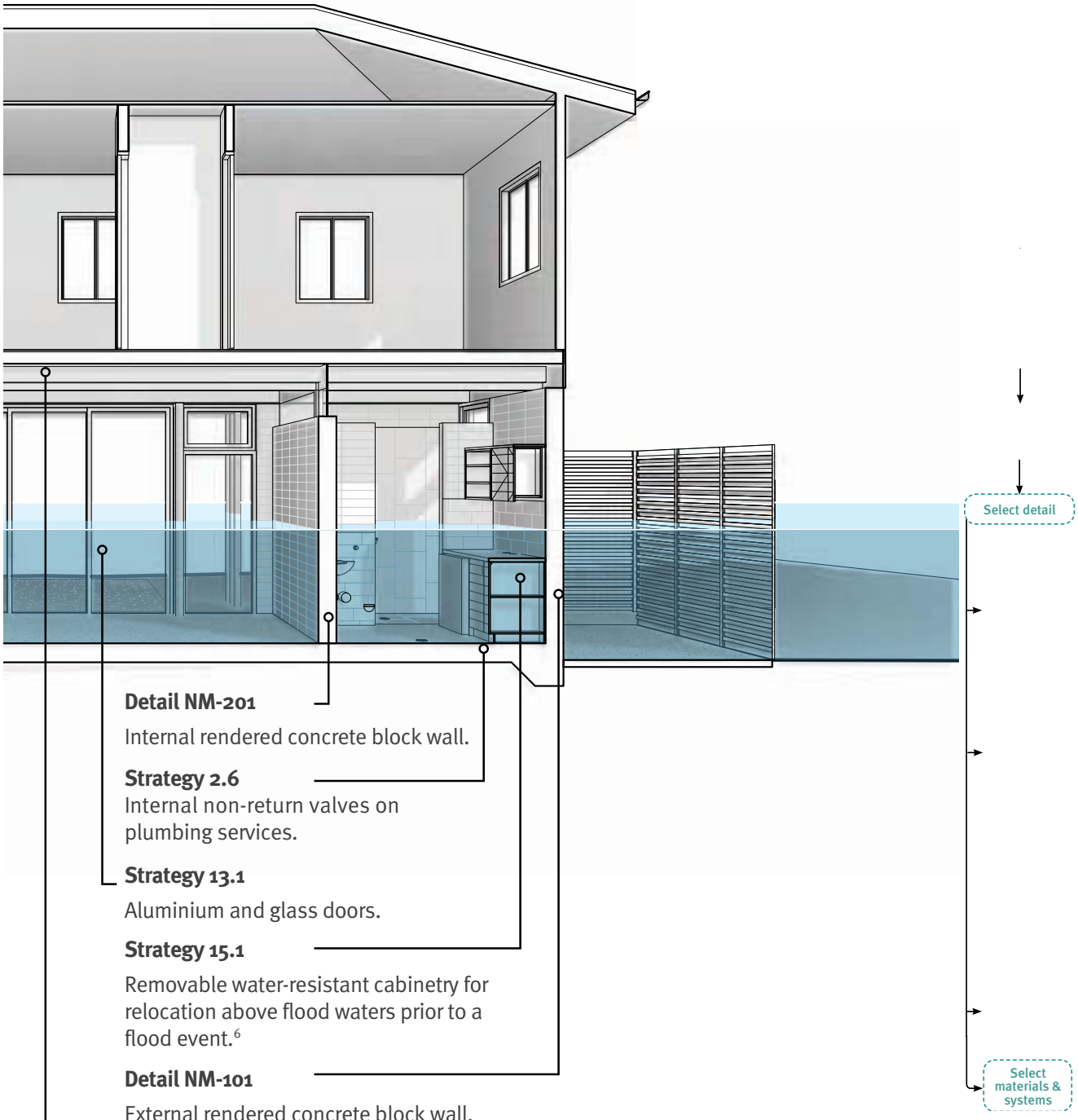
Strategy 1.2
Permeable hardwood screening.

Strategy 1.8
External hard landscaping falls away from the house.

Strategy 9.1
Polished and sealed concrete slab.

Strategy 9.3
Internal void to allow the relocation of contents upstairs prior to a flood event.

Detail NL-301
Stud wall with exposed hardwood framing adjacent a non-habitable space.



Detail NM-201

Internal rendered concrete block wall.

Strategy 2.6

Internal non-return valves on plumbing services.

Strategy 13.1

Aluminium and glass doors.

Strategy 15.1

Removable water-resistant cabinetry for relocation above flood waters prior to a flood event.[6]

Detail NM-101

External rendered concrete block wall.

Strategy 9.2

No ceiling linings to steel or hardwood structure (depending on flood heights).

New

Masonry | Rendered Concrete Block

Sectional perspective 4

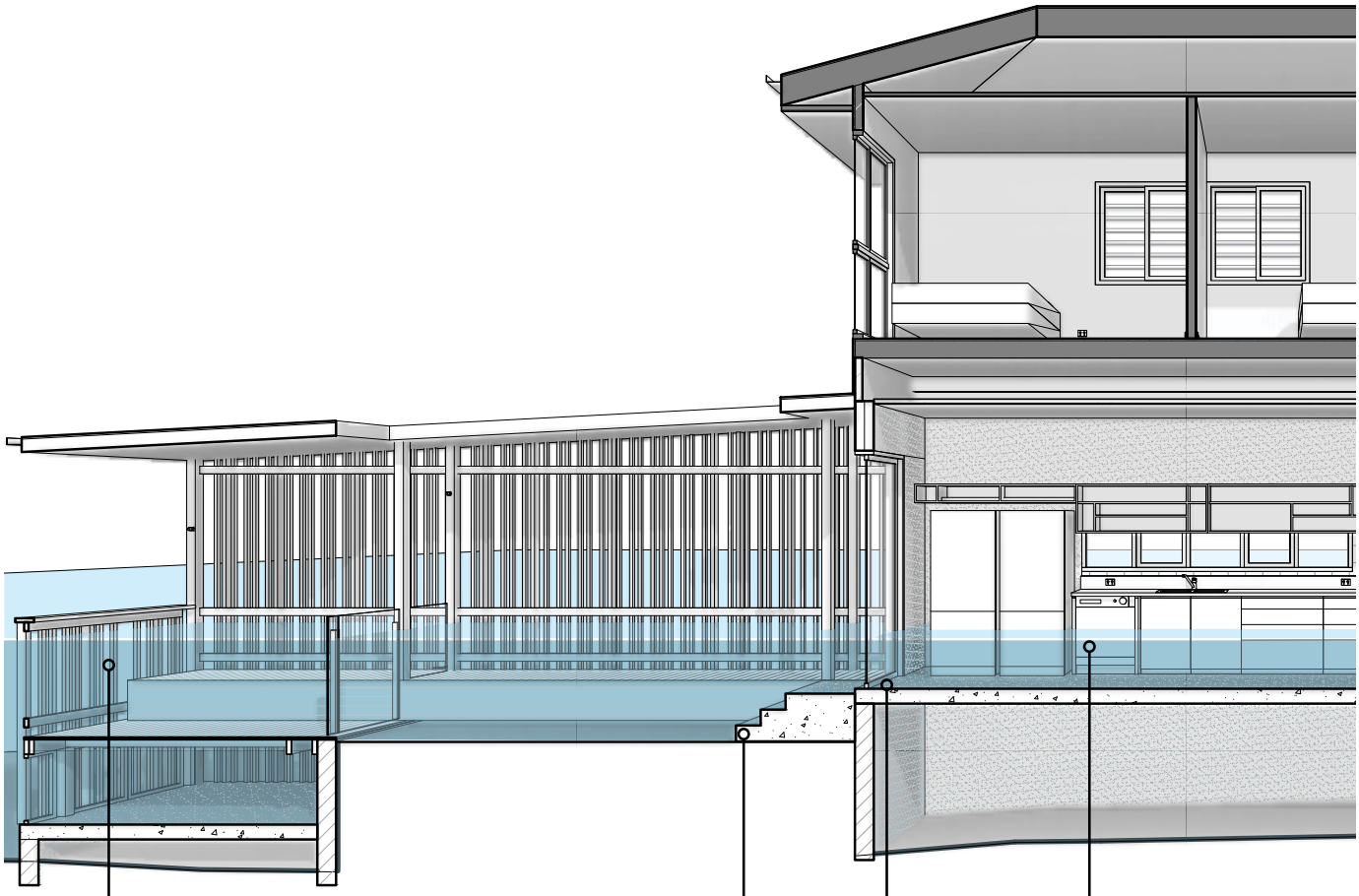
The design strategies, materials and associated construction details contained in this building typology are relevant for:

- new construction
- raising an existing house and building underneath.

The upper floor is raised and the ground level is designed to meet wet-proofing principles.[5]

Construction methods focus on creating an insulated single skin rendered Autoclaved Aerated Concrete (AAC) panel wall system, with water-resistant flooring options.

Given its aerated composition, the AAC system provides the highest thermal rating of all wall systems presented in this guidance. This system includes a concrete render surface treatment which ensures water resistance.



Strategy 3.9

Durable and water-resistant stairs without cavities under.

Threshold Detail NT-102

Strategy 13.2 -13.3

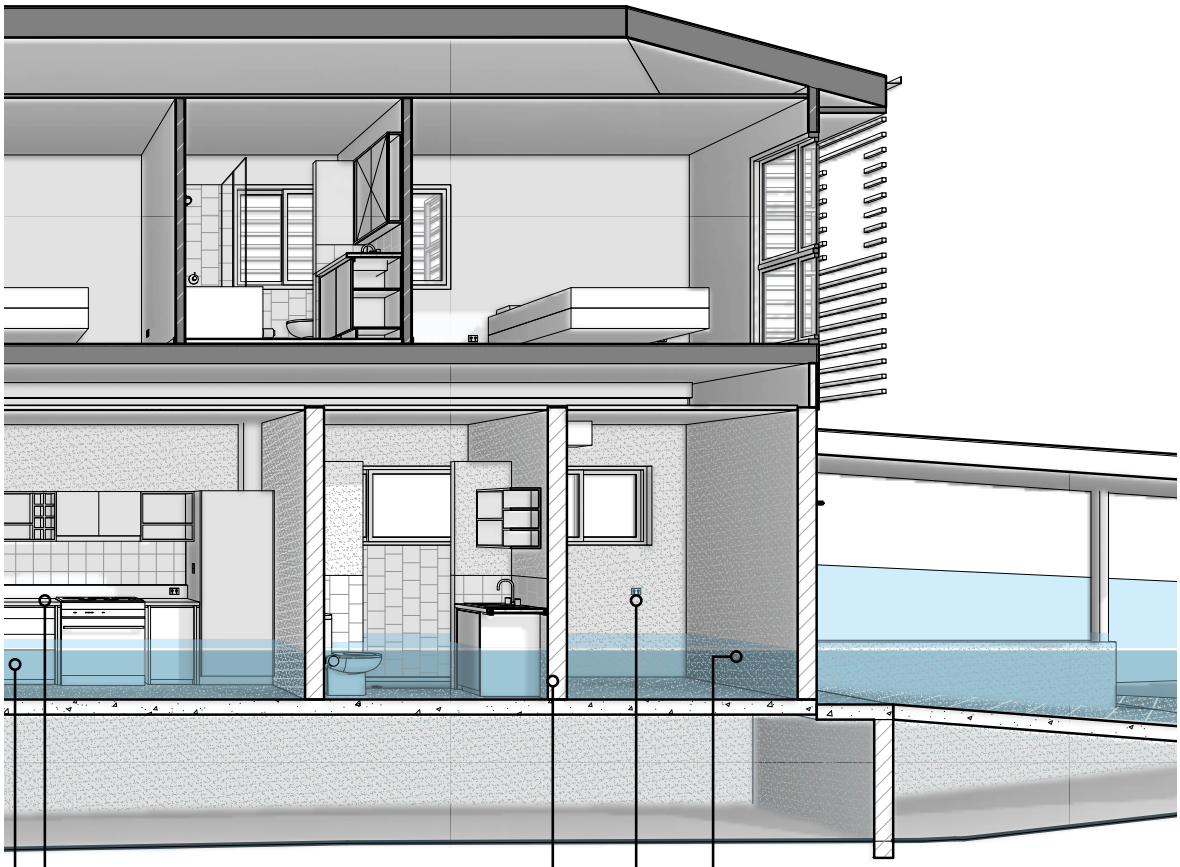
Flush threshold recessed into concrete floor.

Strategy 1.2

Permeable hardwood screening.

Strategy 15.2

Stand-alone appliances can be easily removed and relocated above flood waters prior to a flood event.



Select detail

Detail NM-403

Internal rendered autoclaved aerated concrete (AAC) block walls.

Strategy 15.1

Water-resistant benchtop on independent steel frame.

Strategy 15.1

Removable water-resistant cabinetry for relocation above flood waters prior to a flood event.[6]

Detail NM-301

External rendered autoclaved aerated concrete (AAC) block walls.

Strategy 14.1

Elevate powerpoints and datapoints.

Select materials & systems

New

Masonry | Rendered AAC Block

Sectional perspective 5

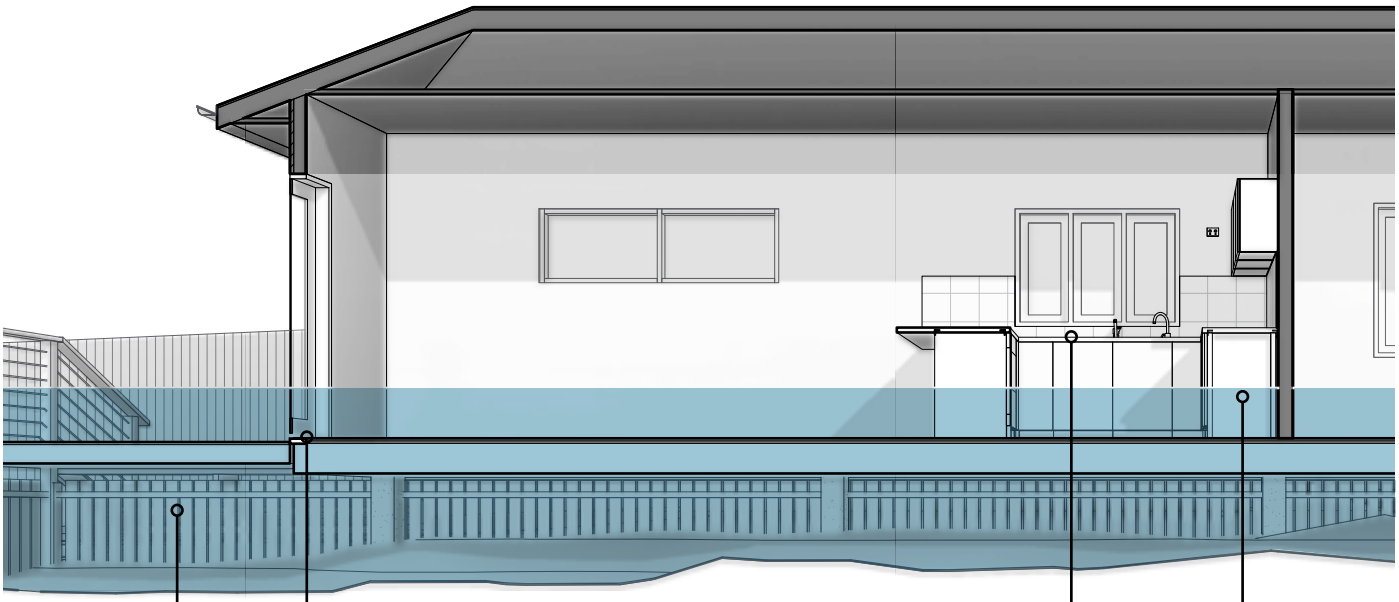
The design strategies, materials and associated construction details contained in this building type are relevant for:

- retrofitting an existing lightweight timber or steel framed house.

Retrofitting an existing house for flood resilience is more complicated than new building construction.

Where an enclosed space exists inside walls, it is almost impossible to keep water out of the exterior walls, which can lead to mould growth inside the wall over time. Construction methods follow the principle that it is more effective to introduce better ventilation systems for airflow into the space inside exterior walls so that water can easily escape and the space inside the wall can quickly dry out after a flood.

Construction details align with industry building standards. In addition, greater use of waterproofing is recommended to protect existing timber wall structure.



Strategy 15.1

Water-resistant benchtop on independent steel frame.

Strategy 15.1

Removable water-resistant cabinetry for relocation above flood waters prior to a flood event.[6]

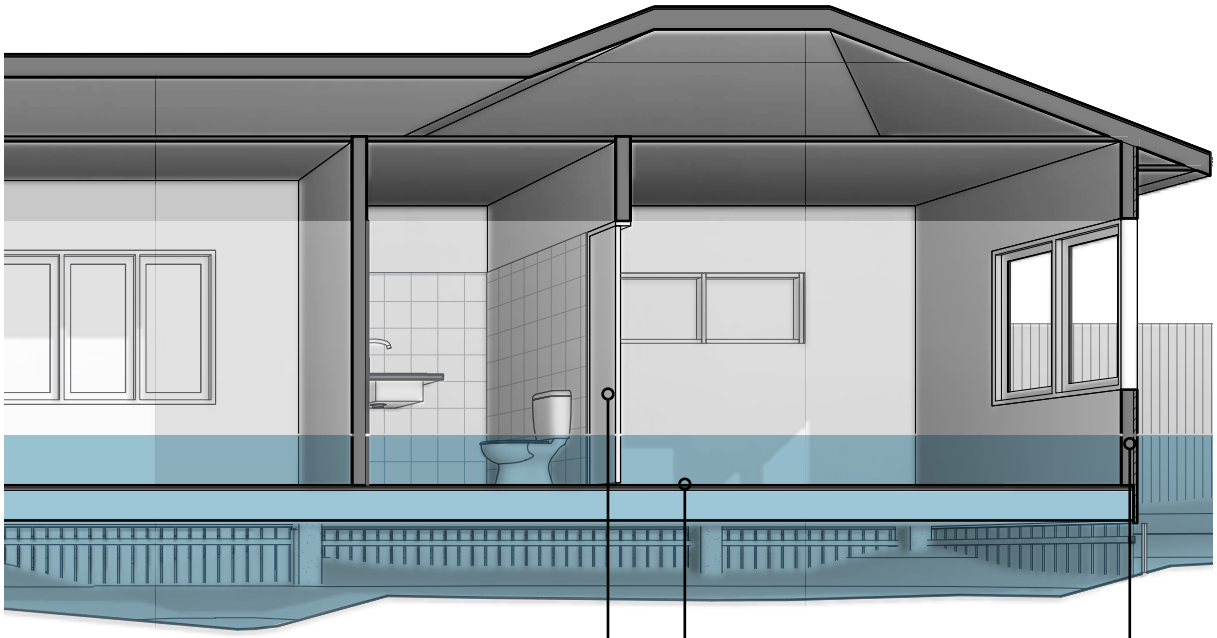
Strategy 13.2 - 13.3

Threshold Detail NT-103

Flush threshold recessed into concrete floor.

Strategy 1.2

Existing permeable hardwood screening is water-resistant.



Select detail

Select materials & systems

Strategy 13.1

Replace hollow core doors with solid core.[7]

Strategy 9.1

Existing hardwood floors are water-resistant.[8]

Detail RL-103

Replace weatherboard cladding below flood line with new cement composite cladding. Spray existing structural members with flexible, waterproof membrane.[9] Replace existing batt insulation with new rigid cell insulation.[10]

Retrofit

Lightweight | Weatherboard

[7] Some solid core doors are susceptible to water damage (e.g. craftwood).

[8] Waterproof flooring may impede drying when placed over timber (plywood). These floors may require special attention to drying and/or repair/replacement.

[9] Ensure membrane covers structural members in their entirety.

[10] Where insulation is fixed to timber frames, water proofing of the frame and ventilation are critical to the prevention of mould build up and deterioration of the frame. Professional advice should be sought to ensure that there is sufficient ventilation to allow the inside of the wall to dry quickly after inundation, taking into account capillary action.

Sectional perspective 6

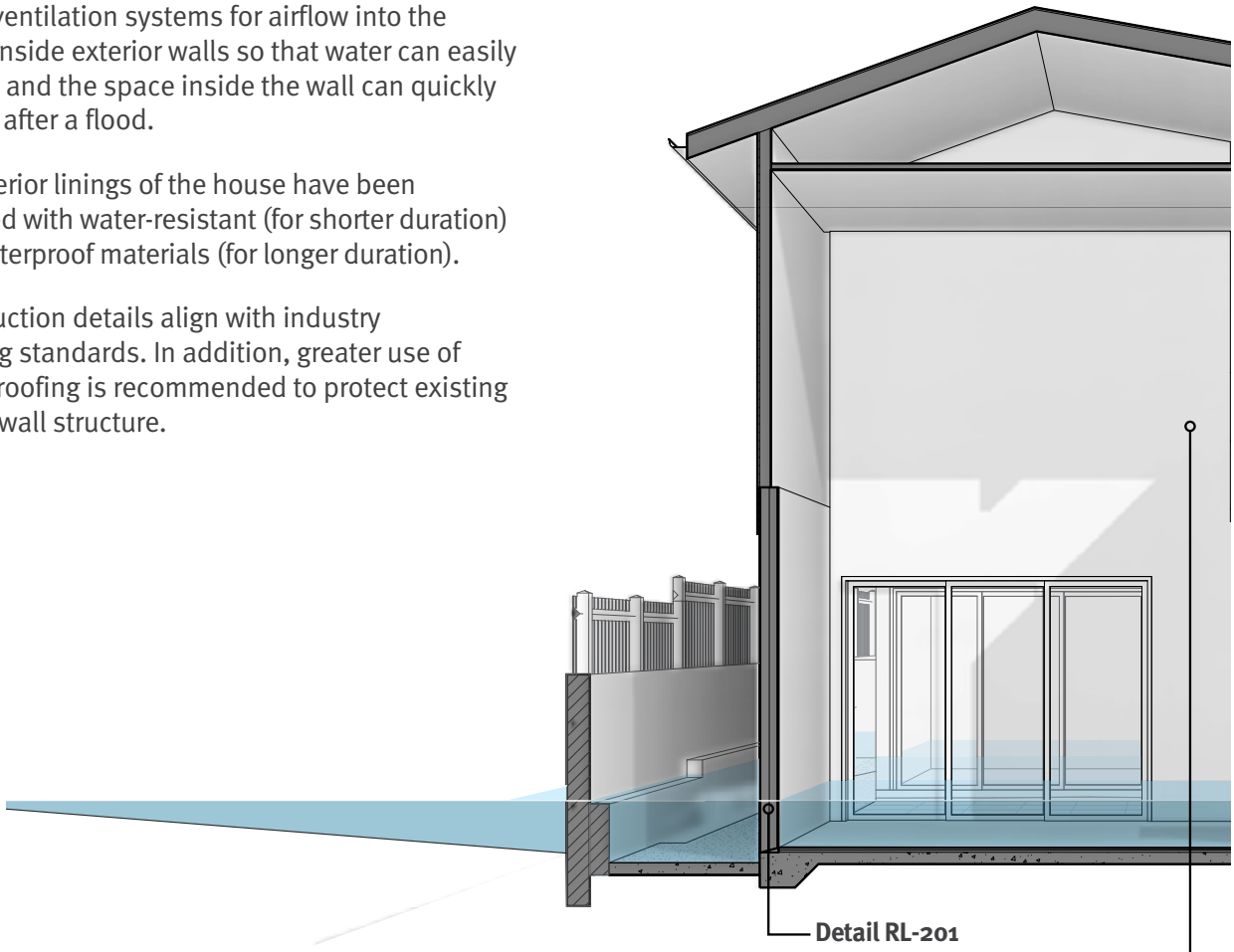
The design strategies, materials and associated construction details contained in this building type are relevant for:

- retrofitting an existing lightweight timber or steel framed house with rendered fibre cement sheet cladding.

Where an enclosed space exists inside walls, it is almost impossible to keep water out of the exterior walls, which can lead to mould growth inside the wall over time. Construction methods follow the principle that it is more effective to introduce better ventilation systems for airflow into the space inside exterior walls so that water can easily escape and the space inside the wall can quickly dry out after a flood.

The interior linings of the house have been replaced with water-resistant (for shorter duration) and waterproof materials (for longer duration).

Construction details align with industry building standards. In addition, greater use of waterproofing is recommended to protect existing timber wall structure.

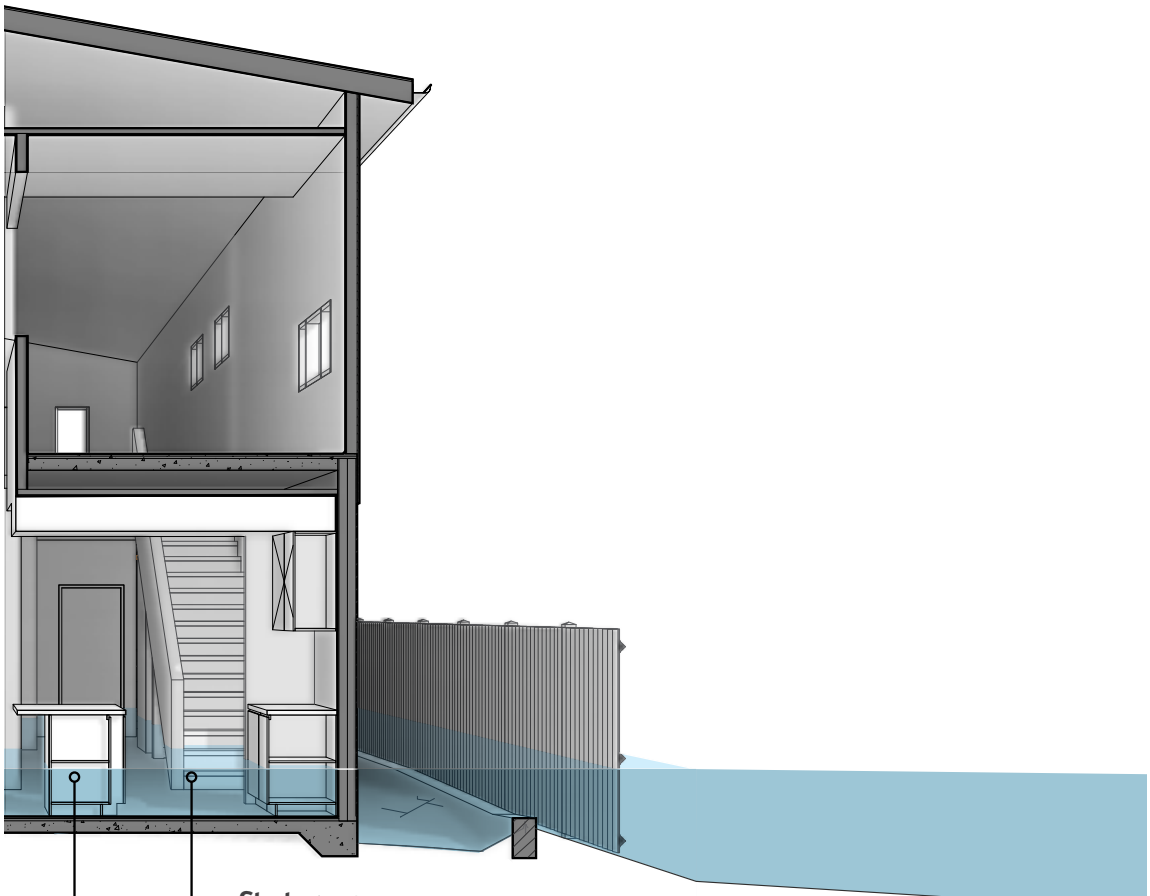


Detail RL-201

Retain existing rendered fibre cement cladding. Replace batt insulation with new closed cell rigid insulation. Replace non-water-resistant internal wall lining with water-resistant wall lining.[10]

Strategy 9.3

Internal void to assist in relocation of contents upstairs prior to a flood event.



Strategy 12.1

Retrofit stair to allow for open, bolt-fixed removable treads.

Strategy 15.1

Install elevated or removable water-resistant cabinetry.[6]

Select detail

Select materials & systems

Retrofit

Lightweight | Rendered FC

Sectional perspective 7

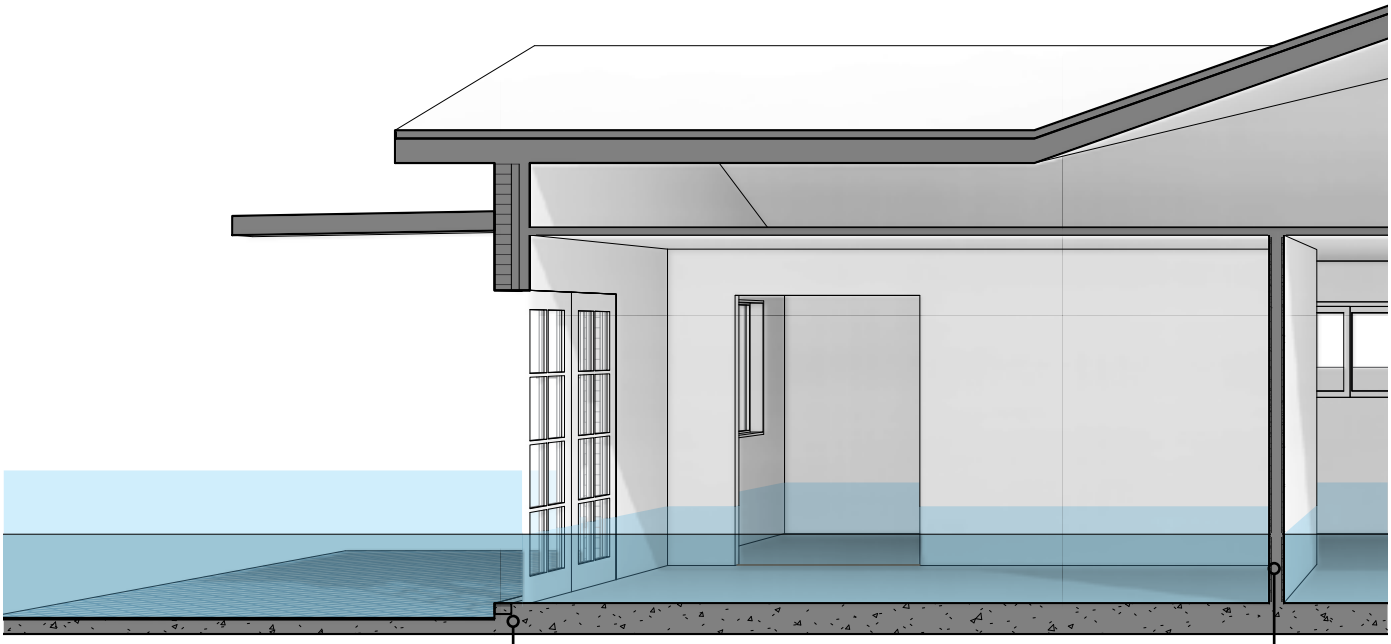
The design strategies, materials and associated construction details contained in this building type are relevant for:

- retrofitting an existing concrete slab-on-ground brick veneer home.

Where an enclosed space exists inside walls, it is almost impossible to keep water out of the exterior walls, which can lead to mould growth inside the wall over time. Construction methods follow the principle that it is more effective to introduce better ventilation systems for airflow into the space inside exterior walls so that water can easily escape and the space inside the wall can quickly dry out after a flood.

The interior linings of the house are replaced with water-resistant (for shorter duration) and waterproof materials (for longer duration).

Construction details align with industry building standards.



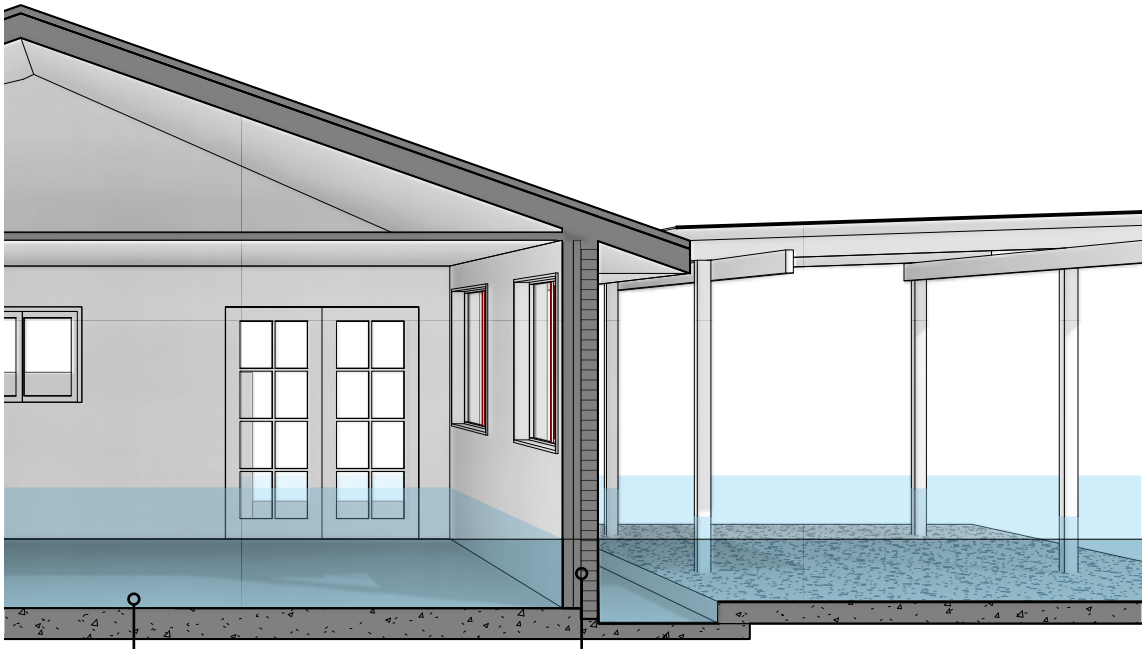
Strategy 13.2 - 13.3

Threshold Detail NT-103

Door sills set down into concrete.

Detail RL-301

Existing stud walls retrofitted. Replace batt insulation with new closed cell rigid insulation. Replace non-water-resistant internal wall lining with water-resistant wall lining.[10]



Select detail

Detail RM-102

Existing brick veneer walls retrofitted. Replace batt insulation with new closed cell rigid insulation. Replace non-water-resistant internal wall lining with water-resistant wall lining.[10]

Select materials & systems

Strategy 9.1

Remove non-resilient materials to reveal existing concrete slab. Seal existing concrete or install resilient flooring.

Retrofit

Masonry | Brick Veneer

Sectional perspective 8

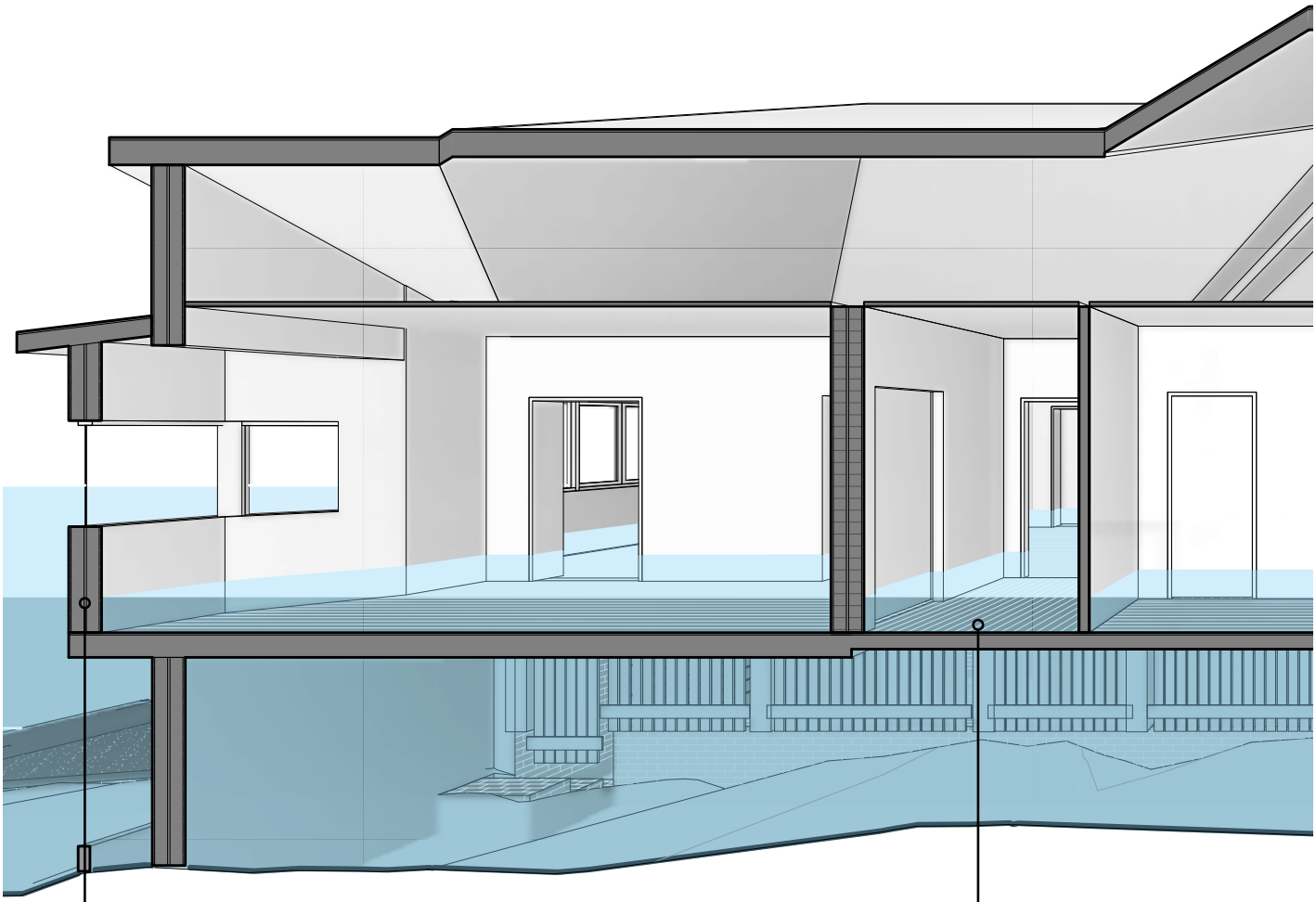
The design strategies, materials and associated construction details contained in this building type are relevant for:

- retrofitting an existing double-brick house with an elevated timber frame.

Where an enclosed space exists inside walls, it is almost impossible to keep water out of the exterior walls, which can lead to mould growth inside the wall over time. Construction methods follow the principle that it is more effective to introduce better ventilation systems for airflow into the space inside exterior walls so that water can easily escape and the space inside the wall can quickly dry out after a flood.

The interior linings of the house are replaced with water-resistant (for shorter duration) and waterproof materials (for longer duration).

Construction details align with industry building standards.



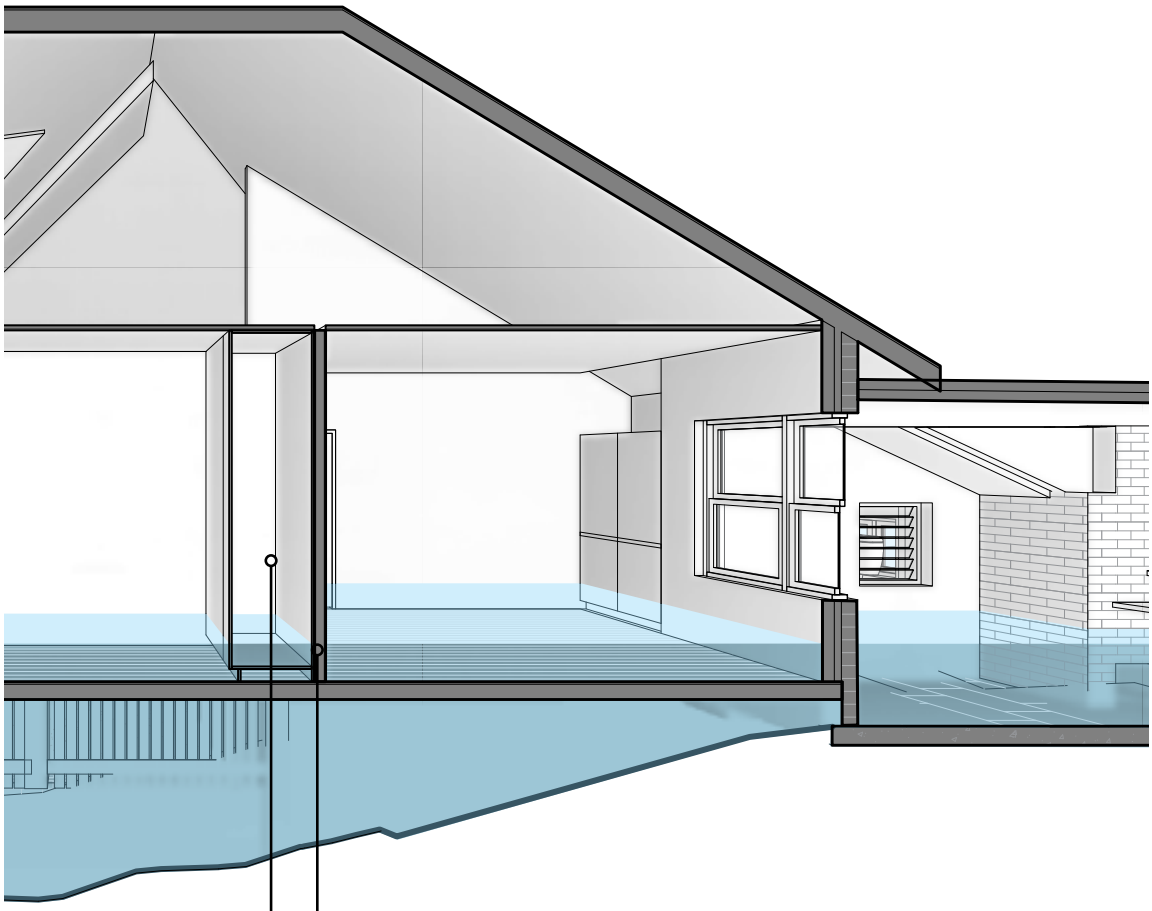
Detail RM-201

Existing double brick to be retained.
Additional weep holes to be added.[11]

Strategy 9.1

Remove non-water-resistant floor material to reveal existing floor structure. Install resilient flooring.[8]

[11] Adequate ventilation is critical to allow airflow inside the exterior walls in order to prevent mould build up. Mechanical ventilation may be considered to circulate airflow and assist in allowing the space inside the walls to dry quickly.



Select detail

Select materials & systems

Detail RL-301

Existing stud wall framing to be retained and sprayed with flexible, waterproof membrane. Existing internal wall lining to be replaced with new water-resistant wall lining to above flood level.

Strategy 15.1

Install elevated or removable water-resistant cabinetry.[6]

Retrofit

Masonry | Double Brick

Flood resilient strategy table

The following strategies in the *flood resilient strategy table* have been organised according to building element type as follows:

1 Landscaping

2 External services

3 External cladding and structure

4 Double brick construction

5 Brick veneer construction

6 Wall framing

7 Insulation

8 Internal structural members

9 Internal floors and ceilings

10 Internal walls

11 Wet areas

12 Internal stairs

13 Doors and windows

14 Internal services - electrical

15 Cabinetry.

The following additional considerations are applicable to some of the strategies outlined in the following table

(#) Strategy may be within the scope of the Building Assessment Provisions. Local governments may only refer to this guidance material as an optional matter for consideration in the assessment of building work.

(*) Strategy may require planning approval. Reference should be made to local planning provisions to ensure legislative requirements are met.

(^) Strategy requires advice from a landscape architect.

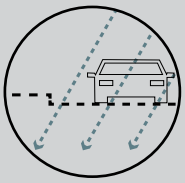
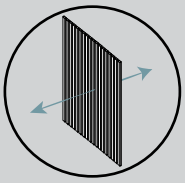
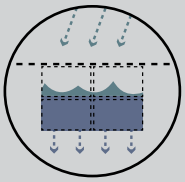
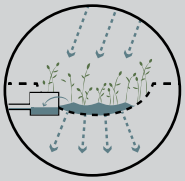
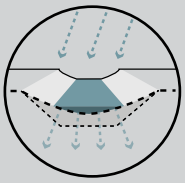
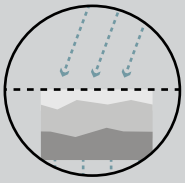
(+) Strategy requires advice from a registered RPEQ Structural Engineer.

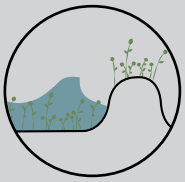
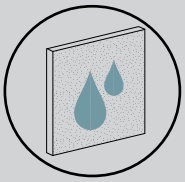
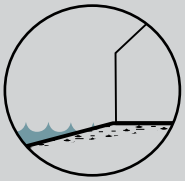
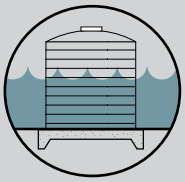
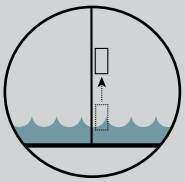
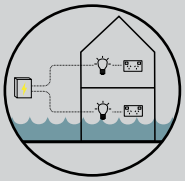
(=) Suitable for retrofit only.

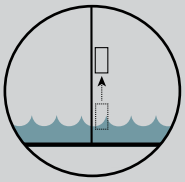
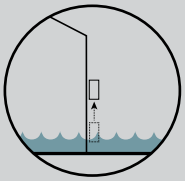
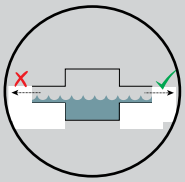
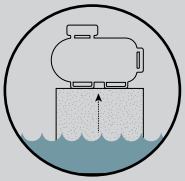
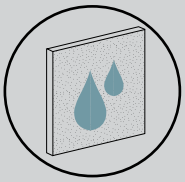
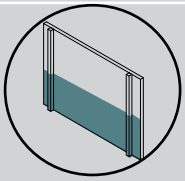
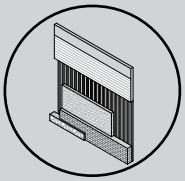
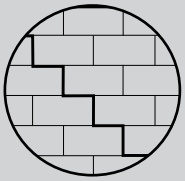
(X) Ensure no adverse impact on neighbouring properties.

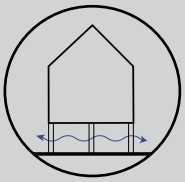
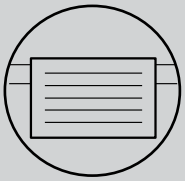
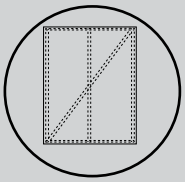
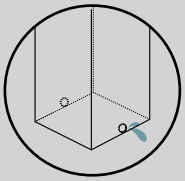
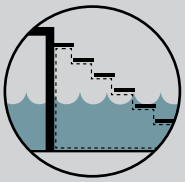
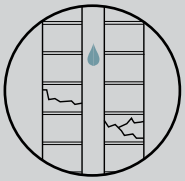
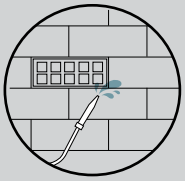
(|) Strategy requires advice from a registered RPEQ Civil and/or Hydraulic Engineer.

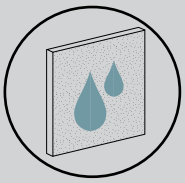
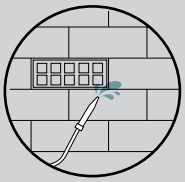
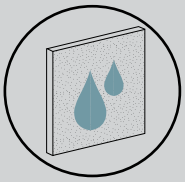
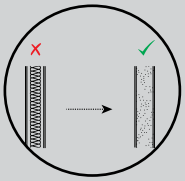
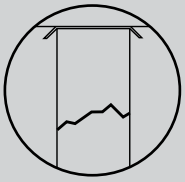
The requirements of the Building Assessment Provisions must be met with respect to safeguards against illness and disability access.

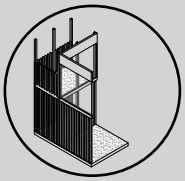
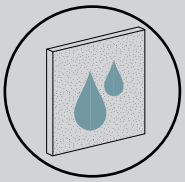
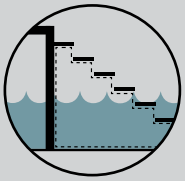
Strategy reference	Flood resilient strategy	Diagram
1	**Landscaping**	
1.1	**Reduce impervious surface areas** • use pervious pavement materials • reduce the length and width of large paving areas such as driveways • use water resilient materials. Note: Consult a registered RPEQ Structural Engineer if expansive soils and if close to dwelling.	Pervious paving 
1.2	**Permeable fencing to allow flood waters through** Flood damage to fences can be avoided by ensuring the fence is water permeable and made of a resilient material.	
1.3	**Localised yard-based drainage solution** ^ # ⓘ * X The following drainage solutions can be considered: • swale • surface drain • spoon drain • trench and channel drain • infiltration box or tank system • infiltration plane system • detention basin or dry pond. Note: Consult a registered RPEQ Structural Engineer if expansive soils and if close to dwelling.	Infiltration box  Detention basin 
1.4	**Bioswale and/or rain garden system** **Bioswale** ^ # * Bioswales are a landscaping feature used to slow, collect and filter flood waters. Bioswales help to redirect flood water away from the house. NOTE: Consult a Landscape Architect **Rain garden** ^ * # Rain gardens collect water and are vegetated with water plants. Note: Consult a registered RPEQ Structural Engineer if expansive soils and if close to dwelling.	Bioswale  Rain garden 

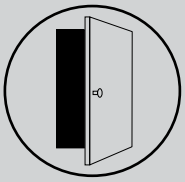
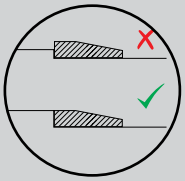
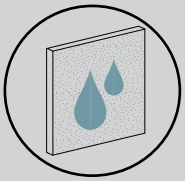
Strategy reference	Flood resilient strategy	Diagram
1.5	**Berms** ^ * # X Berms are small landscaped mounds covered in vegetation that help to divert flood waters. Strategically placed berms can divert flood water away from the house while maintaining existing flow paths so as to not adversely impact neighbouring properties.	
1.6	**Water-resistant materials** X Refer to the **Flood resilient materials table and product listing** *for a list of water-resistant materials suitable for landscaping*.	
1.7	**Relocate yard based structures** ^ + # Consult a landscape architect and/or a registered RPEQ Structural Engineer for recommendations.	
1.8	**Yard levels** ^ * # X Strategically placed yard levels can divert flood water away from the house while maintaining existing flow paths so as to not adversely impact neighbouring properties.	
1.9	**Rainwater tanks** # Rainwater tanks collect and store stormwater that otherwise may contribute to flooding. The collected water may then be used to water gardens.	
2	**External services**	
2.1	**Anchor rainwater tanks and relocate if necessary** # Floods have the ability to uplift rain water tanks and sweep them downstream toward other properties.	
2.2	**Elevate the electrical meter board** # Ensure the electrical meter board and all other services are installed above the possible flood line.	
2.3	**Install separate circuits (with breakers) on ground and upper levels** #	

Strategy reference	Flood resilient strategy	Diagram
2.4	**Elevate the air conditioner condenser** (#) Ensure the air conditioner condenser and all other services are installed above the possible flood line.	
2.5	**Elevate the hot water unit** (#) Ensure the hot water unit and all other services are installed above the possible flood line.	
2.6	**Install non-return valves** (#) Consult your water provided to ensure a non-return valve is installed for the stormwater and sewer pipes servicing the property.	
2.7	**Elevate the pool pump and electrical power systems** (#) Ensure the pool pump and all other services are installed above the possible flood line.	
3	**External cladding and structure**	
3.1	**Install water-resistant external cladding** (#) Refer to the **Flood resilient materials table and product listing** for a list of water-resistant materials for external cladding.	
3.2	**Use single skin construction systems** (#) New construction should incorporate single skin construction systems that can be easily cleaned after floods, and do not contain cavity spaces where mould can grow.	
3.3	**Use composite construction systems** (#) New construction should incorporate single skin construction systems below the possible flood line that can be easily cleaned after floods, and do not contain cavity spaces where mould can grow.	
3.4	**Consult a registered RPEQ Structural Engineer for advice regarding damage to the external structure and cladding** (#)	

Strategy reference	Flood resilient strategy	Diagram
3.5	**Provide adequate drainage and ventilation to the subfloor area** (=) (+) (#) When retrofitting an existing house, install additional air vents or weep holes above the possible flood line to allow wall and subfloor areas to quickly dry out.	
3.6	**Install air vents with automatic water prevention** (=) (+) (#) When retrofitting an existing house, install additional air vents or weep holes above the possible flood line to allow for wall and subfloor areas to quickly dry-out.	
3.7	**Replace water damaged or non-water-resistant structural bracing** (+) (#) (=) Re-install water-resistant bracing. Refer to the **Flood resilient materials table and product listing**.	
3.8	**Allow water to drain from within steel columns** (+) (#) Drill small holes at the base of steel posts to allow water to drain.	
3.9	**Design without cavities under stairs** (#) To enable post-flood clean-out, the following strategies may be appropriate: • remove all cavities under stairs that are below the possible flood line and replace with open bolt-fixed removable treads made of water-resistant materials • replace the existing stair with a solid concrete stair below the possible flood line. Refer to the **Flood resilient materials table and product listing**.	
4	**Double brick construction** (=)	
4.1	**Consult a registered RPEQ Structural Engineer for recommendations on any structural damage to external cladding and structure** (#)	
4.2	**Clean out any blocked weep holes** (+) (#) Ensure all termite protection systems remain intact.	
4.3	**Add more weep holes for water to escape** (+) (#) Note: Consult a registered (RPEQ) Structural Engineer for recommendations.	

Strategy reference	Flood resilient strategy	Diagram
5	**Brick veneer construction** ⊜	
5.1	**Remove non-water-resistant internal linings** # Replace with water-resistant internal linings. Refer to the **Flood resilient materials table and product listing**.	
5.2	**Consult a registered RPEQ Structural Engineer for recommendations on any structural damage** #	
5.3	**Clean out any blocked weep holes** ⊕ # Ensure all termite protection systems remain intact. Note: Consult a registered (RPEQ) Structural Engineer for recommendations.	
5.4	**Add more weep holes for water to escape** ⊕ # NOTE: Consult a registered (RPEQ) Structural Engineer for recommendations.	
6	**Wall framing**	
6.1	**Install water-resistant framing** # ⊕ Refer to the **Flood resilient materials table and product listing**.	
7	**Insulation**	
7.1	**Install suitable closed-cell insulation** # The following closed-cell insulation types may be appropriate: • extruded polystyrene (XPS) • thermoset polyisocyanurate (PIR) • phenolic.	
8	**Internal structural members**	
8.1	**Consult a registered RPEQ Structural Engineer for advice regarding internal structural damage** ⊕ #	

Strategy reference	Flood resilient strategy	Diagram
9	**Internal floors and ceilings**	
9.1	**Install water-resistant flooring** (#) Refer to the **Flood resilient materials table and product listing**.	
9.2	**Design ceilings without linings and cavities** (+) (#) This strategy is only recommended where flood waters reach ceiling height. Ceilings under roofs are typically used as diaphragms for horizontal loading. If removed, an alternative mechanism may be required.	
9.3	**Design internal voids and elevated storage spaces** (#) Internal voids and elevated storage spaces above the possible flood line can be used to relocate house contents out of the way of waters before a flood. Spaces intended for such use need to be designed for appropriate imposed loads.	
10	**Internal walls**	
10.1	**Install water-resistant linings** (#) Refer to the **Flood resilient materials table and product listing**.	
11	**Wet areas**	
11.1	**Avoid baths with low height cavity walls** (#) Alternatives are: • free standing baths that can be cleaned underneath • showers	
12	**Internal stairs**	
12.1	**Design without cavities under stairs** (#) To enable post-flood clean-out, the following strategies may be appropriate: • remove all cavities under stairs that are below the possible flood line and replace with open bolt-fixed removable treads made of water-resistant materials • replace the existing stair with a solid concrete stair below the possible flood line. Refer to the **Flood resilient materials table and product listing**.	

Strategy reference	Flood resilient strategy	Diagram
13	**Doors and windows**	
13.1	**Replace hollow core doors** (#) Replace hollow core doors with: • solid core doors[7] • aluminium and glass doors.	
13.2	**Install flush thresholds** (#) Remove all thresholds which obstruct the drainage and discharge of flood waters from the interior.	
13.3	**Seal all frames to building fabric** (#) (+) Ensure door and window frames are weatherproof sealed to avoid the flood waters coming into the house.	
13.4	**Install corrosion resistant door and window hardware** (#)	
14	**Internal electrical services**	
14.1	**Elevate powerpoints and datapoints** (#) Ensure the powerpoints, datapoints and all other services are installed above the possible flood line.	
15	**Cabinetry**	
15.1	**Install water-resistant cabinetry** (#) Strategies include: • water resistant and waterproof materials • raise cabinetry above the possible flood line • design removable cabinetry below the possible flood line, which is able to be transported to storage areas above the possible flood line[6] • install removable kick plates to enable cleaning under cabinetry. Refer to the **Flood resilient materials table and product listing**.	
15.2	**Install stand-alone appliances** (#) Stand-alone appliances can be easily removed and relocated above the possible flood line.	

Flood resilient construction systems

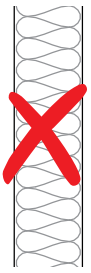
This section contains construction details with reference to suitable flood resilient materials. Refer to the **Flood resilient materials table** for information about the advantages and disadvantages of various material types.

This section provides information about flood resilient construction systems applicable to:

- wet-proofing strategies for new homes
- retrofitting existing homes.[5]

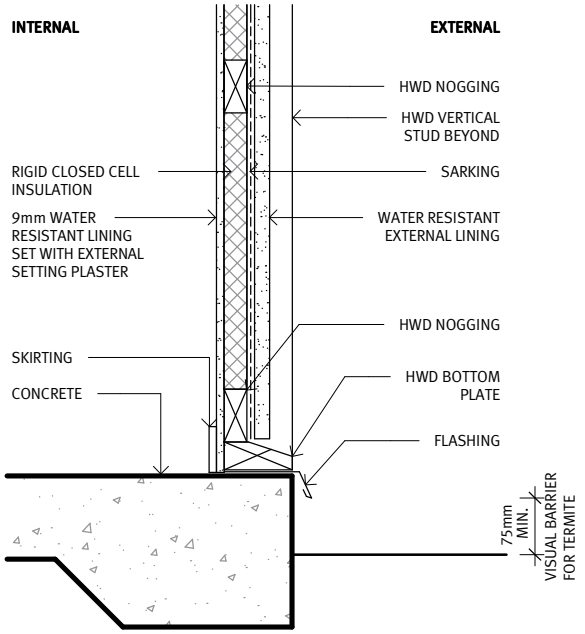
Note: the details on the following pages are not represented to scale.

Closed Cell
Rigid Insulation



Open Cell
Batt Insulation

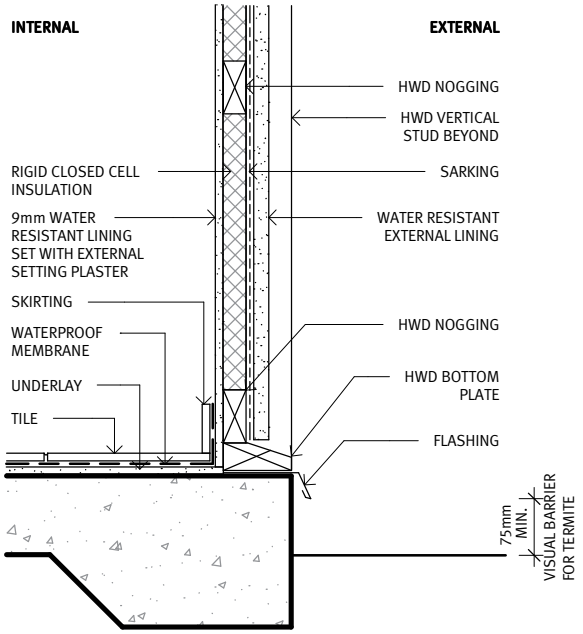
Photo reproduced courtesy of Brisbane City Council and James Davidson Architect



TYPOLOGY:	LIGHTWEIGHT
WALL TYPE:	EXTERNAL | EXPOSED STUD WALL
FLOOR FINISH:	CONCRETE
R-VALUE:	1.52
CODE:	NL-101

Framing:	Hardwood timber
External lining:	Water resistant external lining
Insulation:	Rigid closed cell insulation. Thickness of insulation to match depth of stud frame. Seal edges of insulation to frame.
Internal lining:	9mm water resistant lining set with external setting plaster to above flood level
Skirting:	Hardwood or other water resistant skirting
Floor finish:	Concrete with non-slip penetrative sealant

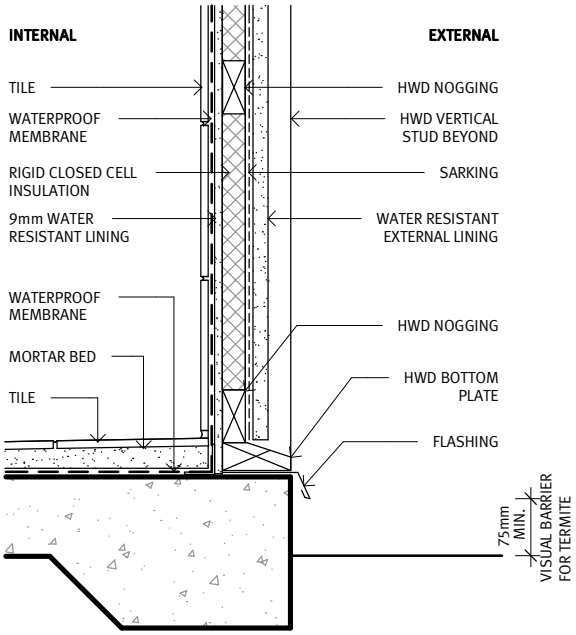
NL-101
External | exposed stud wall
Concrete floor finish



TYPOLOGY:	LIGHTWEIGHT
WALL TYPE:	EXTERNAL | EXPOSED STUD WALL
FLOOR FINISH:	TILE
R-VALUE:	1.52
CODE:	NL-102

Framing:	Hardwood timber
External lining:	Water resistant external lining
Insulation:	Rigid closed cell insulation. Thickness of insulation to match depth of stud frame. Seal edges of insulation to frame.
Internal lining:	9mm water resistant lining set with external setting plaster to above flood level
Skirting:	Tile or other water resistant skirting
Floor finish:	Tile + waterproof membrane + underlay

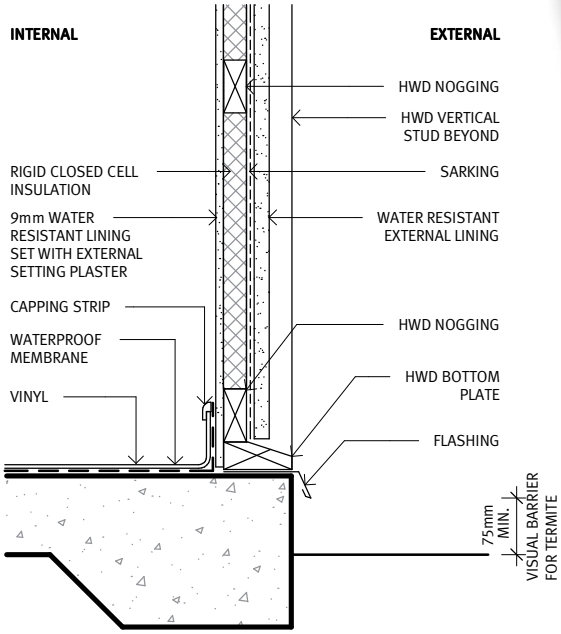
NL-102
External | exposed stud wall
Tile floor finish



TYPOLOGY:	LIGHTWEIGHT
WALL TYPE:	EXTERNAL | EXPOSED STUD WALL
FLOOR FINISH:	TILE | WET AREA
R-VALUE:	1.55
CODE:	NL-103

Framing:	Hardwood timber
External lining:	Water resistant external lining
Insulation:	Rigid closed cell insulation. Thickness of insulation to match depth of stud frame. Seal edges of insulation to frame.
Internal lining:	Tile + waterproof membrane + 9mm water resistant lining to above flood level
Skirting:	N/A
Floor finish:	Tile + bedding + waterproof membrane

NL-103
External | exposed stud wall
Tile floor finish | wet area



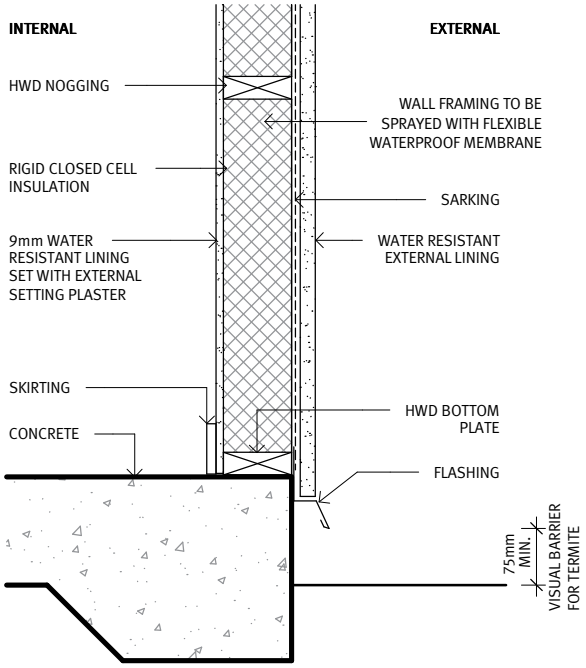
TYPOLOGY:	LIGHTWEIGHT
WALL TYPE:	EXTERNAL | EXPOSED STUD WALL
FLOOR FINISH:	VINYL
R-VALUE:	1.52
CODE:	NL-104

Framing:	Hardwood timber
External lining:	Water resistant external lining
Insulation:	Rigid closed cell insulation. Thickness of insulation to match depth of stud frame. Seal edges of insulation to frame.
Internal lining:	9mm water resistant lining set with external setting plaster to above flood level
Skirting:	Coved vinyl or other water resistant skirting
Floor finish:	Vinyl + waterproof membrane

NL-104
External | exposed stud wall
Vinyl floor finish

New

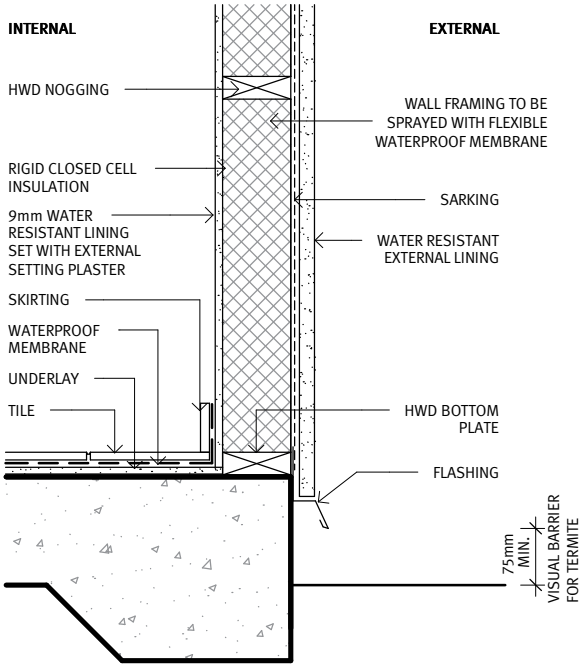
Lightweight | Weatherboards + VJ Boards



TYPOLOGY:	LIGHTWEIGHT
WALL TYPE:	EXTERNAL | SINGLE SKIN WALL
FLOOR FINISH:	CONCRETE
R-VALUE:	1.47
CODE:	NL-201

Framing:	Hardwood timber
External lining:	Water resistant external lining
Insulation:	Rigid closed cell insulation. Thickness of insulation to match depth of stud frame. Seal edges of insulation to frame.
Internal lining:	9mm water resistant lining set with external setting plaster to above flood level
Skirting:	Hardwood or other water resistant skirting
Floor finish:	Concrete with non-slip penetrative sealant

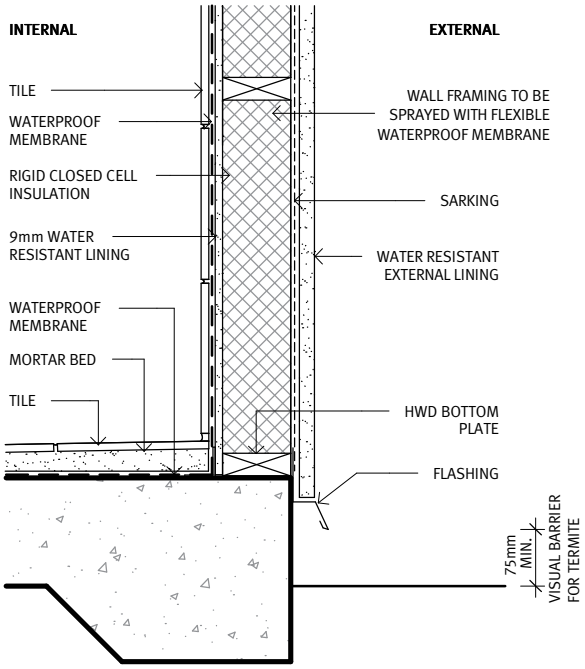
NL-201
External | single skin wall
Concrete floor finish



TYPOLOGY:	LIGHTWEIGHT
WALL TYPE:	EXTERNAL | SINGLE SKIN WALL
FLOOR FINISH:	TILE
R-VALUE:	1.47
CODE:	NL-202

Framing:	Hardwood timber
External lining:	Water resistant external lining
Insulation:	Rigid closed cell insulation. Thickness of insulation to match depth of stud frame. Seal edges of insulation to frame.
Internal lining:	9mm water resistant lining set with external setting plaster to above flood level
Skirting:	Tile or other water resistant skirting
Floor finish:	Tile + waterproof membrane + underlay

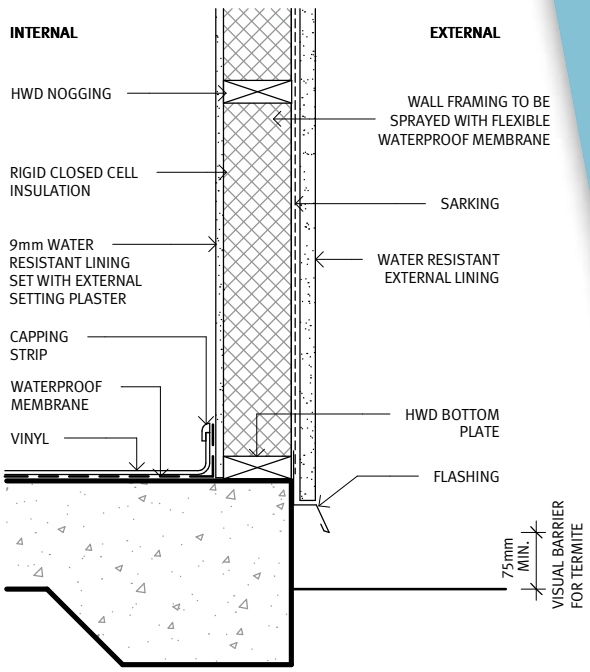
NL-202
External | single skin wall
Tile floor finish



TYPOLOGY:	LIGHTWEIGHT
WALL TYPE:	EXTERNAL | SINGLE SKIN WALL
FLOOR FINISH:	TILE | WET AREA
R-VALUE:	1.5
CODE:	NL-203

Framing:	Hardwood timber
External lining:	Water resistant external lining
Insulation:	Rigid closed cell insulation. Thickness of insulation to match depth of stud frame. Seal edges of insulation to frame.
Internal lining:	Tile + waterproof membrane + 9mm water resistant lining to above flood level
Skirting:	N/A
Floor finish: membrane	Tile + bedding + waterproof

NL-203
External | single skin wall
Tile floor finish | wet area

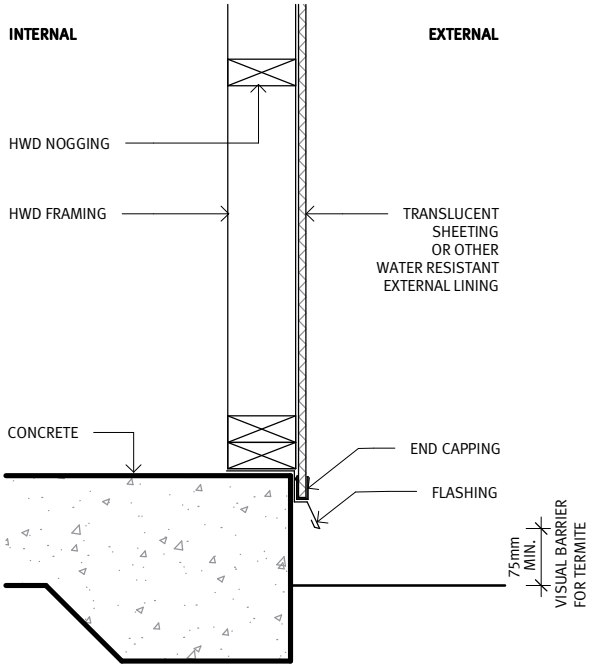


TYPOLOGY:	LIGHTWEIGHT
WALL TYPE:	EXTERNAL | SINGLE SKIN WALL
FLOOR FINISH:	VINYL
R-VALUE:	1.47
CODE:	NL-204

Framing:	Hardwood timber
External lining:	Water resistant external lining
Insulation:	Rigid closed cell insulation. Thickness of insulation to match depth of stud frame. Seal edges of insulation to frame.
Internal lining:	9mm water resistant lining set with external setting plaster to above flood level
Skirting:	Coved vinyl or other water resistant skirting
Floor finish:	Vinyl + waterproof membrane

NL-204
External | single skin wall
Vinyl floor finish

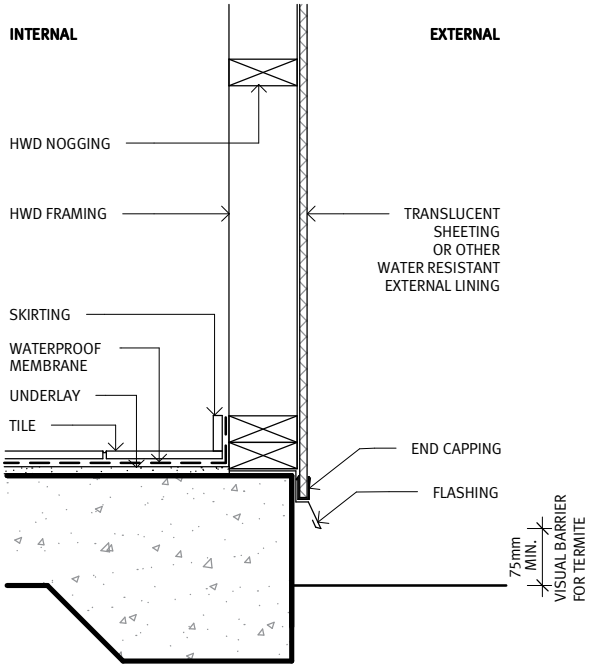
New
Lightweight | Weatherboards + VJ Boards



TYPOLOGY:	LIGHTWEIGHT
WALL TYPE:	EXTERNAL | SINGLE SKIN NON-HABITABLE
FLOOR FINISH:	CONCRETE
R-VALUE:	0.18
CODE:	NL-301

Framing:	Hardwood timber
External lining:	Translucent sheeting or other water resistant external lining
Insulation:	N/A
Internal lining:	N/A
Skirting:	N/A
Floor finish:	Concrete with non-slip penetrative sealant
NOTE:	This detail only applies to a non-habitable room

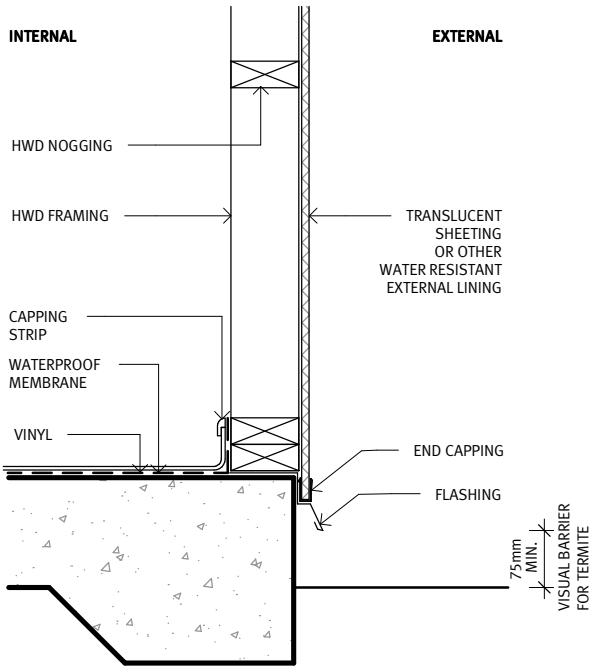
NL-301
External | single skin | non-habitable
Concrete floor finish



TYPOLOGY:	LIGHTWEIGHT
WALL TYPE:	EXTERNAL | SINGLE SKIN NON-HABITABLE
FLOOR FINISH:	TILE
R-VALUE:	0.18
CODE:	NL-302

Framing:	Hardwood timber
External lining:	Translucent sheeting or other water resistant external lining
Insulation:	N/A
Internal lining:	N/A
Skirting:	Tile or other water resistant skirting
Floor finish:	Tile + waterproof membrane + underlay
NOTE:	This detail only applies to a non-habitable room

NL-302
External | single skin | non-habitable
Tile floor finish

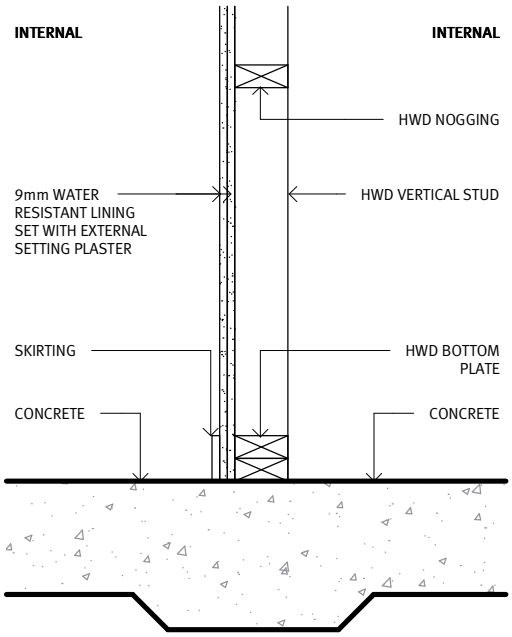


TYPOLOGY:	LIGHTWEIGHT
WALL TYPE:	EXTERNAL | SINGLE SKIN NON-HABITABLE
FLOOR FINISH:	VINYL
R-VALUE:	0.18
CODE:	NL-303

Framing:	Hardwood timber
External lining:	Translucent sheeting or other water resistant external lining
Insulation:	N/A
Internal lining:	N/A
Skirting:	Coved vinyl or other water resistant skirting
Floor finish:	Vinyl + waterproof membrane
NOTE:	This detail only applies to a non-habitable room

NL-303
External | single skin | non-habitable
Vinyl floor finish

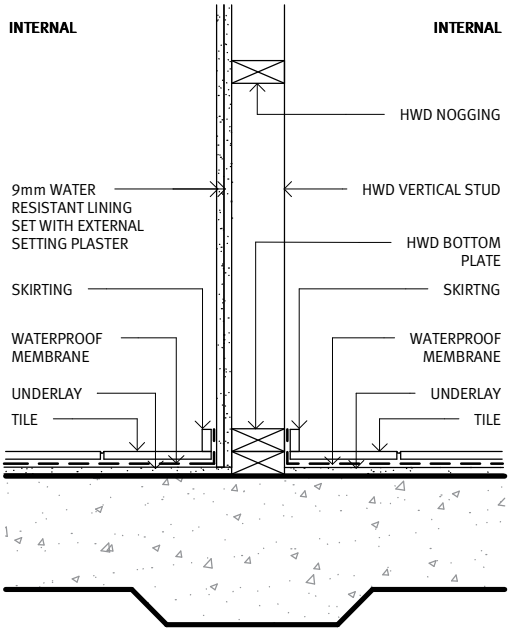
New
Lightweight | Rendered FC + Metal Sheeting



TYPOLOGY:	LIGHTWEIGHT
WALL TYPE:	INTERNAL | EXPOSED STUD WALL
FLOOR FINISH:	CONCRETE
CODE:	NL-401

Framing:	Hardwood timber
Insulation:	N/A
Internal lining:	2 x 9mm water resistant lining set with external setting plaster
Skirting:	Hardwood or other water resistant skirting
Floor finish:	Concrete with non-slip penetrative sealant

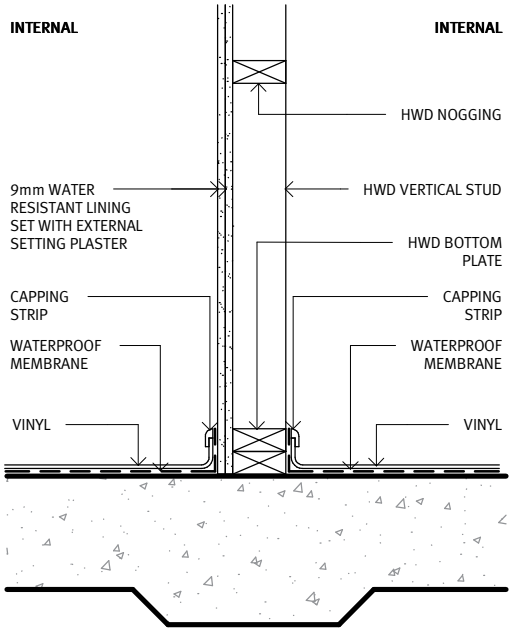
NL-401
Internal | single skin wall
Concrete floor finish



TYPOLOGY:	LIGHTWEIGHT
WALL TYPE:	INTERNAL | EXPOSED STUD WALL
FLOOR FINISH:	TILE
CODE:	NL-402

Framing:	Hardwood timber
Insulation:	N/A
Internal lining:	2 x 9mm water resistant lining set with external setting plaster
Skirting:	Tile or other water resistant skirting
Floor finish:	Tile + waterproof membrane + underlay

NL-402
Internal | single skin wall
Tile floor finish

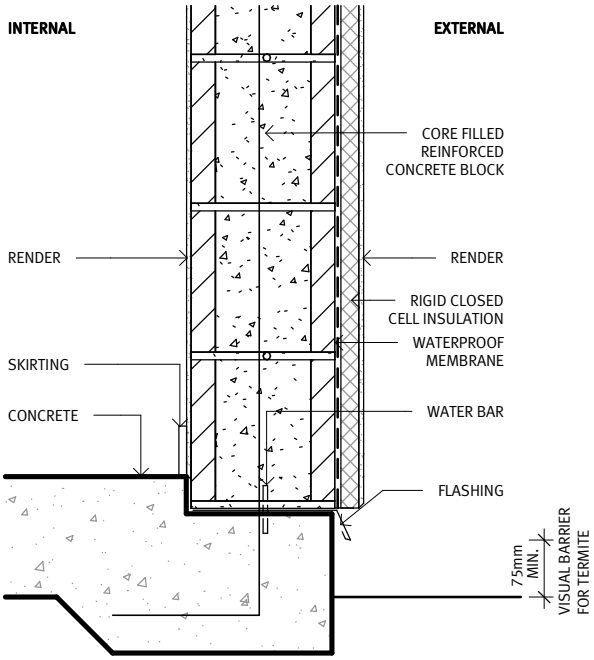


TYPOLOGY:	LIGHTWEIGHT
WALL TYPE:	INTERNAL | EXPOSED STUD WALL
FLOOR FINISH:	VINYL
CODE:	NL-403

Framing:	Hardwood timber
Insulation:	N/A
Internal lining:	2 x 9mm water resistant lining set with external setting plaster
Skirting:	Coved vinyl or other water resistant skirting
Floor finish:	Vinyl + waterproof membrane

NL-403
Internal | single skin wall
Vinyl floor finish

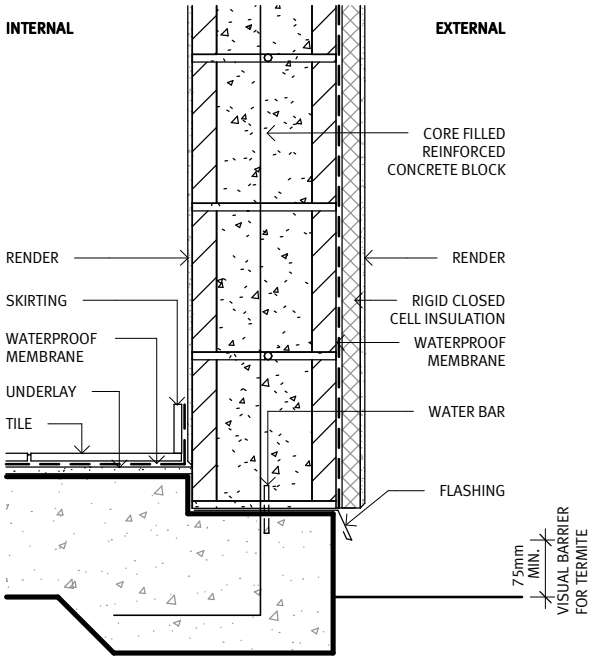
New
Lightweight | Hardwood Frame



TYPOLOGY:	MASONRY
WALL TYPE:	EXTERNAL | CONCRETE BLOCK WALL
FLOOR FINISH:	CONCRETE FLOOR FINISH
R-VALUE:	1.6
CODE:	NM-101

Structure:	Core filled reinforced concrete block
Insulation:	Rigid closed cell insulation
External lining:	Render + waterproof membrane to above flood level
Internal lining:	Render
Skirting:	Hardwood or other water resistant skirting
Floor finish:	Concrete with non-slip penetrative sealant

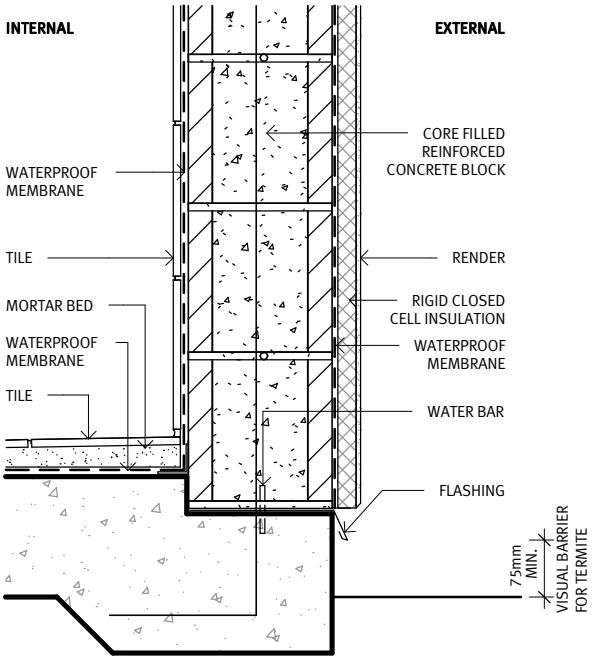
NM-101
External | concrete block wall
Concrete floor finish



TYPOLOGY:	MASONRY
WALL TYPE:	EXTERNAL | CONCRETE BLOCK WALL
FLOOR FINISH:	TILE
R-VALUE:	1.6
CODE:	NM-102

Structure:	Core filled reinforced concrete block
Insulation:	Rigid closed cell insulation
External lining:	Render + waterproof membrane to above flood level
Internal lining:	Render
Skirting:	Tile or other water resistant skirting
Floor finish:	Tile + waterproof membrane + underlay

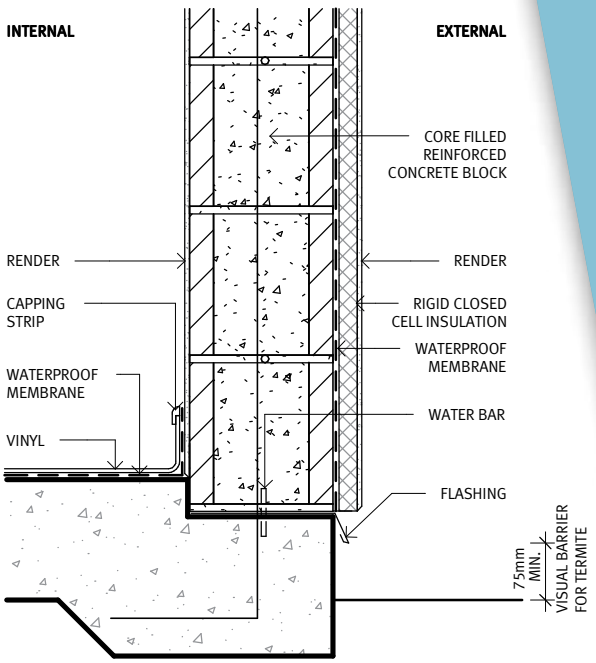
NM-102
External | concrete block wall
Tile floor finish



TYPOLOGY:	MASONRY
WALL TYPE:	EXTERNAL | CONCRETE BLOCK WALL
FLOOR FINISH:	TILE | WET AREA
R-VALUE:	1.63
CODE:	NM-103

Structure:	Core filled reinforced concrete block
Insulation:	Rigid closed cell insulation
External lining:	Render + waterproof membrane to above flood level
Internal lining:	Tile + waterproof membrane to above flood level
Skirting:	N/A
Floor finish:	Tile + bedding + waterproof membrane

NM-103
External | concrete block wall
Tile floor finish | wet area

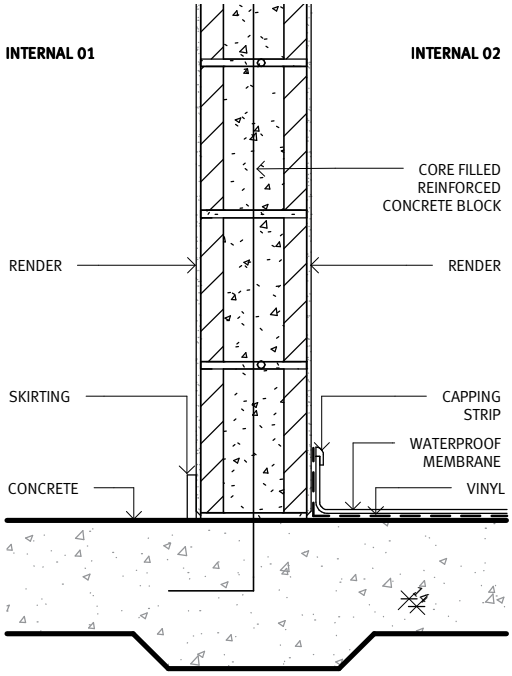


TYPOLOGY:	MASONRY
WALL TYPE:	EXTERNAL | CONCRETE BLOCK WALL
FLOOR FINISH:	VINYL
R-VALUE:	1.6
CODE:	NM-104

Structure:	Core filled reinforced concrete block
Insulation:	Rigid closed cell insulation
External lining:	Render + waterproof membrane to above flood level
Internal lining:	Render
Skirting:	Coved vinyl or other water resistant skirting
Floor finish:	Vinyl + waterproof membrane

NM-104
External | concrete block wall
Vinyl floor finish

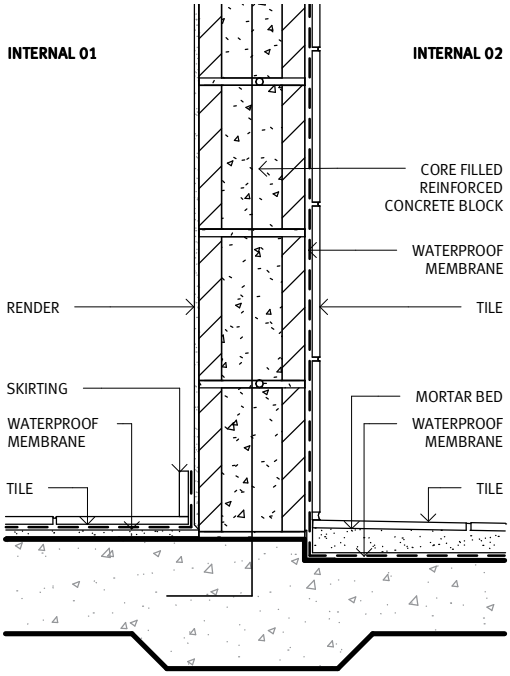
New
Masonry | Concrete Block



TYPOLOGY:	MASONRY
WALL TYPE:	INTERNAL | CONCRETE BLOCK WALL
FLOOR FINISH:	CONCRETE / VINYL
CODE:	NM-201

Structure:	Core filled reinforced concrete block
Insulation:	N/A
Internal lining 01:	Render
Skirting 01:	Hardwood or other water resistant skirting
Floor finish 01:	Concrete with non-slip penetrative sealant
Internal lining 02:	Render
Skirting 02:	Vinyl or other water resistant skirting
Floor finish 02:	Vinyl + waterproof membrane

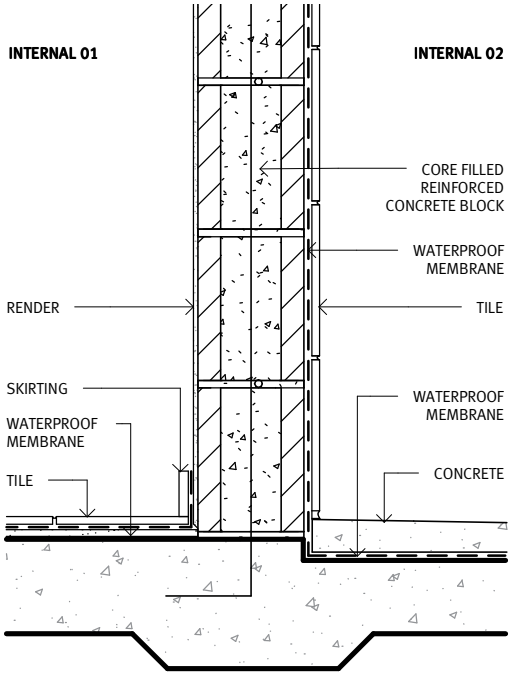
NM-201
Internal | concrete block wall
Concrete / vinyl floor finish



TYPOLOGY:	MASONRY
WALL TYPE:	INTERNAL | CONCRETE BLOCK WALL
FLOOR FINISH:	TILE / TILE | WET AREA
CODE:	NM-202

Structure:	Core filled reinforced concrete block
Insulation:	N/A
Internal lining 01:	Render
Skirting 01:	Tile or other water resistant skirting
Floor finish 01:	Tile + waterproof membrane + underlay
Internal lining 02:	Tile + waterproof membrane to above flood level
Skirting 02:	N/A
Floor finish 02:	Tile + bedding + waterproof membrane

NM-202
Internal | concrete block wall
Tile / tile floor finish | wet area

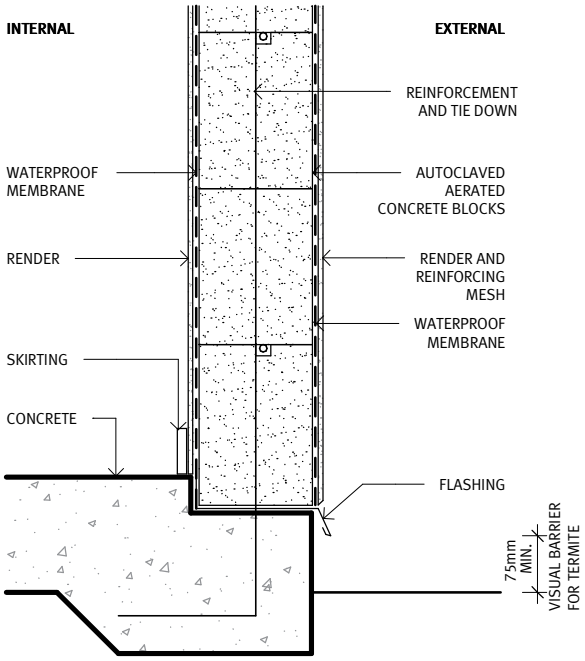


TYPOLOGY:	MASONRY
WALL TYPE:	INTERNAL | CONCRETE BLOCK WALL
FLOOR FINISH:	TILE / CONCRETE | WET AREA
CODE:	NM-203

Structure:	Core filled reinforced concrete block
Insulation:	N/A
Internal lining 01:	Render
Skirting 01:	Tile or other water resistant skirting
Floor finish 01:	Tile + waterproof membrane
Internal lining 02:	Tile + waterproof membrane to above flood level
Skirting 02:	N/A
Floor finish 02:	Concrete + waterproof membrane

NM-203
Internal | concrete block wall
Tile / concrete floor finish | wet area

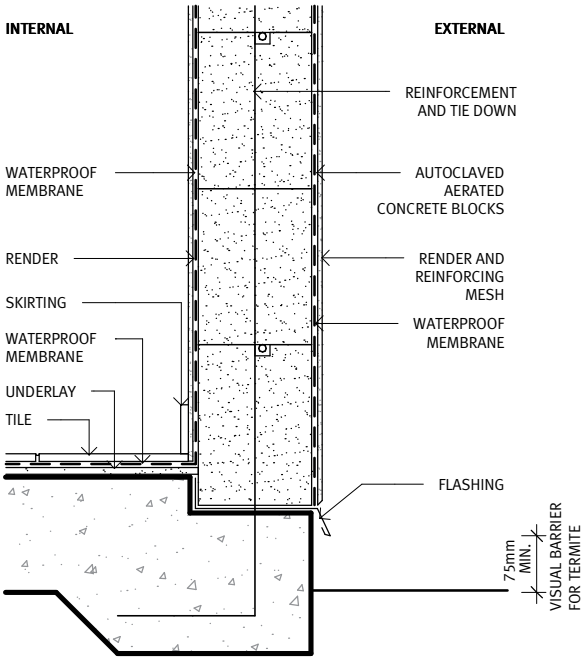
New
Masonry | Internal Concrete Block



TYPOLOGY:	MASONRY
WALL TYPE:	EXTERNAL | AAC BLOCK WALL
FLOOR FINISH:	CONCRETE
R-VALUE:	2.13
CODE:	NM-301

Structure:	AAC block wall
Insulation:	N/A
External lining:	Render + waterproof membrane
Internal lining:	Render + waterproof membrane
Skirting:	Hardwood or other water resistant skirting
Floor finish:	Concrete with non-slip penetrative sealant

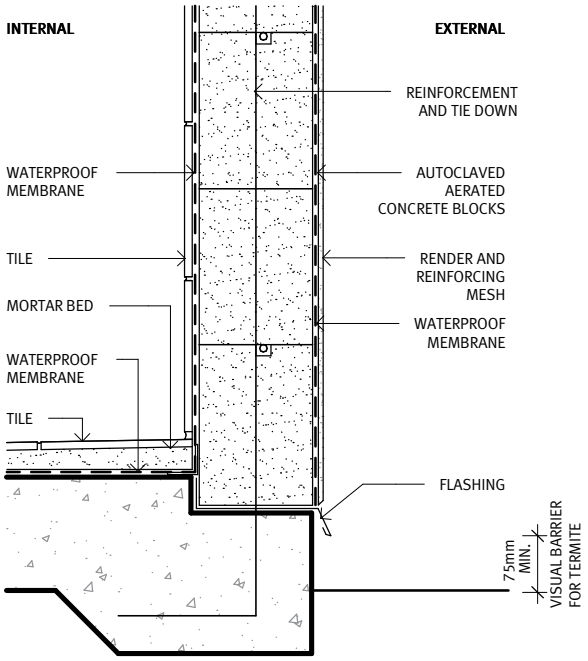
NM-301
External | AAC wall
Concrete floor finish



TYPOLOGY:	MASONRY
WALL TYPE:	EXTERNAL | AAC BLOCK WALL
FLOOR FINISH:	TILE
R-VALUE:	2.13
CODE:	NM-302

Structure:	AAC block wall
Insulation:	N/A
External lining:	Render + waterproof membrane
Internal lining:	Render + waterproof membrane
Skirting:	Tile or other water resistant skirting
Floor finish:	Tile + waterproof membrane + underlay

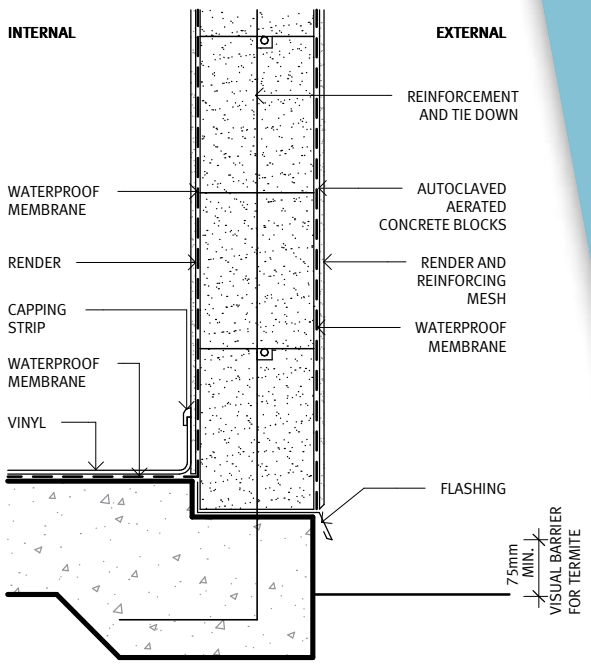
NM-302
External | AAC wall
Tile floor finish



TYPOLOGY:	MASONRY
WALL TYPE:	EXTERNAL | AAC BLOCK WALL
FLOOR FINISH:	TILE | WET AREA
R-VALUE:	2.16
CODE:	NM-303

Structure:	AAC block wall
Insulation:	N/A
External lining:	Render + waterproof membrane
Internal lining:	Tile + waterproof membrane
Skirting:	N/A
Floor finish:	Tile + bedding + waterproof membrane

NM-303
External | AAC wall
Tile floor finish | wet area

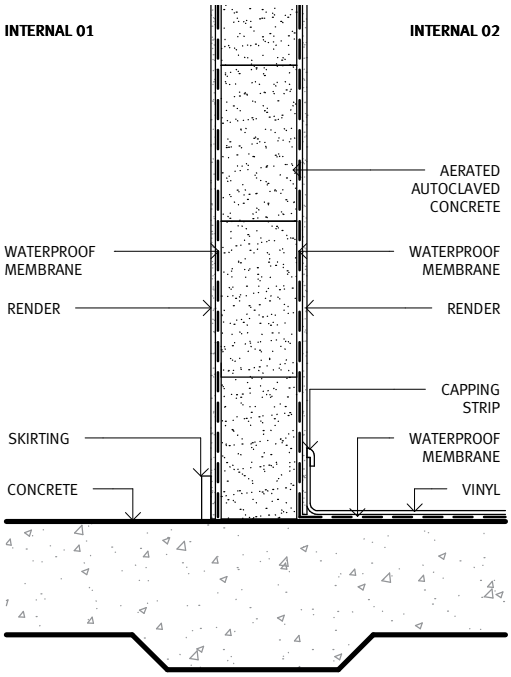


TYPOLOGY:	MASONRY
WALL TYPE:	EXTERNAL | AAC BLOCK WALL
FLOOR FINISH:	VINYL
R-VALUE:	2.13
CODE:	NM-304

Structure:	AAC block wall
Insulation:	N/A
External lining:	Render + waterproof membrane
Internal lining:	Render + waterproof membrane
Skirting:	Coved vinyl or other water resistant skirting
Floor finish:	Vinyl + waterproof membrane

NM-304
External | AAC wall
Vinyl floor finish

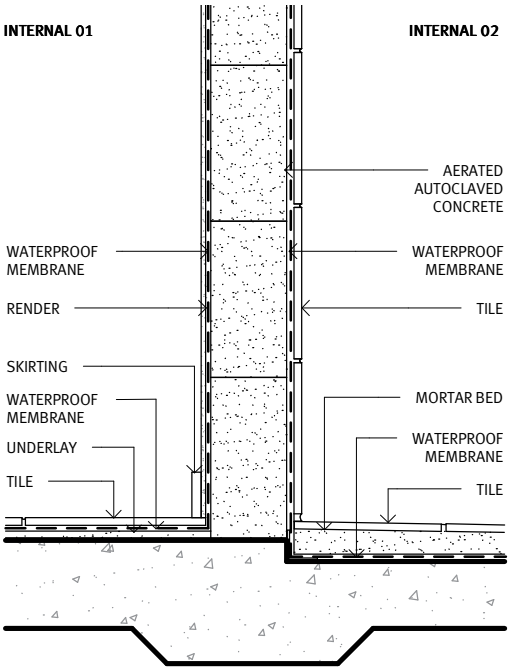
New
Masonry | AAC Block + AAC Panel



TYPOLOGY:	MASONRY
WALL TYPE:	INTERNAL | AAC BLOCK WALL
FLOOR FINISH:	CONCRETE / VINYL
CODE:	NM-401

Structure:	AAC block wall
Insulation:	N/A
Internal lining 01:	Render + waterproof membrane
Skirting 01:	Hardwood or other water resistant skirting
Floor finish 01:	Concrete with non-slip penetrative sealant
Internal lining 02:	Render + waterproof membrane
Skirting 02:	Coved vinyl or other water resistant skirting
Floor finish 02:	Vinyl + waterproof membrane

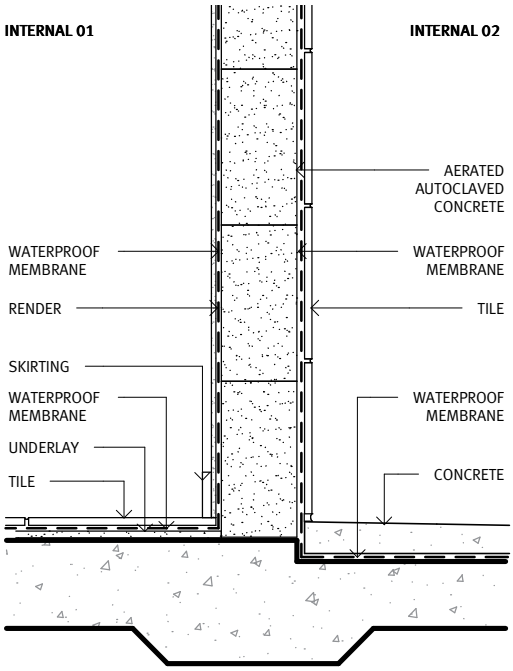
NM-401
Internal | AAC wall
Concrete / vinyl floor finish



TYPOLOGY:	MASONRY
WALL TYPE:	INTERNAL | AAC BLOCK WALL
FLOOR FINISH:	TILE / TILE | WET AREA
CODE:	NM-402

Structure:	AAC block wall
Insulation:	N/A
Internal lining 01:	Render + waterproof membrane
Skirting 01:	Tile or other water resistant skirting
Floor finish 01:	Tile + waterproof membrane + underlay
Internal lining 02:	Tile + waterproof membrane to above flood level
Skirting 02:	N/A
Floor finish 02:	Tile + bedding + waterproof membrane

NM-402
Internal | AAC wall
Tile / tile floor finish | wet area

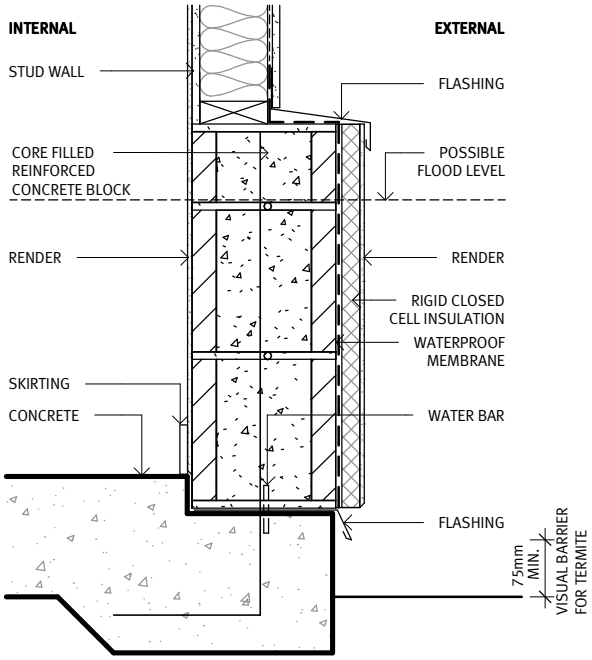


TYPOLOGY:	MASONRY
WALL TYPE:	INTERNAL | AAC BLOCK WALL
FLOOR FINISH:	TILE / CONCRETE | WET AREA
CODE:	NM-403

Structure:	AAC block wall
Insulation:	N/A
Internal lining 01:	Render + waterproof membrane
Skirting 01:	Tile or other water resistant skirting
Floor finish 01:	Tile + waterproof membrane + underlay
Internal lining 02:	Tile + waterproof membrane to above flood level
Skirting 02:	N/A
Floor finish 02:	Concrete + waterproof membrane

NM-403
Internal | AAC wall
Tile / concrete floor finish | wet area

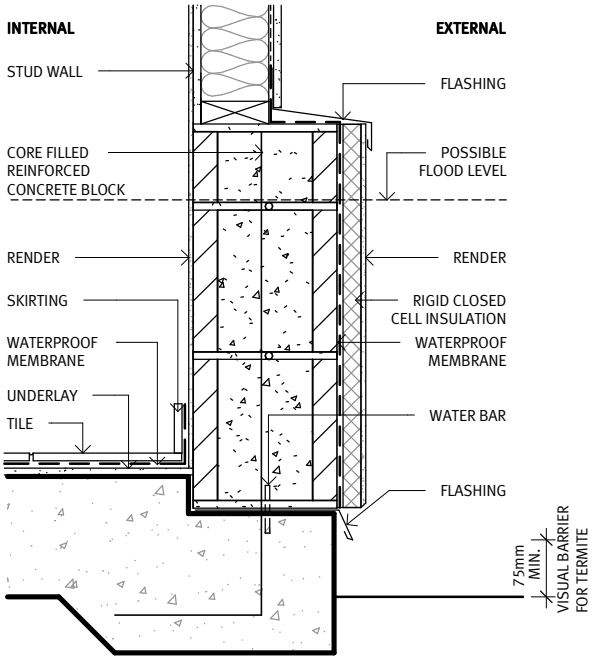
New
Masonry | Internal AAC Block + AAC Panel



TYPOLOGY:	COMPOSITE - LIGHTWEIGHT/MASONRY
WALL TYPE:	EXTERNAL | CONCRETE BLOCK AND STUD WALL
FLOOR FINISH:	CONCRETE FLOOR FINISH
R-VALUE:	1.6
CODE:	NC-101

Structure:	Core filled reinforced concrete block to above flood level. Standard stud wall construction on top of blockwork.
Insulation:	Rigid closed cell insulation
External lining:	Render
Internal lining:	Render
Skirting:	Hardwood or other water resistant skirting
Floor finish:	Concrete with non-slip penetrative sealant

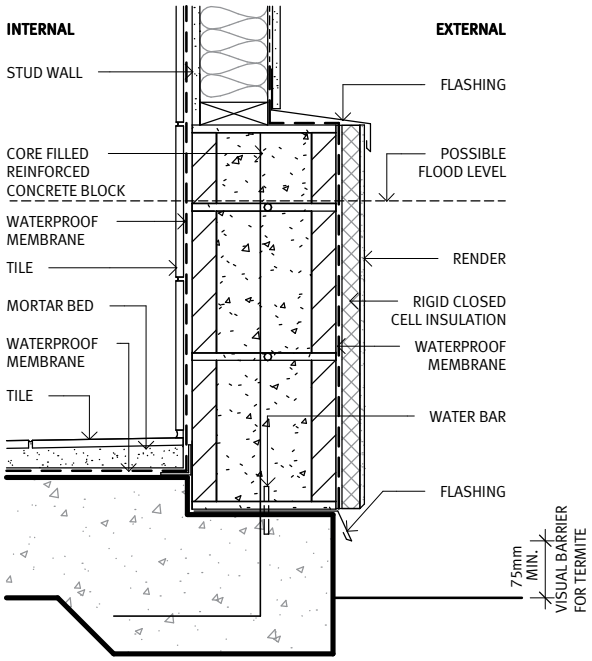
NC-101
External | composite wall
Concrete floor finish



TYPOLOGY:	COMPOSITE - LIGHTWEIGHT/MASONRY
WALL TYPE:	EXTERNAL | CONCRETE BLOCK AND STUD WALL
FLOOR FINISH:	CONCRETE FLOOR FINISH
R-VALUE:	1.6
CODE:	NC-102

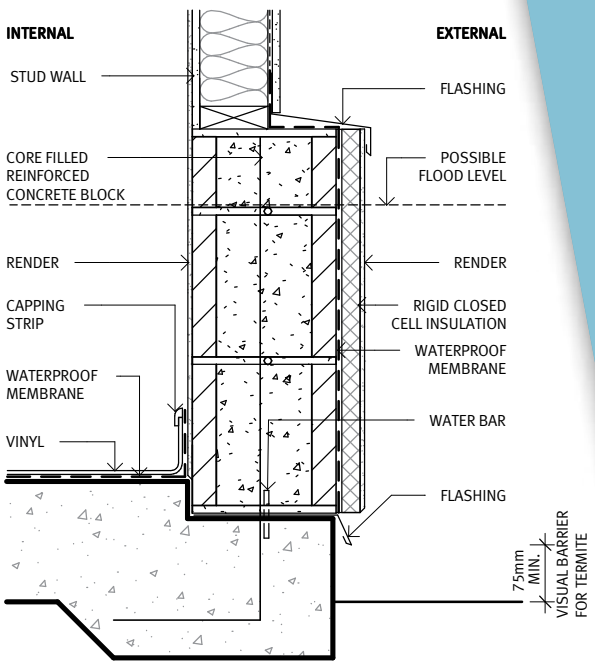
Structure:	Core filled reinforced concrete block to above flood level. Standard stud wall construction on top of blockwork.
Insulation:	Rigid closed cell insulation
External lining:	Render
Internal lining:	Render
Skirting:	Tile or other water resistant skirting
Floor finish:	Tile + waterproof membrane + underlay

NC-102
External | composite wall
Tile floor finish



TYPOLOGY:	COMPOSITE - LIGHTWEIGHT/MASONRY
WALL TYPE:	EXTERNAL | CONCRETE BLOCK AND STUD WALL
FLOOR FINISH:	CONCRETE FLOOR FINISH
R-VALUE:	1.63
CODE:	NC-103
Structure:	Core filled reinforced concrete block to above flood level. Standard stud wall construction on top of blockwork.
Insulation:	Rigid closed cell insulation
External lining:	Render
Internal lining:	Tile + waterproof membrane to above flood level
Skirting:	N/A
Floor finish:	Tile + bedding + waterproof membrane

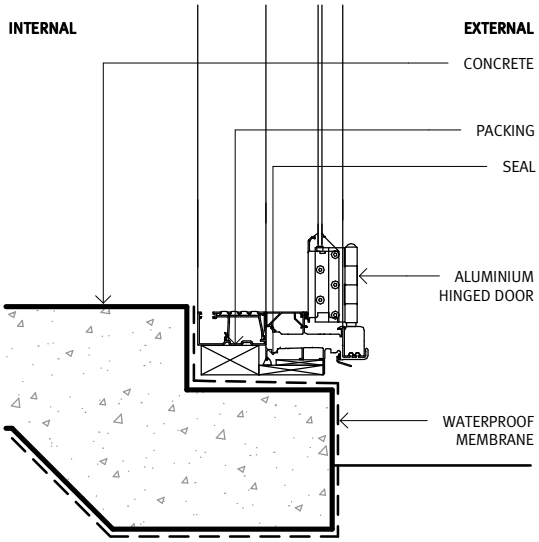
NC-103
External | composite wall
Tile floor finish | wet area



TYPOLOGY:	COMPOSITE - LIGHTWEIGHT/MASONRY
WALL TYPE:	EXTERNAL | CONCRETE BLOCK AND STUD WALL
FLOOR FINISH:	CONCRETE FLOOR FINISH
R-VALUE:	1.6
CODE:	NC-104
Structure:	Core filled reinforced concrete block to above flood level. Standard stud wall construction on top of blockwork.
Insulation:	Rigid closed cell insulation
External lining:	Render
Internal lining:	Render
Skirting:	Coved vinyl or other water resistant skirting
Floor finish:	Vinyl + waterproof membrane

NC-104
External | composite wall
Vinyl floor finish

New
Lightweight + Masonry | Composite Wall

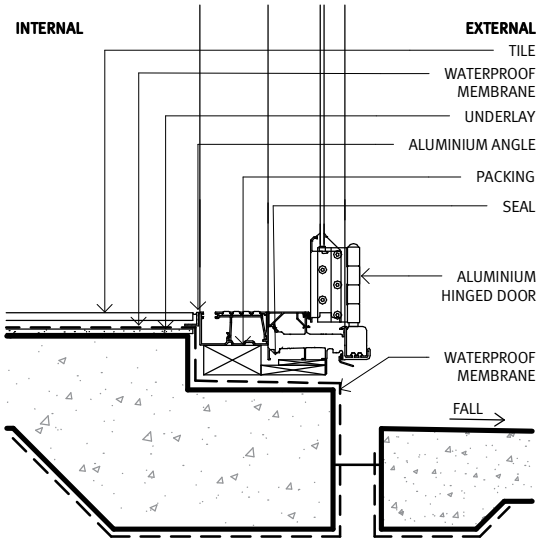


TYPOLOGY:	THRESHOLD
WALL TYPE:	N/A
FLOOR FINISH:	CONCRETE | GROUND
R-VALUE:	N/A
CODE:	NT-101

Framing:	Aluminium
External cladding:	N/A
Insulation:	N/A
Internal lining:	N/A
Skirting:	N/A
Floor finish:	Concrete with non-slip penetrative sealant

NOTES: Ensure termite barrier requirements are met

NT-101
Threshold | aluminium frame
Concrete floor finish / ground

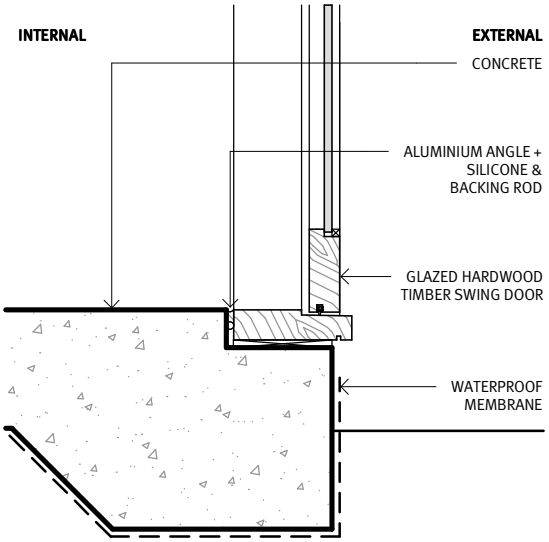


TYPOLOGY:	THRESHOLD
WALL TYPE:	N/A
FLOOR FINISH:	TILE | CONCRETE
R-VALUE:	N/A
CODE:	NT-102

Framing:	Aluminium
External cladding:	N/A
Insulation:	N/A
Internal lining:	N/A
Skirting:	N/A
Floor finish:	Tile + waterproof membrane + underlay

NOTES: Ensure termite barrier requirements are met

NT-102
Threshold | aluminium frame
Tile floor finish / paving slab

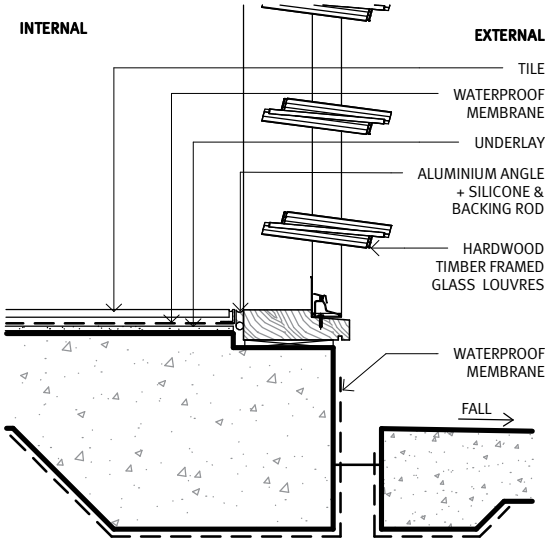


TYPOLOGY:	THRESHOLD
WALL TYPE:	EXTERNAL | SINGLE SKIN
FLOOR FINISH:	CONCRETE | GROUND
R-VALUE:	N/A
CODE:	NT-103

Framing:	Hardwood timber
External cladding:	N/A
Insulation:	N/A
Internal lining:	N/A
Floor finish:	Concrete with non-slip penetrative sealant

NOTES: Ensure termite barrier requirements are met

NT-103
Threshold | timber frame
Concrete floor finish/ ground



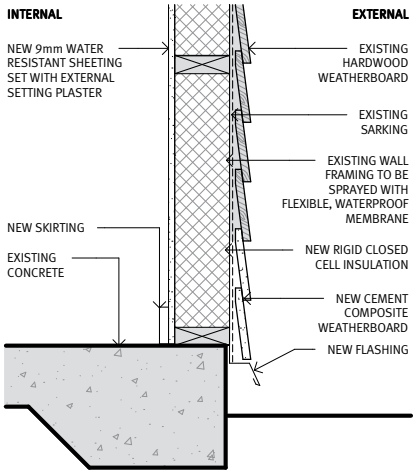
TYPOLOGY:	THRESHOLD
WALL TYPE:	N/A
FLOOR FINISH:	TILE | GROUND
R-VALUE:	N/A
CODE:	NT-104

Framing:	Hardwood timber
External cladding:	N/A
Insulation:	N/A
Internal lining:	N/A
Skirting:	N/A
Floor finish:	Tile + waterproof membrane + underlay

NOTES: Ensure termite barrier requirements are met

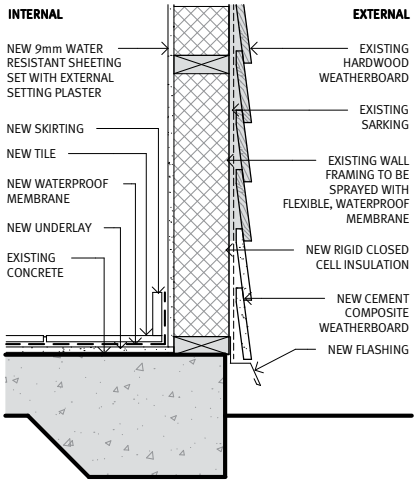
NT-104
Threshold | timber frame
Tile floor finish/ paving slab

New
Lightweight + Masonry | Threshold Details



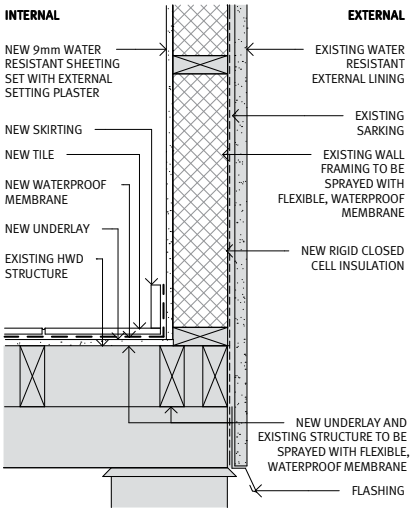
TYPOLOGY:	RETROFIT LIGHTWEIGHT
WALL TYPE:	EXTERNAL | EXISTING STUD WALL
FLOOR TYPE:	EXISTING CONCRETE SLAB
R-VALUE:	3.34
CODE:	RL-101
Framing:	Existing pine or hardwood framing to be retained and sprayed with flexible, waterproof membrane
External lining:	Existing hardwood weatherboard to above flood level to be replaced with new cement composite weatherboard
Insulation:	Existing batt insulation to be replaced with new rigid closed cell insulation. Thickness of insulation to match depth of stud frame. Seal edges of insulation to frame.
Internal lining:	Existing internal lining to be replaced with new 9mm water resistant sheeting set with external setting plaster to above flood level
Skirting:	Hardwood or other water resistant skirting
Floor finish:	Existing concrete to be retained. Apply new non-slip penetrative sealant.
NOTES:	Where insulation is fixed to timber frames, ventilation is critical to allow airflow inside the exterior walls in order to prevent mould build up and deterioration of the frame. Consult builder regarding termite barriers required.

RL-101
External | existing stud wall
Existing concrete floor finish



TYPOLOGY:	RETROFIT LIGHTWEIGHT
WALL TYPE:	EXTERNAL | EXISTING STUD WALL
FLOOR TYPE:	EXISTING NON WATER RESISTANT FLOOR FINISH ON CONCRETE SLAB
R-VALUE:	3.34
CODE:	RL-102
Framing:	Existing pine or hardwood framing to be retained and sprayed with flexible, waterproof membrane
External lining:	Existing hardwood weatherboard to above flood level to be replaced with new cement composite weatherboard
Insulation:	Existing batt insulation to be replaced with new rigid closed cell insulation. Thickness of insulation to match depth of stud frame. Seal edges of insulation to frame.
Internal lining:	Existing internal lining to be replaced with new 9mm water resistant sheeting set with external setting plaster to above flood level
Skirting:	Tile or other water resistant skirting
Floor finish:	Existing non water resistant floor finish to be replaced with new tile + waterproof membrane + underlay. Please note that removal of a timber floating floor is preferred as waterproof flooring may impede drying when placed over timber.
NOTES:	Where insulation is fixed to timber frames, ventilation is critical to allow airflow inside the exterior walls in order to prevent mould build up and deterioration of the frame. Consult builder regarding termite barriers required.

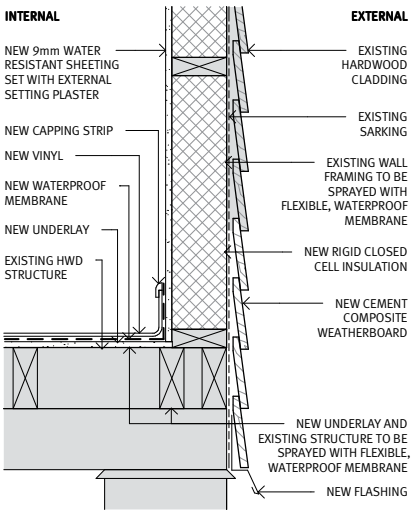
Rl-102
External | existing stud wall
New tile floor finish



TYPOLOGY: RETROFIT LIGHTWEIGHT
WALL TYPE: EXTERNAL | EXISTING STUD WALL
FLOOR TYPE: EXISTING NON WATER RESISTANT FLOOR FINISH ON TIMBER STRUCTURE
R-VALUE: 3.29
CODE: RL-203

Framing:	Existing pine or hardwood framing to be retained and sprayed with flexible, waterproof membrane
External lining:	Existing water resistant external lining to be retained
Insulation:	Existing batt insulation to be replaced with new rigid closed cell insulation. Thickness of insulation to match depth of stud frame. Seal edges of insulation to frame.
Internal lining:	Existing internal lining to be replaced with new 9mm water resistant sheeting set with external setting plaster to above flood level
Skirting:	Tile or other water resistant skirting
Floor finish:	Existing non water resistant floor finish to be replaced with new tile + waterproof membrane + underlay. Underside of new underlay and existing structure to be sprayed with flexible, waterproof membrane.
NOTES:	Check existing floor framing can withstand the additional flooring load. Consult registered RPEQ Structural Engineer
	Where insulation is fixed to timber frames, ventilation is critical to allow airflow inside the exterior walls in order to prevent mould build up and deterioration of the frame.
	Waterproof flooring may impede drying when placed over timber (plywood). These floors may require special attention to drying and/or repair/replacement

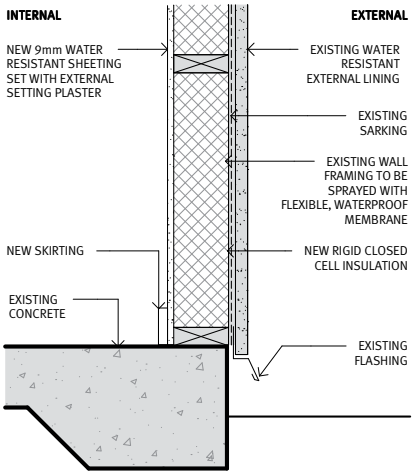
RL-103
External | existing stud wall
New tile floor finish + underlay



TYPOLOGY: RETROFIT LIGHTWEIGHT
WALL TYPE: EXTERNAL | EXISTING STUD WALL
FLOOR TYPE: EXISTING NON WATER RESISTANT FLOOR FINISH ON TIMBER STRUCTURE
R-VALUE: 3.34
CODE: RL-104

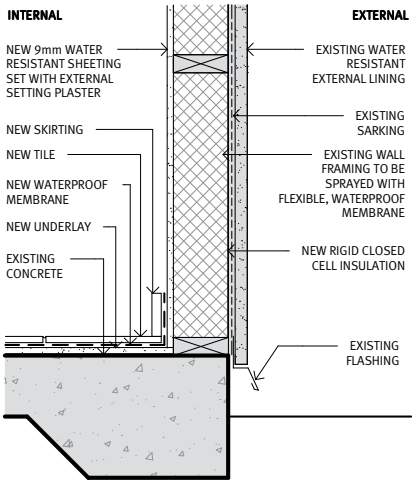
Framing:	Existing pine or hardwood framing to be retained and sprayed with flexible, waterproof membrane
External lining:	Existing hardwood weatherboard to above flood level to be replaced with new cement composite weatherboard
Insulation:	Existing batt insulation to be replaced with new rigid closed cell insulation. Thickness of insulation to match depth of stud frame. Seal edges of insulation to frame.
Internal lining:	Existing internal lining to be replaced with new 9mm water resistant sheeting set with external setting plaster to above flood level
Skirting:	Coved vinyl or other water resistant skirting
Floor finish:	Existing non water resistant floor finish to be replaced with new vinyl + waterproof membrane + underlay. Underside of new underlay and existing structure to be sprayed with flexible, waterproof membrane.
NOTES:	Check existing floor framing can withstand the additional flooring load. Consult registered RPEQ Structural Engineer
	Where insulation is fixed to timber frames, ventilation is critical to allow airflow inside the exterior walls in order to prevent mould build up and deterioration of the frame.
	Waterproof flooring may impede drying when placed over timber (plywood). These floors may require special attention to drying and/or repair/replacement

RL-104
External | existing stud wall
New vinyl floor finish + underlay



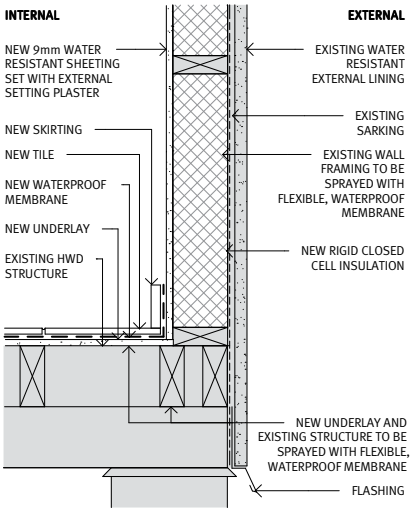
TYPOLOGY:	RETROFIT LIGHTWEIGHT
WALL TYPE:	EXTERNAL | EXISTING STUD WALL
FLOOR TYPE:	EXISTING CONCRETE SLAB
R-VALUE:	3.29
CODE:	RL-201
Framing:	Existing pine or hardwood framing to be retained and sprayed with flexible, waterproof membrane
External lining:	Existing water resistant external lining to be retained
Insulation:	Existing batt insulation to be replaced with new rigid closed cell insulation. Thickness of insulation to match depth of stud frame. Seal edges of insulation to frame.
Internal lining:	Existing internal lining to be replaced with new 9mm water resistant sheeting set with external setting plaster to above flood level
Skirting:	Hardwood or other water resistant skirting
Floor finish:	Existing concrete to be retained. Apply new non-slip penetrative sealant.
NOTES:	Where insulation is fixed to timber frames, ventilation is critical to allow airflow inside the exterior walls in order to prevent mould build up and deterioration of the frame. Consult builder regarding termite barriers required.

RL-201
External | existing stud wall
Existing concrete floor finish



TYPOLOGY:	RETROFIT LIGHTWEIGHT
WALL TYPE:	EXTERNAL | EXISTING STUD WALL
FLOOR TYPE:	EXISTING NON WATER RESISTANT FLOOR FINISH ON CONCRETE SLAB
R-VALUE:	3.29
CODE:	RL-203
Framing:	Existing pine or hardwood framing to be retained and sprayed with flexible, waterproof membrane
External lining:	Existing water resistant external lining to be retained
Insulation:	Existing batt insulation to be replaced with new rigid closed cell insulation. Thickness of insulation to match depth of stud frame. Seal edges of insulation to frame.
Internal lining:	Existing internal lining to be replaced with new 9mm water resistant sheeting set with external setting plaster to above flood level
Skirting:	Tile or other water resistant skirting
Floor finish:	Existing non water resistant floor finish to be replaced with new tile + waterproof membrane + underlay. Please note that removal of a timber floating floor is preferred as waterproof flooring may impede drying when placed over timber.
NOTES:	Where insulation is fixed to timber frames, ventilation is critical to allow airflow inside the exterior walls in order to prevent mould build up and deterioration of the frame. Consult builder regarding termite barriers required.

RL-202
External | existing stud wall
New tile floor finish



TYPOLOGY:	RETROFIT LIGHTWEIGHT
WALL TYPE:	EXTERNAL | EXISTING STUD WALL
FLOOR TYPE:	EXISTING NON WATER RESISTANT FLOOR FINISH ON TIMBER STRUCTURE
R-VALUE:	3.29
CODE:	RL-203

Framing:	Existing pine or hardwood framing to be retained and sprayed with flexible, waterproof membrane
External lining:	Existing water resistant external lining to be retained
Insulation:	Existing batt insulation to be replaced with new rigid closed cell insulation. Thickness of insulation to match depth of stud frame. Seal edges of insulation to frame.
Internal lining:	Existing internal lining to be replaced with new 9mm water resistant sheeting set with external setting plaster to above flood level
Skirting:	Tile or other water resistant skirting
Floor finish:	Existing non water resistant floor finish to be replaced with new tile + waterproof membrane + underlay. Underside of new underlay and existing structure to be sprayed with flexible, waterproof membrane.

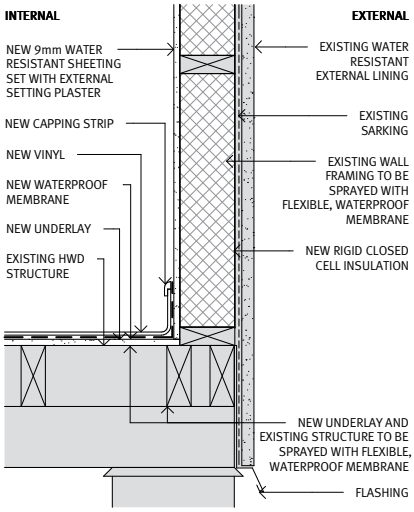
NOTES:

Check existing floor framing can withstand the additional flooring load. Consult registered RPEQ Structural Engineer

Where insulation is fixed to timber frames, ventilation is critical to allow airflow inside the exterior walls in order to prevent mould build up and deterioration of the frame.

Waterproof flooring may impede drying when placed over timber (plywood). These floors may require special attention to drying and/or repair/replacement

RL-203
External | existing stud wall
New tile floor finish + underlay



TYPOLOGY:	RETROFIT LIGHTWEIGHT
WALL TYPE:	EXTERNAL | EXISTING STUD WALL
FLOOR TYPE:	EXISTING NON WATER RESISTANT FLOOR FINISH ON TIMBER STRUCTURE
R-VALUE:	3.29
CODE:	RL-204

Framing:	Existing pine or hardwood framing to be retained and sprayed with flexible, waterproof membrane
External lining:	Existing water resistant external lining to be retained
Insulation:	Existing batt insulation to be replaced with new rigid closed cell insulation. Thickness of insulation to match depth of stud frame. Seal edges of insulation to frame.
Internal lining:	Existing internal lining to be replaced with new 9mm water resistant sheeting set with external setting plaster to above flood level
Skirting:	Coved vinyl or other water resistant skirting
Floor finish:	Existing non water resistant floor finish to be replaced with new vinyl + waterproof membrane + underlay. Underside of new underlay and existing structure to be sprayed with flexible, waterproof membrane.

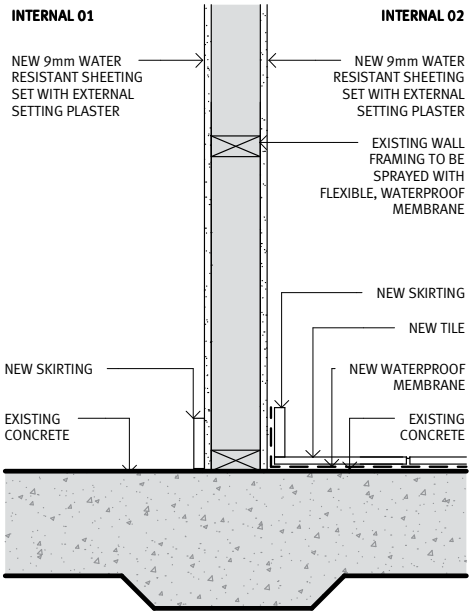
NOTES:

Check existing floor framing can withstand the additional flooring load. Consult registered RPEQ Structural Engineer

Where insulation is fixed to timber frames, ventilation is critical to allow airflow inside the exterior walls in order to prevent mould build up and deterioration of the frame.

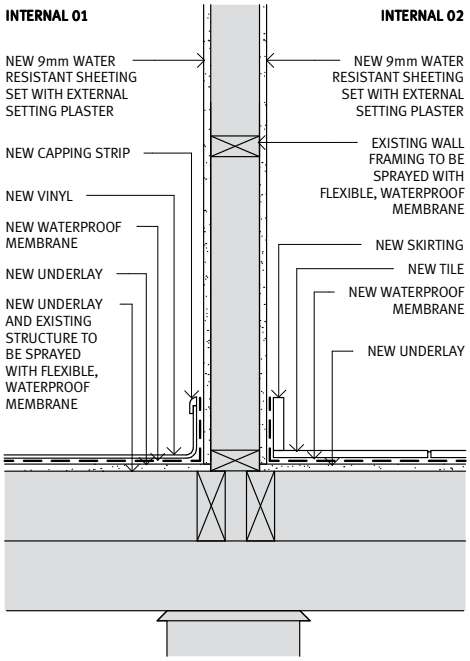
Waterproof flooring may impede drying when placed over timber (plywood). These floors may require special attention to drying and/or repair/replacement

RL-204
External | existing stud wall
New vinyl floor finish + underlay



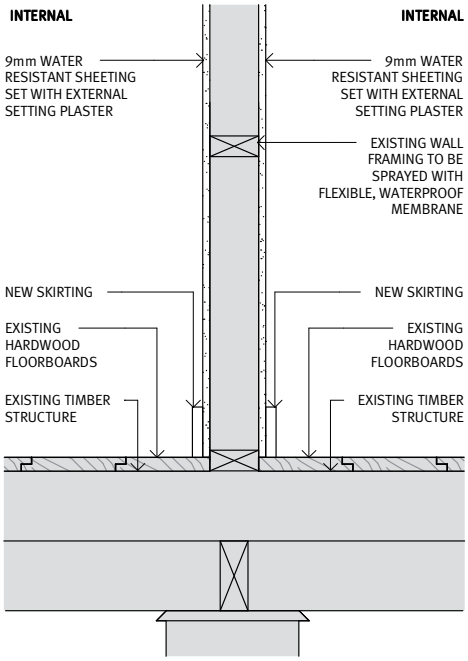
TYPOLOGY:	RETROFIT LIGHTWEIGHT
WALL TYPE:	INTERNAL | EXISTING STUD WALL
FLOOR TYPE:	EXISTING NON WATER RESISTANT FLOOR FINISH ON CONCRETE SLAB
CODE:	RL-301
Framing:	Existing pine/hardwood timber to be retained and sprayed with flexible, waterproof membrane
Internal lining:	Existing internal lining to be replaced with new 9mm water resistant sheeting set with external setting plaster to above flood level
Skirting 01:	Hardwood or other water resistant skirting
Floor finish 01:	Existing concrete to be retained. Apply new non-slip penetrative sealant.
Skirting 02	Tile or other water resistant skirting
Floor finish 02:	Existing non water resistant floor finish to be replaced with new tile + waterproof membrane + underlay. Existing concrete to be retained.

RL-301
Internal | existing stud wall
Existing concrete / new tile floor finish



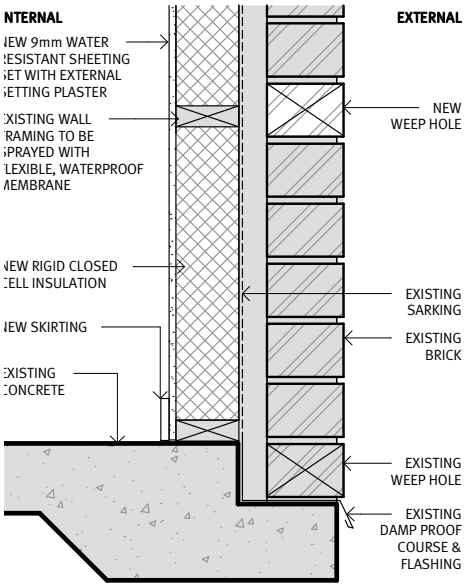
TYPOLOGY:	RETROFIT LIGHTWEIGHT
WALL TYPE:	INTERNAL | EXISTING STUD WALL
FLOOR TYPE:	EXISTING NON WATER RESISTANT FLOOR FINISH ON TIMBER STRUCTURE
CODE:	RL-302
Framing:	Existing pine/hardwood timber to be retained and sprayed with flexible, waterproof membrane
Internal lining:	Existing internal lining to be replaced with new 9mm water resistant sheeting set with external setting plaster to above flood level
Skirting 01:	Coved vinyl or other water resistant skirting
Floor finish 01:	Existing non water resistant floor finishes such as carpet and timber to be replaced with new vinyl + waterproof membrane + underlay. Underside of new underlay and existing structure to be sprayed with flexible, waterproof membrane.
Skirting 02:	Tile or other water resistant skirting
Floor finish 02:	Existing non water resistant floor finish to be replaced with new tile + waterproof membrane + underlay. Underside of new underlay and existing structure to be sprayed with flexible, waterproof membrane.
NOTE:	Waterproof flooring may impede drying when placed over timber (plywood). These floors may require special attention to drying and/or repair/replacement.

RL-302
Internal | existing stud wall
New vinyl / new tile floor finish + underlay



TYPOLOGY:	RETROFIT LIGHTWEIGHT
WALL TYPE:	INTERNAL | EXISTING STUD WALL
FLOOR TYPE:	EXISTING HARDWOOD TIMBER FLOORBOARDS ON TIMBER STRUCTURE
CODE:	RL-303
Framing:	Existing pine/hardwood timber to be retained and sprayed with flexible, waterproof membrane
Internal lining:	Existing internal lining to be replaced with new 9mm water resistant sheeting set with external setting plaster to above flood level
Skirting:	Hardwood or other water resistant skirting
Floor finish:	Existing hardwood timber floorboards on timber structure to be retained.

RL-303
Internal | existing stud wall
Existing hwd floorboards



TYPOLOGY: MASONRY
WALL TYPE: EXTERNAL | EXISTING BRICK VENEER
FLOOR TYPE: EXISTING CONCRETE SLAB
R-VALUE: 3.44
CODE: RM-101

Framing: Existing pine or hardwood framing to be retained and sprayed with flexible, waterproof membrane

External lining: Existing brick veneer to be retained. Additional weep holes to be added where possible.

nsulation: Existing batt insulation to be replaced with new rigid closed cell insulation. Thickness of insulation to match depth of stud frame. Seal edges of insulation to frame.

nternal lining: Existing internal lining to be replaced with new 9mm water resistant sheeting set with external setting plaster to above flood level

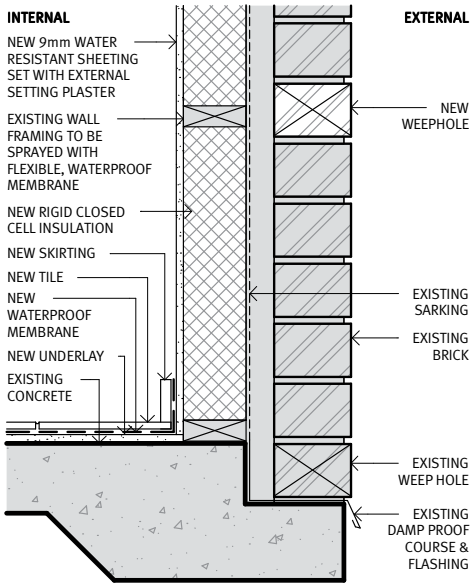
Skirting: Hardwood or other water resistant skirting

Floor finish: Existing concrete to be retained. Apply new non-slip penetrative sealant.

NOTES: Where insulation is fixed to timber frames, ventilation is critical to allow airflow inside the exterior walls in order to prevent mould build up and deterioration of the frame.

Consult builder regarding termite barriers required.

RM-101
External | existing brick veneer
Existing concrete floor finish



TYPOLOGY: MASONRY
WALL TYPE: EXTERNAL | EXISTING BRICK VENEER
FLOOR TYPE: EXISTING NON WATER RESISTANT FLOOR FINISH ON CONCRETE SLAB
R-VALUE: 3.44
CODE: RM-102

Framing: Existing pine or hardwood framing to be retained and sprayed with flexible, waterproof membrane

External lining: Existing brick veneer to be retained. Additional weep holes to be added where possible.

Insulation: Existing batt insulation to be replaced with new rigid closed cell insulation. Thickness of insulation to match depth of stud frame. Seal edges of insulation to frame.

Internal lining: Existing internal lining to be replaced with new 9mm water resistant sheeting set with external setting plaster to above flood level

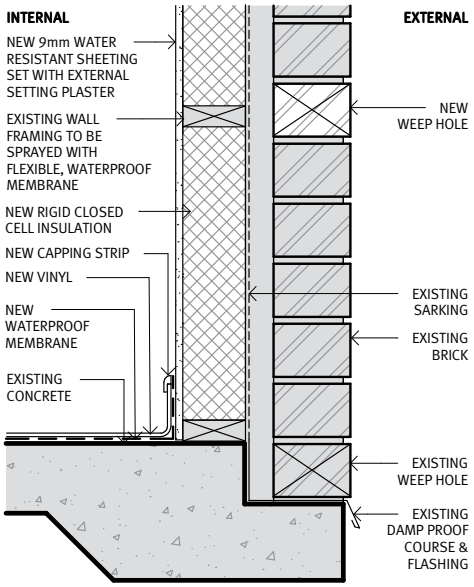
Skirting: Tile or other water resistant skirting

Floor finish: Existing non water resistant floor finish to be replaced with new tile + waterproof membrane + underlay. Please note that removal of a timber floating floor is preferred as waterproof flooring may impede drying when placed over timber.

NOTES: Where insulation is fixed to timber frames, ventilation is critical to allow airflow inside the exterior walls in order to prevent mould build up and deterioration of the frame.

Consult builder regarding termite barriers required.

RM-102
External | existing brick veneer
New tile floor finish

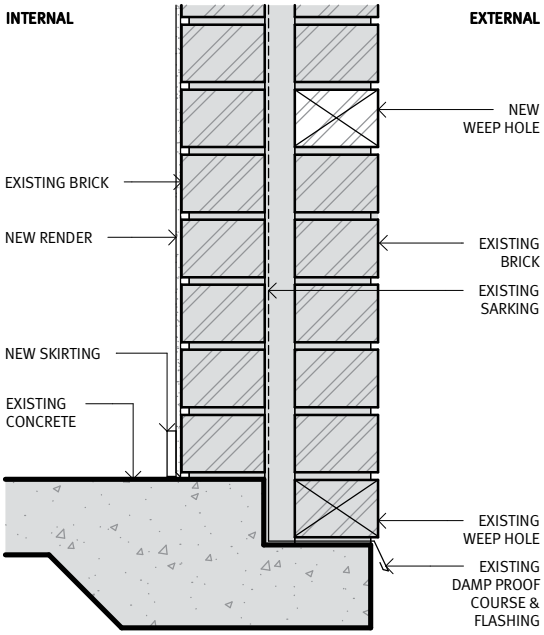


TYPOLOGY:	MASONRY
WALL TYPE:	EXTERNAL | EXISTING BRICK VENEER
FLOOR TYPE:	EXISTING NON WATER RESISTANT FLOOR FINISH ON CONCRETE SLAB
R-VALUE:	3.44
CODE:	RM-103

Framing:	Existing pine or hardwood framing to be retained and sprayed with flexible, waterproof membrane
External lining:	Existing brick veneer to be retained. Additional weep holes to be added where possible.
Insulation:	Existing batt insulation to be replaced with new rigid closed cell insulation. Thickness of insulation to match depth of stud frame. Seal edges of insulation to frame.
Internal lining:	Existing internal lining to be replaced with new 9mm water resistant sheeting set with external setting plaster to above flood level
Skirting:	Coved vinyl or other water resistant skirting
Floor finish:	Existing non water resistant floor finish to be replaced with new vinyl + waterproof membrane + underlay. Please note that removal of a timber floating floor is preferred as waterproof flooring may impede drying when placed over timber.

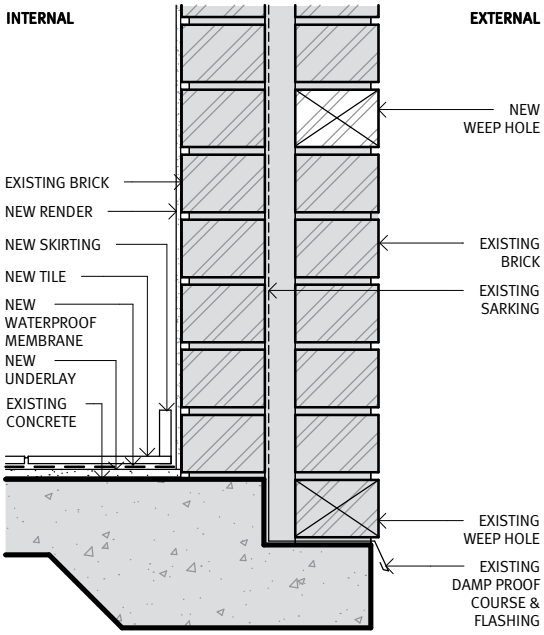
NOTES:	Where insulation is fixed to timber frames, ventilation is critical to allow airflow inside the exterior walls in order to prevent mould build up and deterioration of the frame. Consult builder regarding termite barriers required.

RM-103
External | existing brick veneer
New vinyl floor finish



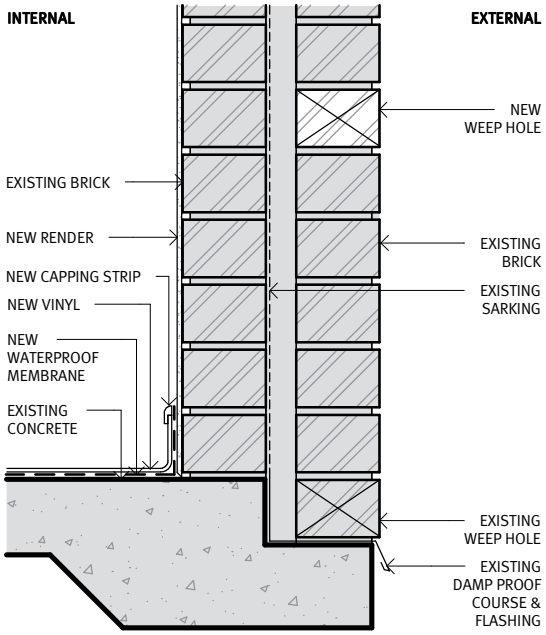
TYPOLOGY:	MASONRY
WALL TYPE:	EXTERNAL | EXISTING DOUBLE BRICK
FLOOR TYPE:	EXISTING CONCRETE SLAB
R-VALUE:	0.69
CODE:	RM-201
Structure:	Existing brick to be retained
Framing:	Existing pine or hardwood framing to be retained and sprayed with flexible, waterproof membrane
External lining:	Existing brick veneer to be retained. Additional weep holes to be added where possible.
Insulation:	N/A
Internal lining:	New render to above the flood line.
Skirting:	Hardwood or other water resistant skirting
Floor finish:	Existing concrete to be retained. Apply new non-slip penetrative sealant.
NOTES:	Adequate ventilation is critical to allow airflow inside the exterior walls in order to prevent mould build up. Consult builder regarding termite barriers required.

RM-201
External | existing double brick
Existing concrete floor finish



TYPOLOGY:	MASONRY
WALL TYPE:	EXTERNAL | EXISTING DOUBLE BRICK
FLOOR TYPE:	EXISTING NON WATER RESISTANT FLOOR FINISH ON CONCRETE SLAB
R-VALUE:	0.69
CODE:	RM-202
Structure:	Existing brick to be retained
Framing:	Existing pine or hardwood framing to be retained and sprayed with flexible, waterproof membrane
External lining:	Existing brick veneer to be retained. Additional weep holes to be added where possible.
Insulation:	N/A
Internal lining:	New render to above the flood line.
Skirting:	Tile or other water resistant skirting
Floor finish:	Existing non water resistant floor finish to be replaced with new tile + waterproof membrane + underlay. Please note that removal of a timber floating floor is preferred as waterproof flooring may impede drying when placed over timber.
NOTES:	Adequate ventilation is critical to allow airflow inside the exterior walls in order to prevent mould build up. Consult builder regarding termite barriers required.

RM-202
External | existing double brick
New tile floor finish



TYPOLOGY:	MASONRY
WALL TYPE:	EXTERNAL | EXISTING DOUBLE BRICK
FLOOR TYPE:	EXISTING NON WATER RESISTANT FLOOR FINISH ON CONCRETE SLAB
R-VALUE:	0.69
CODE:	RM-203

Structure:	Existing brick to be retained
Framing:	Existing pine or hardwood framing to be retained and sprayed with flexible, waterproof membrane
External lining:	Existing brick veneer to be retained. Additional weep holes to be added where possible.
Insulation:	N/A
Internal lining:	New render to above the flood line.
Skirting:	Coved vinyl or other water resistant skirting
Floor finish:	Existing non water resistant floor finish to be replaced with new vinyl + waterproof membrane + underlay. Please note that removal of a timber floating floor is preferred as waterproof flooring may impede drying when placed over timber.
NOTES:	Adequate ventilation is critical to allow airflow inside the exterior walls in order to prevent mould build up. Consult builder regarding termite barriers required.

RM-203
External | existing double brick
New vinyl floor finish

Flood resilient materials

This section details the advantages and disadvantages of different materials and systems referred to throughout this guideline.

Once a material and or system has been selected, refer to the **Flood resilient product listing** for product selection.

Flood resilient materials table

The following materials in the flood resilient materials table have been categorised according to the building element type as follows:

1 Landscaping

2 External services

3 External cladding and structure

4 Double brick construction

5 Brick veneer construction

6 Wall framing

7 Insulation

8 Internal structural members

9 Internal floors and ceilings

10 Internal walls

11 Wet areas

12 Internal stairs

13 Doors and windows

14 Internal electrical services

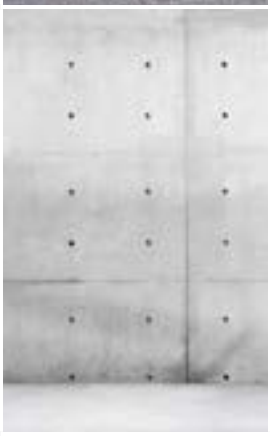
15 Cabinetry.

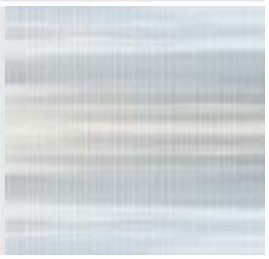
Reference	Flood resilient materials	Advantages	Disadvantages	Image
1	Landscaping			
1.1	Pervious resin bound aggregate surface	• reduce site run-off • flexibility in shape of design • potential to include a recycled component to the mix such as recycled glass	• installed by supplier	
	Permeable paving	• reduce site run-off • easily installed • any damaged pavers can be easily replaced		
1.2	Hardwood timber fencing	• recyclable, readily available material • easily repaired or replaced	• some warping may occur • maintanence may be required	
	Composite timber fencing	• no maintenance	• not as easily repaired or replaced	
1.3	Spoon drain	• easily cleaned and maintained	• less aesthetically pleasing	
	Infiltration box	• reduce site run-off • can be integrated into driveways or adjacent to property boundaries	• high clogging potential • build-up of pollution difficult to monitor • failure common due to poor maintenance	
	Detention basin	• reduce site run-off	• build-up of pollution difficult to monitor • requires maintenance and cleaning out every two to five years.	

Reference	Flood resilient materials	Advantages	Disadvantages	Image
1.4	**Swale**	• reduce / delay stormwater run-off • retain particulate pollutants • more aesthetically appealing than kerb and gutter • relatively inexpensive to build	• limited removal of fine sediment and dissolved pollutants • use more land area than kerb and gutter, and restrict car parking space • require a sunny aspect for plant growth, which limits their application in shaded areas • only suitable for gentle slopes of less than 5% gradient • require regular inspections	
	Rain garden system	• reduce stormwater run-off while harnessing natural landscape catchments • retain particulate pollutants • more aesthetically appealing than kerb and gutter • relatively inexpensive to build	• may capture a high sediment load • build-up of pollution difficult to monitor • require a sunny aspect for plant growth, which limits their application in shaded areas	
1.5	**Berms**	• redirects run-off away from vulnerable structures and buildings • more aesthetically pleasing than walls and barriers	• use more land area • require a sunny aspect for plant growth, which limits their application in shaded areas	
1.6	**Composite timber decking**	• no maintenance	• not as easily repaired or replaced	
2	**External services**			
2.1	**Rainwater tank anchor / tie-down**	• avoid added damage due to the movement of heavy rainwater tanks		

Reference	Flood resilient materials	Advantages	Disadvantages	Image
2.6	Non-return valve	• protect internal areas, pumps and compressor equipment from damage caused by sewerage and stormwater backflow		
3	External cladding and structure			
3.1 RM-100 RM-200	Double brick and brick veneer*	• durable and water-resistant • minimal clean-up and repair • extra weight helps to cancel uplift forces • skirtings and architraves not required for double brick walls • face or glazed brick is more durable than common (clay) brick • waterproof cement render finish provides a durable external barrier • structural glazed clay tile also provides a durable external barrier	• Not recommended for new construction as double brick and brick veneer walls will take considerable time to dry after a flood • To retrofit this construction type extensive use of waterproofing spray may be necessary to protect any timber framing	
NM-200 NC-100	Concrete block	• durable, water and fire resilient • minimal maintenance • no cavity to hold moisture and/or silt when fully core filled • minimal clean-up and repair • extra weight helps to cancel uplift forces • can be constructed relatively quickly • can be reinforced for additional strength	• can be less aesthetically pleasing unless rendered and painted	

* Retrofit only

Reference	Flood resilient materials	Advantages	Disadvantages	Image
NM-100 NM-300	Rendered autoclaved aerated concrete block or panel (aac)	• durable and water-resistant (only with waterproof render) • minimal maintenance • no cavity to hold moisture and/or silt • minimal clean-up • can be constructed relatively quickly	• only recommended if waterproof rendered	
3.1 NM-100 NM-200 NM-300 NM-400	Waterproof render	• durable and water-resistant • unaffected by water immersion • not prone to impact damage • easy to clean or repaint	• slightly higher cost compared to alternative finishes	
	Off-form concrete	• no cavity to hold moisture and/or silt • very strong • immune to water damage • minimal clean-up and repair • extra weight helps to cancel uplift forces • skirtings and architraves commonly not used • low maintenance	• specialised construction needed for in-situ and concrete panel • unfinished concrete may not be acceptable for appearance reasons	
NL-200	Fibre cement	• water-resistant • affordable • easily repaired and replaced • variety of colours and textures	• requires some maintenance	
NL-100 NL-200	Hardwood	• water-resistant • easily repaired and replaced • renewable resource	• requires regular maintenance	
NL-200	Composite timber	• durable, water, mould and termite resilient • recyclable • low maintenance	• more difficult to repair and replace	

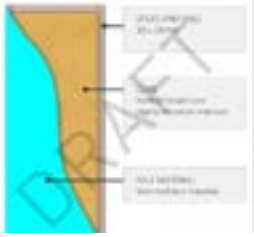
Reference	Flood resilient materials	Advantages	Disadvantages	Image
NL-200	Metal	• water-resistant • low maintenance	• more difficult to repair and replace	
3.1 NL-200	Tile	• durable, water-resistant • minimal maintenance • can be temperature, chemical and impact resistant • impervious to mould and termites • low maintenance	• more difficult to repair and replace	
NL-300	Translucent sheeting	• water-resistant • minimal maintenance • allows light in	• only for walls adjacent to non-habitable rooms • no insulation if translucency is to be maintained	
6	Wall framing			
6.1 Refer all wall details	Hardwood framing	• durable, water-resistant and has thermally insulating properties • flexibility of design, allows for modification on site • timber is a humidity regulator	• can be host to mould and termites (although poses less risk than softwood)	
	Steel framing	• durable and water-resistant • impervious to mould and termites • can include a recycled material component	• factory pre-fabricated and pre-cut steel frames do not allow for modification on site • higher cost than hardwood framing	

Reference	Flood resilient materials	Advantages	Disadvantages	Image
7	**Insulation**			
7.1 NL-100 NL-200 NM-100	Xps rigid thermal insulation	• durable and water-resistant • higher r-values compared to loose-fill or open cell insulation	• susceptible to sunlight	
	Closed cell flexible sheet insulation	• durable and water-resistant • higher r-values compared to loose-fill or open cell insulation	• susceptible to sunlight	
	Sprayed polyurethane foam (spuf) or closed-cell plastic foams	• durable and water-resistant • higher r-values compared to loose-fill or open cell insulation	• denser than open-cell foam, requiring more material • more expensive than open-cell	
9	**Internal floors and ceilings**			
9.1 Refer all construction details	Raised concrete slab	• all the advantages of slab on ground construction • raised floor (on fill, waffle pod, suspended slabs) minimises risk of water entering house when surrounding ground is flooded • suitable for uneven ground / sloping site - avoids need for cut and fill and reduces costs of retaining walls and drainage • can also utilise a range of proprietary precast flooring systems where fill is not employed	• steps may be required	

Reference	Flood resilient materials	Advantages	Disadvantages	Image
Refer all construction details	**Slab on ground**	• generally undamaged by immersion for any period • the additional weight and strength helps to resist buoyancy forces • slab on ground floors tend to be the least expensive option • allows for easier post-flood cleaning / hose down	• for a given ground level, slab on ground floors will normally be only slightly higher and more vulnerable to inundation including local overland flooding • potentially suffers from scouring undermining effects	
Refer all construction details	**Tile**	• durable and water-resistant • minimal maintenance • can be temperature, chemical and impact resistant • impervious to mould and termites • low maintenance	• more difficult to repair and replace	
9.1 **RL-100** **RL-200** **RL-300**	**Suspended hardwood timber floor**	• likely extra elevation reduces the flood risk • the house can be designed so that minor flooding and overland flow can pass under the floor • quick and economic construction	• timber components more prone to damage and may need replacing or repairing • timber strip flooring should not suffer any significant loss in strength but may swell or cup (moisture resistant flooring, bearers and joists could be used as substitute for natural timbers) • house could be more prone to uplift (especially sheet clad houses) • suspended floors are more expensive	

Reference	Flood resilient materials	Advantages	Disadvantages	Image
Refer all construction details	Rubber / vinyl/ marmoleum	• durable and water-resistant • easily and quickly installed • minimal maintenance • variety of colours and textures • rubber flooring can have a very high recycled component	• may impede drying when placed over timber (plywood) • more difficult to repair and replace • can be discoloured or damaged by some chemical cleaners • must be purposefully installed and sealed to be flood resilient • vinyl is not biodegradable or commonly recycled	
10	**Internal walls**			
10.1 NM-400	Rendered autoclaved aerated concrete block or panel (aac)	• durable and water-resistant (only with waterproof render) • minimal maintenance • no cavity to hold moisture and/or silt • minimal clean-up • can be constructed relatively quickly	• only recommended if waterproof rendered	
NL-100 NL-200 NL-400 RL-100 RL-200 RL-300 RM-100	Moisture resistant internal wall cladding	• durable, fire and water-resistant • resistant to mould and termites		
10.1 RL-100 NL-200 NL-400 RL-100 RL-200 RL-300 RM-100	Fibre cement cladding	• water-resistant • affordable • easily repaired and replaced • variety of colours and textures	• requires some maintenance	
RL-100 NL-200 NL-400 RL-100 RL-200 RL-300 RM-100	Marine grade and moisture resistant plywood	• water and impact resilient • highly pliable for design flexibility • can be stained or painted	• increased cost compared to other internal wall finishes • requires some maintenance • not suitable for long duration flood events • edges must be purposefully covered and sealed to be flood resilient	

Reference	Flood resilient materials	Advantages	Disadvantages	Image
NL-400	**Single skin hardwood timber framed**	• timber frame construction is traditional and economic • least expensive construction	• frame can warp or swell in flood event • frame may suffer decay or mould can grow if not dried • exterior cladding or brick veneer can be damaged with movement of the wall frame • some internal linings may need extensive replacement • some types of bulk insulation retain moisture and may need to be removed to aid drying – replacement would only follow adequate drying of structure. • some bracing types may need replacing	
	Paint - polyester-epoxy	• water and stain resistant	• limited ability to repair because does not bond to previous coating • can cause health issues if inhaled • limitations depending on surface type • highly flamable	
10.1	**Paint - alkyd (oil-based)**	• water and stain resistant • easily washable and more chemically resistant than latex • better when repainting than other paint options	• longer drying time • not mould resilient • releases voc's • does not breath., therefore will peel if exposed to moisture	
	Paint - latex	• water, mould, fire and fade resistant • more easily applied than other paint options • quicker drying time than alkyd paints	• adheres badly to pre-painted, dirty or chalky walls • can shrink and cause surface stress • does not perform as well as alkyd paint in areas of high humidity	

Reference	Flood resilient materials	Advantages	Disadvantages	Image
13	**Doors and windows**			
13.1 NT-100	Solid core door	• water and fire resilient and durable • low maintenance • noise mitigating and thermal insulating	• more expensive • heavy • may need periodic maintenance due to expansion and contraction	
13.2 NT-100	Flush threshold	• water may be easily flushed out of the building	• more expensive due to labor cost of recessing the door sill • not weatherproof as the door has nothing to seal against - may require brush or rubber seals to be fixed to the bottom of the door	
15	**Cabinetry**			
15.1	Compact laminate	• durable, water, mould, fire and termite resilient • low maintenance, long lasting • resistant to chemical cleaners • various colours, patterns and textures	• more difficult to repair and replace if colours / patterns become discontinued	
	Acrylic solid surface	• durable, water, mould, fire and termite resilient • low maintenance, long lasting • resistant to chemical cleaners • various colours, patterns and textures	• more expensive • not heat resistant • not as environmentally friendly as other resilient cabinetry options	
	Marine plywood	• water and impact resilient • highly pliable for design flexibility • can be stained or painted	• increased cost compared to other internal wall finishes • requires some maintenance • not suitable for long duration flood events • edges must be purposefully covered and sealed to be flood resilient	

Reference	Flood resilient materials	Advantages	Disadvantages	Image
	Composite timber panel	• durable, water, mould and termite resilient • recyclable • low maintenance	• more difficult to repair and replace	

Flood resilient products listing

This section provides a list of flood resilient building products commonly available in Queensland.

Reference list

1 Landscaping

- 1.1 Paving and decking
- 1.2 Fencing
- 1.3 Water retention and drainage systems

2 External services

- 2.1 External services

3 External cladding and structure

- 3.1 External wall finishes
- 3.2 Air vents

7 Insulation

- 7.1 Insulation

9 Internal floors

- 9.1 Internal floor finishes

10 Internal walls

- 10.1 Internal wall finishes

13 Doors and windows

- 13.1 Doors

15 Cabinetry

- 15.1 Cabinetry and joinery

16 Adhesives, sealants and coatings

- 16.1 Adhesives
- 16.2 Sealants and coatings
- 16.3 Waterproofing systems

17 Clean and dry out materials

Photo reproduced courtesy of Brisbane City Council and James Davidson Architect

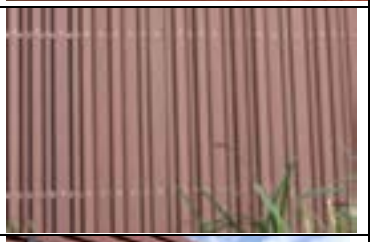
1.0 LANDSCAPING

DESCRIPTION	PRODUCT NAME	COMPANY
Pervious Resin Bound Aggregate Surface	Porous Paving or Overlay Paving	**StoneSet**
Permeable Paving	Ecotrihex / Ecopave 50 / Ecopave 80 / Turfstone	**AbriMasonry**
Permeable Paving	HydroSTON	**HydroCON**
Permeable Paving 600 x 300mm 300 x 300mm 200 x 100mm	Hydropavers	**Hydropavers**
Solid WPC Composite Decking 86mm x 23mm; 138mm x 23mm; 5400mm lengths	CleverDeck Composite Decking	**Futurewood**

COLOUR & FINISH	WEBSITE	CERTIFICATIONS	IMAGES
Warm Natural Colours; Black & White; Recycled Coloured Glass	http://www.stoneset.com.au/products/		
Charcoal; Natural; Oatmeal	http://www.adbrimasonry.com.au		
Standard: Charcoal; Natural	http://hydroston.com.au/		
Light Grey; Dark Grey; Sand; Brown	https://www.hydropavers.com.au/		
Colour: Chocolate; Mahogany; Saltbush; Slate Grey; Walnut; and Custom Finish: Indented grain/ sanded; plain coarse sanded	https://www.futurewood.com.au/decking/		

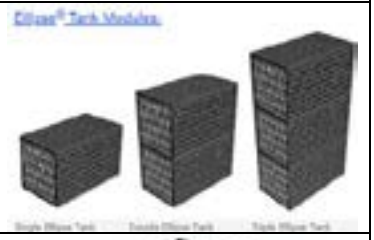
1.0 LANDSCAPING

DESCRIPTION	PRODUCT NAME	COMPANY
Composite Decking Solid Decking 88 x 23 mm Wide Decking 137 x 23 mm Marina Board 137 x 32 mm Flame Shield 137 x 23 mm	Modwood Decking	**Modwood**
Composite Timber Decorative Cladding 70mm x 15mm, 40mm x 30mm and 60mm x 40mm 5400mm lengths Fixed horizontally or vertically	EnviroSlat Decorative Cladding	**Futurewood**
Composite Screening Mini Board 68 x 17 mm	Modwood Screening	**Modwood**
Underground trafficable stormwater detention and infiltration system Modular system / custom designed 2,350 mm wide x 4,000 mm long SingleTrap - 600 - 1,500 mm max height DoubleTrap - 1,200 - 3,000 mm max	StormTrap	**Humes / Holcim Australia**
Vertical Perforated Liners Various diameters 600mm – 1200mm depths Trafficable / non-trafficable covers	Soakwells	**Humes / Holcim Australia**

COLOUR & FINISH	WEBSITE	CERTIFICATIONS	IMAGES
Colour: Black Bean; Jarrah; Sahara; Silver Gum Finish: Brushed; Smooth	http://www.modwood.com.au/decking/	Green Tag Certified	
Slate grey, Walnut	https://www.futurewood.com.au/cladding/		
Colour: Black Bean; Jarrah; Sahara; Silver Gum Finish: Brushed; Smooth	http://www.modwood.com.au/decking/	Green Tag Certified	
	http://www.humes.com.au/precast-concrete-solutions/stormwater-solutions/stormwater-detention.html		
	http://www.humes.com.au/precast-concrete-solutions/stormwater-solutions/stormwater-detention.html		

1.0 LANDSCAPING

DESCRIPTION	PRODUCT NAME	COMPANY
Modular Infiltration Tank System 600mm L x 400mm W x 450mm H 105ltr capacity + AUSDRAIN EnviroSump or other Gross Pollutant Trap (GPT) + Geotextile fabric + Overflow pit	EnviroModule2 Infiltration Tank	**AUSDRAIN**
Modular Infiltration Tank System 715mm L x 400mm W x 440mm H 125ltr capacity	Elipse Tank Modules	**Rainsmart Solutions**
Modular Infiltration Plane System 30mm; 50mm	Nero Pave Cell	**Rainsmart Solutions**
Modular Infiltration Tank System VT250–500mm L x 250mm W x 560mm H VT550–500mm L x 500mm W x 560mm H VT+840–745mm L x 395mm W x 425mm H VT+880–745mm L x 790mm W x 425MM H	VersiTank	**Elmich**
Modular Infiltration Plane System 30mm H	VersiCell	**Elmich**

COLOUR & FINISH	WEBSITE	CERTIFICATIONS	IMAGES
	http://www.ausdrain.com/products/modular-tanks/infiltration		
	http://www.rainsmartsolutions.com		
	http://www.rainsmartsolutions.com/50mm_nero_pave.html		
	https://elmich.com.au/products/versitank-rainwater-tank/		
	https://elmich.com.au/products/versicell-subsoil-drainage/		

2 EXTERNAL SERVICES

DESCRIPTION	PRODUCT NAME	COMPANY
2.1 External Services		
Tank Tie Down Block Integrated galvanised threads and/or ferrules	TTB-2500	**Coerco**

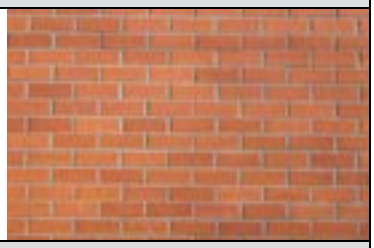
WET-PROOF PRODUCTS & MATERIAL SYSTEMS

DESCRIPTION	PRODUCT NAME	COMPANY

3 EXTERNAL CLADDING & STRUCTURE

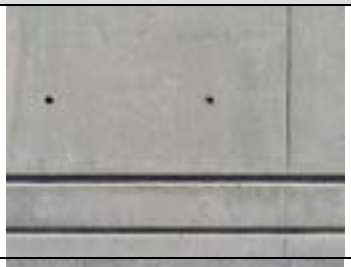
3.1 EXTERNAL WALL FINISHES		
BRICK		
Brick + Sealant / waterproofing?	-	**-**
CEMENT COMPOSITE		
Cement Composite Weatherboard 16mm Tongue and Groove 4200 x 150mm 4200 x 180mm	Scyon Linea	**James Hardie**

COLOUR & FINISH	WEBSITE	CERTIFICATIONS	IMAGES
	https://www.coerco.com.au/product-category/tank-fittings-and-accessories/tank-tie-down-block/		

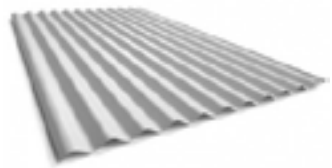
COLOUR & FINISH	WEBSITE	CERTIFICATIONS	IMAGES
	-	-	
	http://www.jameshardie.com.au/products/external-cladding/scyon-linea-weatherboard/		

WET-PROOF PRODUCTS & MATERIAL SYSTEMS

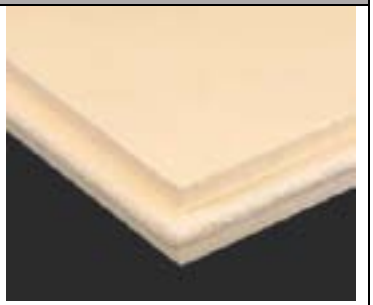
DESCRIPTION	PRODUCT NAME	COMPANY
CONCRETE, CONCRETE BLOCK, PANEL & COMPOSITES		
Concrete (off-form) + Sealant / waterproofing	-	-
Concrete block + Sealant / waterproofing + Waterproof render	-	-
Steel reinforced Autoclaved Aerated Concrete (AAC) Panels 75mm	PowerPanel PowerFloor PowerFence PowerBlock PowerSheild SoundBarrier	**CSR Hebel**
Insulating Concrete Form (ICF) Wall System 101mm wall thickness (1219 x 406 x 229mm) 152mm wall thickness (1219 x 406 x 279mm) 203mm wall thickness (1219 x 406 x 330mm)	Eco Block	**Eco Block**
FIBRE CEMENT SHEETING		
Fibre cement sheeting	Scyon, HardieFlex, HardiePanel, Primeline, PanelClad, HardieTex, HardiePlank, ExoTec, Easylap, ComTex, Easylap, HardieGroove, Versilux	**James Hardie**

COLOUR & FINISH	WEBSITE	CERTIFICATIONS	IMAGES
Ground / Polished	-	-	
	-	-	
+ Rendered finish	http://hebel.com.au/		
	https://www.eco-blockaustralia.com.au/index.htm		
Numerous colours/textures	http://www.jameshardie.com.au/products/external-cladding/		

WET-PROOF PRODUCTS & MATERIAL SYSTEMS		
DESCRIPTION	**PRODUCT NAME**	**COMPANY**
Fibre Cement Cladding Product ranges: Territory; Surround; Barestone	Cemintel	**CSR**
HARDWOOD TIMBER		
Treated hardwood H4 minimum H6 Turpentine works best submerged Best painted to avoid leeching of chemicals into environment	-	-
METAL		
Metal Cladding		**Lysaght (custom orb)** **Stratco**
RENDER		
Render Cementitious Polymer Modified Adhesive Base Coat For use on pre-painted surfaces If used over Fibre cement sheeting + 2mm dry film build Acrylic Render finishing coat	Keycote	**Rockcote**
Blue Board System Lengths: 2440mm; 2725mm; 3000mm Widths: 900mm; 1200mm Thickness: 7.5mm	HardieTex	**James Hardie**
TILE		
Technical Porcelain Façade Tiles + Butech bonded façade system Formats: Mosaic 31.6 x 31.6; 33 x 66; 43.5 x 65.9; 44 x 66; 40 x 80; 45 x 90; 59.6 x 120; 59.6 x 180; 59.6 x 59.6; 80 x 80; 14.3 x 90; 5 x 59.6 cm	Porcelanosa STON-KER Façade Tiles	**Earp Bros**
CLADDING SYSTEMS		
High Density Polyethylene (HDPE)	Smartboard	**Cosset**

COLOUR & FINISH	WEBSITE	CERTIFICATIONS	IMAGES
Numerous colours/textures	http://www.cemintel.com.au	Codemark	
	-		
			
	https://www.rockcote.com.au/products/keycote	Nil	
	http://www.jameshardie.com.au/products/external-cladding/hardietex-system/		
Range of tile colours and patterns	http://www.ston-ker.com/en/		
Colours: Black	http://www.cosset.com.au/sheeting		

WET-PROOF PRODUCTS & MATERIAL SYSTEMS		
DESCRIPTION	**PRODUCT NAME**	**COMPANY**
100% post consumer waste HDPE Sheet size: 2400mm x 1200mm Thicknesses: 6;7;8;9;12;15;19;25;35;40;45;50;55;60;65 (Need to allow for thermal movement)		
Composite Timber Shiplap Cladding 156mm x 21mm x 4000mm shiplap boards Other sizes may be custom made to order	EnviroSlat Weatherproof Cladding	**Futurewood**
3.5 AIR VENTS		
Automatic Airbrick flood protection device	The 'SMART' Airbrick	**MUNA**
7 INSULATION		
7.1 INSULATION		
Extruded Polystyrene (XPS) Rigid Thermal Insulation Non-porous, closed cell, high performance extruded polystyrene general application insulation board for use in floor, wall and roof applications. Nominal Thickness: 25, 30, 40, 50, 60, 75, 80, 90, 100 and 120mm Width: 600 mm Length: 2500 mm	DCT GA 300	**Dynamic Composite Technologies (DCTECH)**

COLOUR & FINISH	WEBSITE	CERTIFICATIONS	IMAGES
(standard); White; Safety yellow; Red; Mid Green; Orange; Blue; Light grey; Off white	/smartboard		
Walnut; Slate Grey; and Custom colour	https://www.futurewood.com.au/cladding/		
	https://www.munauk.co.uk/smart-airbrick	-	
	http://www.dctech.com.au/dct-ga-300/	Nil	

WET-PROOF PRODUCTS & MATERIAL SYSTEMS

DESCRIPTION	PRODUCT NAME	COMPANY
Extruded Polystyrene (XPS) Board Thickness: 30mm (R 1.1) 40mm (R 1.4) – (Note: lower R-value than Foilstar) 50 mm (R 1.8) 70mm (R 2.7) Width: 600mm; 1200mm Length: 1200mm; 2200mm	ClimaFoam XPS Board	**Knauf Insulation**
Closed Cell Underfloor Insulation 4mm thickness 2.4m max span without support mesh Closed-cell, cross-linked foam structure sandwiched by highly reflective foil surfaces Water and vapour permeable	AIR-CELL Permifloor	**Kingspan**
Rigid Thermoset Closed Cell Phenolic Insulation Boards Floorboards / Wall Boards / Cavity Boards / Soffit Boards / Framing Boards	Kooltherm	**Kingspan**
Aluminium Faced Rigid Phenolic Insulation Foilstar 25mm (R2.5 min.) Foilstar 40mm (R3.1 min.) – (Note: much higher R-value than Knauf) 2350 x 1200mm	Foilstar	**Foilboard**
Thermal & Acoustic Wall Batts Thermally bonded polyester fibres Up to 80% recycled material / no waste in manufacture Low allergen / VOC free	Polymax Insulation	**Bradford** Ed Hanley: 0419476140 EHANLEY@csr.com.au

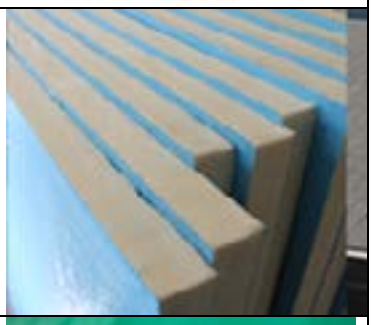
COLOUR & FINISH	WEBSITE	CERTIFICATIONS	IMAGES
	https://www.knaufinsulation.com.au/home-owners/insulation-range/extruded-polystyrene-xps-board		
	https://www.kingspan.com/au/en-au/products-brands/insulation/reflective-flexible-insulation/air-cell-permifloor	CodeMark (BCA compliant)	
	https://www.kingspan.com/au/en-au/products-brands/insulation/insulation-boards/kooltherm-range	CodeMark (Group 1 NCC BCA fire classification); AS/NZS 4859.1 compliant	
	https://www.foilboard.com.au/foilstar/	CFC/HCFC-free	
	https://www.bradfordinsulation.com.au/home-insulation/walls/polymax-insulation/polymax-ceiling-batts#current	AS 4859.1 compliant	

WET-PROOF PRODUCTS & MATERIAL SYSTEMS		
DESCRIPTION	**PRODUCT NAME**	**COMPANY**
Thermoset Polyisocyanurate (PIR) Foam Slimline Rigid Board	Xtratherm - XtroLiner Std (silver/silver) - XtroLiner Duo (silver/white)	**Bradford** Ed Hanley: 0419476140 EHANLEY@csr.com.au
Polyisocyanurate (PIR) Foam Rigid Board Width: 1200mm or 1350mm Thickness: 25mm,30mm 40mm, 50mm, 60mm, 75mm & 100mm Length: up to 7 metres	Polyisoboard	**Polyisoboard**
Non-Permeable reflective foil vapour barrier	Thermoseal Wall Wrap Or Thermoseal ResiWrap (suitable for metal roofs)	**Bradford**
Non-Permeable reflective foil vapour barrier	Thermoseal Roof Sarking (suitable for tiled roofs)	**Bradford**

9 INTERNAL FLOORS

9.1 INTERNAL FLOOR FINISHES

RUBBER		
Rubber Flooring 1.1m roll width 3.0; 5.0 thickness + Two Component Polyurethane Flooring Adhesive	Jazz Flooring + PU-KIT + Sikaflex 221	**A1 Rubber**

COLOUR & FINISH	WEBSITE	CERTIFICATIONS	IMAGES
	https://www.bradfordinsulation.com.au/commercial-and-industrial-insulation/underslab/xtratherm	Green Guide rating A+ /A (BRE) BREEAM highest score ISO14001 certification	
	http://www.polyisoboard.com.au/		
	https://www.bradfordinsulation.com.au/home-insulation/wall-wraps/thermoseal-wall-wrap		
	https://www.bradfordinsulation.com.au/home-insulation/roof-sarking/thermoseal-roof-sarking	AS3959 compliant (Bushfire)	
12 standard colours	http://a1rubber.com/our-products/commercial-rubber-flooring/jazz-flooring/		A1 RUBBER #1 in Rubber Upcycling

WET-PROOF PRODUCTS & MATERIAL SYSTEMS		
DESCRIPTION	**PRODUCT NAME**	**COMPANY**
+ Single Component Polyurethane Adhesive Around edges of walls only to avoid water penetration sideways OR Install with carpet tape for cleaning / inspection / drying		
STONE & RECONSTITUTED STONE		
Stone + Sealant + vapour barrier under + chemical-set adhesive + concrete floor (NO plywood underflooring)	-	-
TILES		
Ceramic / Porcelain Tiles + Epoxy coating for further water resilience + chemical-set adhesive + concrete floor (NO plywood underflooring)	-	-
VINYL		
Vinyl with chemical set adhesives	Polyflor	

10 INTERNAL WALLS

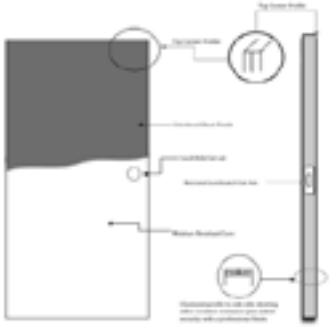
10.1 INTERNAL WALL FINISHES		
FIBRE CEMENT LINING		
Fibre Cement Lining		James Hardie
Fibre Cement Lining (Wet area applications)	Villaboard lining	James Hardie

COLOUR & FINISH	WEBSITE	CERTIFICATIONS	IMAGES
			*Needs testing and evaluation
-	-	-	
-	-	-	
	http://www.jameshardie.com.au/products/internal-lining/villaboard-lining/		

WET-PROOF PRODUCTS & MATERIAL SYSTEMS		
DESCRIPTION	**PRODUCT NAME**	**COMPANY**
MARINE PLYWOOD		
Marine Plywood A-A face; A bond Thicknesses: 1.5, 3, 4, 6.5, 9.5, 12.5, 16, 19, 25, 32mm Dimensions: 2400 x 1200, 2700 x 1200mm	Austral Marine Plywood	**Austral**
SKIRTINGS		
Stainless steel skirtings	-	**-**
PAINT		
Polyester- epoxy / oil-based waterproof	-	-
Oil-based waterproof	-	-
Latex	-	-

13 DOORS & WINDOWS

13.1 DOORS		
Solid core timber doors	-	-
Aluminium + glass doors	-	-
Commercial heavy duty metal door 0.55mm Zincalume / Colorbond sheeting standard	Bulwark 2000	**Spartan Doors**
Hardwood mouldings	Meranti mouldings	**Meranti**

COLOUR & FINISH	WEBSITE	CERTIFICATIONS	IMAGES
Water-resistant finish / fibreglass?	http://www.australply.com.au/products/standard/austral-marine	Super E0 Formaldehyde Emissions rating	
Stainless steel	-	-	
	-	-	
	-	-	
	-	-	
Colorbond colours			
			

WET-PROOF PRODUCTS & MATERIAL SYSTEMS		
DESCRIPTION	**PRODUCT NAME**	**COMPANY**
15 CABINETRY		
15.1 CABINETRY & JOINERY		
Acetylated Wood Fibreboard Thickness: 6, 9, 12, 15 and 18mm Sizes: 2440 x 1220mm; 3050 x 1220mm 25 yr warranty 100% waterproof	Tricoya EXDF	**Gunnersens**
Acrylic Solid Surface Thickness: 6,9,12 & 19mm Size: 3680 x 760 Non-porous; fully repairable if damaged Min. 10 yr warranty	HI-MACS	**Gunnersens**
Marine Plywood A-A face; A bond Thicknesses: 1.5, 3, 4, 6.5, 9.5, 12.5, 16, 19, 25, 32mm Dimensions: 2400 x 1200, 2700 x 1200mm	Austral Marine Plywood	**Austral**
Compact Laminate 13mm; 6mm thickness 3050mm x 1300mm UV coating	Laminex Alfresco Compact Laminate	**Laminex**
Compact Laminate	Laminex Compact Laminate	**Laminex**

COLOUR & FINISH	WEBSITE	CERTIFICATIONS	IMAGES
Natural finish, paint-ready 2-pac	https://www.gunnersens.com.au/info/tricoya/#technical	N/A	
59 Colours			
Water-resistant finish / fibreglass?	http://www.australply.com.au/products/standard/austral-marine	Super E0 Formaldehyde Emissions rating	AUSTRAL PLYWOODS
8 Colours			 *Note: Warranty invalidated if submerged in water
30 Colours			

WET-PROOF PRODUCTS & MATERIAL SYSTEMS		
DESCRIPTION	**PRODUCT NAME**	**COMPANY**
Compact Laminate	Compact Laminate	**Polytec**
Large Format Porcelain Panels	Maximum	**Maximum Australia**
Foamed PVC Panels 12mm, 16mm, 18mm 2440 x 1220mm 3600 x 1560mm (16mm)	Trade Essentials V-lite	**Laminex**

16 ADHESIVES, SEALANTS & WATERPROOF COATINGS

16.1 ADHESIVES		
Water resistant adhesive		**Ardex**
16.2 SEALANTS & COATINGS		
Concrete Impregnation Sealant Spray-applied product penetrates and reacts with cured structural concrete to form a sub-surface barrier; waterproofing the pores, capillaries and large cracks against the ingress of water and contaminants. No further maintenance is required. 8hr curing 100 yr guarantee	Radcon Formula # 7	**INCONMAT**

COLOUR & FINISH	WEBSITE	CERTIFICATIONS	IMAGES
14 Colours	https://www.polytec.com.au/products/commercial/compact-laminate/		
24 Colours	http://maximumaustralia.com/products		
White	http://tradeessentials.thelaminexgroup.com.au/products.php		
	https://www.radcrete.com.au/product/radcon-formula-7%C2%AE	Ecospecifier	RADCRETE

WET-PROOF PRODUCTS & MATERIAL SYSTEMS		
DESCRIPTION	**PRODUCT NAME**	**COMPANY**
Polyurethane Joint Sealant Formed in place	Sikaflex-PRO	**Sika**
Silicone, formed-in-place	-	-
16.3 WATERPROOFING SYSTEMS		
Capillary Waterproofing System for below grade concrete structures Can be added to concrete as an admixture in new construction, or trowelled onto an existing wall as a slurry coat.	Radmyx	**INCONMAT**

COLOUR & FINISH	WEBSITE	CERTIFICATIONS	IMAGES
	https://aus.sika.com/en/solutions_products/document_library/product-datasheets.html	-	
	-	-	
	https://www.radcrete.com.au/product/radmyx-capillary-waterproofing	(Non-toxic / VOC free / safe for potable water)	radmyx

Appendices

A – Legislative framework for Queensland building controls

B – Economic return on flood resilient homes

C – Literature review of flood resilient building

D – Resources for flood resilient buildings

Appendix A
Legislative framework for Queensland Building Controls

Queensland Floods Commission of Inquiry

In January 2011, Queensland experienced widespread flooding that caused extensive damage to both public and private property, the evacuation of towns and loss of more than 30 lives. The Queensland Floods Commission of Inquiry (QFCOI) examined the 2010-11 floods which affected 70 per cent of Queensland.

The Queensland Flood Commission of Inquiry Final Report (March 2012) states that "government agencies need to engage in a process of floodplain management involving a combination of land planning and building controls, emergency management procedures, and structural mitigation measures".[1]

In response to the QFCoI recommendations, the Brisbane River Catchment Flood Studies (Flood Studies) project was initiated. This project is a partnership between the Queensland Government, Brisbane City Council, Ipswich City Council, Somerset Regional Council, Lockyer Valley Regional Council and Seqwater. The purpose of this work is to establish frameworks for regionally consistent approaches to managing flood risk across the Brisbane River floodplain. The Flood Studies is a major program of work, undertaken through a series of phases, which has resulted in new approaches to integrated management of the Brisbane River floodplain.

The purpose of this Guidance is to improve the flood resilience of Queensland homes to reduce the physical and social costs that can arise when flooding occurs (refer **Figure 1**). It was developed as a part of the Flood Studies, but has statewide application.

Planning schemes and building controls

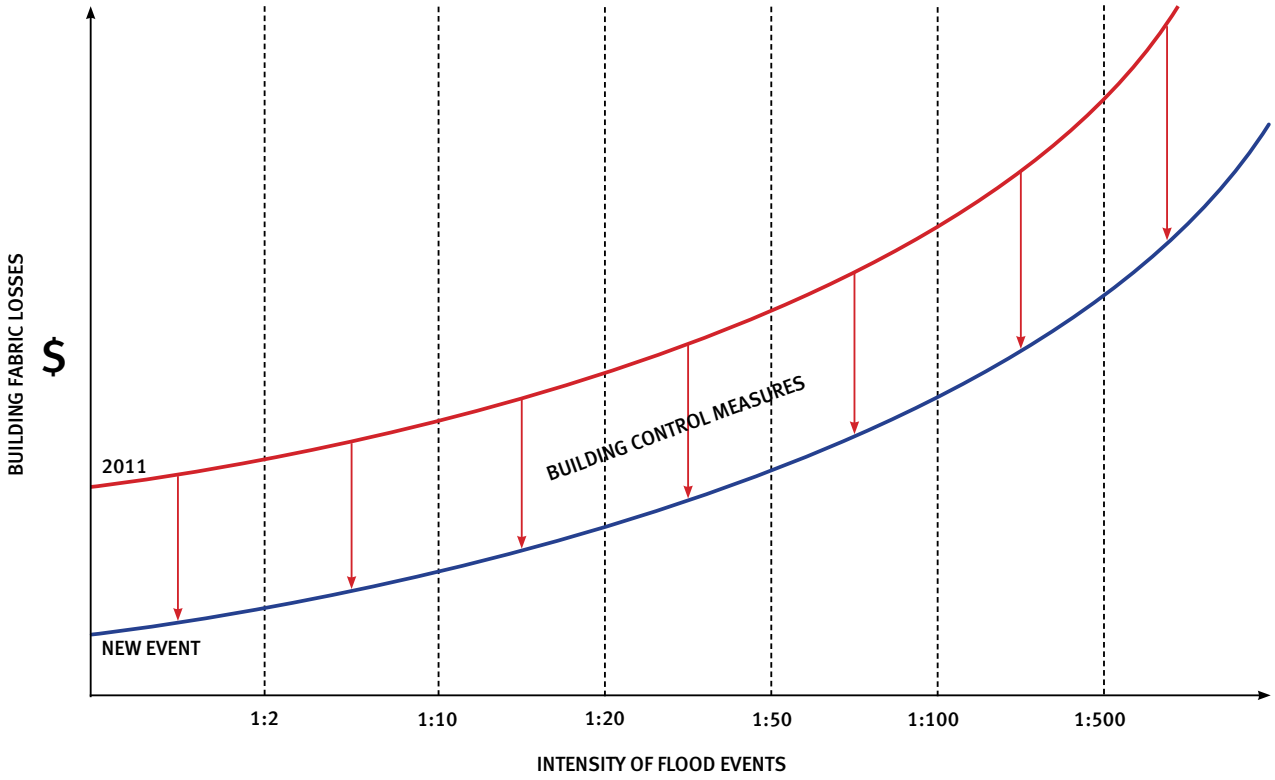
When building or renovating a residential property in Queensland, owners and applicants must comply with local planning schemes and building controls. Local governments approve where certain types of development can occur based on their local planning schemes.

Prior to construction, a building development approval, also known as a building permit, is necessary for most types of residential building work. This approval can be obtained from either local government or a registered private building certifier (or building surveyor in other Australian states) who assesses the building for compliance with the mandatory building controls set out in the National Construction Code (NCC) and the Queensland Development Code (QDC). The *Building Act 1975* and the *Building Regulation 2006* contain current laws and regulations relevant to building controls in Queensland.

Building provisions in planning schemes

Under the *Planning Act 2016*, local planning instruments are unable to include provisions for building work unless allowed under the *Building Act 1975*. Reciprocally, the *Building Act 1975* states that a local planning instrument must not include provisions regarding building work, to the extent that any building work must be regulated under a Building Assessment Provision (BAP) to avoid duplication in the assessment processes. There are several ways BAPs may be included in a planning scheme including through tables of assessment for building work, overlays or codes.

Figure 1. Building control measures help reduce flood related physical losses



Including BAPs in a local planning instrument is rarely permitted.[12]

The residential building provisions allowed in local planning schemes, as stated in the *Building Act 1975*, the *Building Regulation 2006* and the QDC, include the following: (applicable to class 1 and 10 buildings and structures only)[13]:

- boundary clearances
- site cover provisions
- heights of buildings related to obstruction and overshadowing
- siting and design of buildings to provide visual privacy and adequate sight lines (for corner blocks)
- on-site car-parking requirements
- outdoor living spaces
- designating bushfire prone areas for the Building Code of Australia or QDC
- designating a natural hazard management area (flood) and declaring a defined flood level, maximum flow velocity of water, inactive flow or backwater area, freeboard that is more than 300 millimetres or finished floor level of class 1 buildings built in all or part of the designated flood area.
- designating transport noise corridors for the purpose of QDC MP4.4
- additional end-of-trip facilities to those imposed by QDC MP 4.1 e.g. bicycle parking and storage facilities, locker facilities, change rooms, showers, sanitary compartments, wash basins and mirrors.

[12] Department of Housing and Public Works, Guide to Building Provisions in Planning Schemes, 2009 - 2018, [website], http://www.hpw.qld.gov.au/sitecollectiondocuments/guidetobuildingprovisionsinplanningschemesfactsheet.pdf, (accessed May 2018).

[13] Department of Housing and Public Works, Guide to Building Provisions in Planning Schemes, 2009 - 2018, [website], http://www.hpw.qld.gov.au/sitecollectiondocuments/guidetobuildingprovisionsinplanningschemesfactsheet.pdf, (accessed May 2018).

Current flood-related codes and standards

Current provisions for flood resilient construction standards are detailed in the following documents:

- QDC - MP3.5 Construction of Buildings in Flood Hazard Areas
- NCC via the ABCB's Construction of Buildings in Flood Hazard Areas Standard (the Flood Standard) and Handbook (the Flood Handbook).

Both of these documents cover risks associated with building structure and risk to life. They do not, however, cover resilient design or construction and have limited information on non-structural materials.

The purpose of MP3.5 is to ensure that buildings within flood hazard areas:

- resist floatation, collapse or damage
- are safe for people
- are protected from backflow
- have utilities and associated substations that are protected from flood water.

Prior to construction, a certifier assesses new building work within a flood hazard area against MP3.5. Within MP3.5 the Flood Standard is referenced. The Flood Standard points to two publications;

- Reducing Vulnerability of Buildings to Flood Damage: Guidance on Building in Flood Prone Areas (2006), Hawkesbury-Nepean Valley Flood Risk Management Steering Committee
- Technical Bulletin 2, Flood Damage-Resistant Materials Requirements (2008), Federal Emergency Management Agency (USA).

The Hawkesbury-Nepean document is a NSW-centric resource with a focus on double brick and brick veneer construction. It does not contain information about construction types typical in Queensland such as timber framed housing. The FEMA document provides information on resilient materials commonly available in the United States.

Appendix B
Economic benefits of flood resilient homes

1.1 Introduction

Flood resilient design and construction can reduce the long-term costs for home owners by reducing expected costs associated with flood damage and insurance premiums.

A cost benefit analysis was undertaken as part of the development of this Guidance to understand the return on investment for flood resilient homes under different circumstances.

Key findings

Benefits of resilient homes in high flood risk areas

Flood resilient homes are a viable option for flood events up to and including the 1% (1 in 100) AEP. The average Benefit Cost Ratios range from 1.9 to 19.6 and the average payback periods range from one to 12 years depending on building type, treatment adopted and likely frequency of flooding.

Benefits of resilient homes in lower flood risk areas

As the expected flood frequency decreases, so too does the case for resilient homes.

Benefits of resilient homes under future climate change scenarios

The economic case for flood resilient retrofitting of homes becomes even greater under future climate change scenarios. In these scenarios, flood resilient homes are economically viable under all circumstances modelled up to a 0.5% (1 in 200) AEP. The average Benefit Cost Ratios ranges from 1.7 to 27.3 and the average payback period ranges from 1 to 14 years depending on building type, treatment adopted and likely frequency of flooding.

1.2 Economic assessment of resilient options

A detailed economic assessment of resilient options was undertaken for two common Queensland home types. The assessment reviewed the initial investment costs for retrofitting a home to be flood resilient and compared it to savings likely to be generated over time through avoided flood damage costs.

Key considerations of the assessment included:

- whether the benefits of resilient homes following floods is greater than the initial investment costs of making a home flood resilient
- if the likely frequency of flooding impacts the return on investment for a flood resilient home.

1.3 Approach

A Cost Benefit Analysis (CBA) was undertaken to assess the relevant cost and benefits of flood resilient homes. The CBA considered the following:

- the lifecycle costs of a particular option are compared to the benefits
- financial costs of establishing a flood resilient home and the payback period for this investment
- estimated benefits (savings) from reduced flood damage in the future
- the Benefit Cost Ratio (BCR), to estimate the ratio of savings to costs - for an option to be economically viable the BCR should be greater than 1.

The cost data is based on a series of detailed quotes from builders to estimate the cost of establishing a flood resilient home. The benefits are based on the detailed flood damage assessments from the Brisbane River Strategic Floodplain Management Plan (SFMP). Due to the variability in input parameters, significant sensitivity analysis was undertaken on both costs and benefit data using flood modelling to establish a 95 per cent confidence interval for each cost or benefit input.

1.4 Options for assessment

Two common Queensland home types were reviewed for the economic assessment:

1. Sectional perspective 5

- fully detached home on stumps

2. Sectional perspective 6

- fully detached single story home with slab on ground
- fully detached double storey home with slab on ground for the bottom floor only.

1.5 Initial investment cost of a resilient building

Three building companies were engaged to provide fully costed written quotes for undertaking a 'resilient build' and 'like for like' replacement for actual houses used in this report. This enables the estimation of the investment cost of a 'resilient build', specifically an average cost of a 'resilient build' ($/m^2) and the likely range of costs. The range of costs are shown in Table 2.[14]

Table 1 - The additional cost of resilient build (compared to 'like for like' rebuilding)

	Incremental Cost per m^2				
Building type	**Low**	**5th percentile**	**Average**	**95th percentile**	**High**
Perspective 5, fully detached single storey on stumps (FDSS – stumps)	$222	$227	$239	$253	$259
Perspective 5, FDSS – stumps (raise)*	$381	$387	$401	$410	$412
Perspective 6, fully detached single storey – slab on ground (FDSS – SOG), fully detached double storey – slab on ground for the bottom floor only (FDDS – SOG)	$130	$143	$171	$199	$212

Table figures as at 2018. * Compared to not raising.

[14] Based on the quotes received, we calculated the like for like cost of the rebuild and the incremental (additional) cost of the resilient build (both in $/m^2). For each resilient build option, we then ran a monte-carlo simulation (20,000 simulations incorporating the skewness of the data from the quotes) to develop a distribution curve of potential costs ($/m^2). The range of estimates in the tables reflects 90% of the possible range of values from the monte-carlo simulation (i.e. the cheapest and most expensive 5% of estimates from the simulation are excluded).

Key observations as at 2018

- The cost of raising a home is greater than the cost of a resilient build. However raising the home reduces the likelihood that flood inundation will actually occur.
- Anecdotal evidence suggests that the quotes that underpin these estimates may be higher than actual costs due to their unfamiliarity with some materials and approaches. As resilient retrofitting becomes more common, prices will tend to fall.
- Perspective 5 observations
  - the average estimated investment for a resilient build is $239/m^2, with 90 per cent of the estimates within the range of $227-253/m^2
  - the average estimated incremental cost of raising the home would be $401/m^2, with 90 per cent of the estimates within the range of $387-410/m^2
  - Perspective 6 observations
  - the average estimated investment cost of a resilient build is $171/m2, with 90 per cent of the estimates within the range of $143-199/m^2

3.1 Benefits of resilient homes

A reduction in future costs from avoided flood damage include the following household assets:

- contents inside the home
- contents outside of the home such as motor vehicles, fences, gardens and sheds
- building structures including foundations, floors, walls, doors and windows
- permanent fixtures such as built-in cupboards and benches.

Other impacts associated with flood damages include:

- financial costs associated with cleaning up, loss of work and accommodation
- social costs including emotional stress, psychological and physical illness, and loss of life.

Only some of these damages outlined above are typically insurable. Resilient homes will not mitigate all flood damages and costs, and some will only be partially mitigated (if at all). Table 2 indicates the degrees to which different classifications of flood damage are likely to be mitigated by resilient homes.

Table 2 - flood damages mitigated by resilient homes

	Damage categories mitigated				
Building type	**Internal**	**External**	**Structural**	**Indirect**	**Intangible**
Perspective 5 fully detached single storey on stumps	70%	No	No	Partial but not include in CBA	Partial but not include in CBA
Perspective 5 fully detached single storey with stumps raised	70%	No	No	Partial but not include in CBA	Partial but not include in CBA
Perspective 6 fully detached single storey with slab on ground fully detached double storey with slab on ground for bottom floor only	70%	No	No	Partial but not include in CBA	Partial but not include in CBA

Key observations

There is a direct relationship between flood resilient homes and mitigating internal flood damage.

An estimated 70 per cent of all internal flood costs would be avoided in a flood, if all homes were flood resilient. This estimation is based on anecdotal advice from insurance companies.

The economic benefit of resilient building is the reduction in the costs of future flood damage, calculated as a reduction in AAD for internal flood damage.

The majority of benefits will be realised by a homeowner over time.

3.2 Additional benefits of flood resilient homes

There are a number of benefits to flood resilient homes, beyond the savings generated from mitigating flood damages. These include:

- **Lower insurance premiums** than equivalent non-resilient homes, as the expected costs of future flooding is reduced.
- **Avoided non-insurable costs** including cleaning up, mental health and temporary accommodation costs.
- **Increased property value** as buyer awareness of flood risks and subsequent cost of impact on the cost and future savings in lower insurance premiums.

It should be noted that these benefits will likely become more apparent over time as the information available in property markets improves and resilient building becomes more common.

4.1 Economic viability of flood resilient homes - methodology

Resilient homes are economically viable when the reduction in damages and associated costs over time, exceeds the initial investment costs of making a home flood resilient.

In the following case studies, a separate CBA was undertaken for different types of buildings, different resilience options (where feasible) and under different climate change and flood risk assumptions. This analysis enabled estimates to be generated for the Benefit Cost Ratio (BCR) and the payback period (the time required until the benefits exceed the costs).[13]

When the BCR is greater than one, it means the benefits exceed the costs.

Where the BCR is marginally less than one, there may still be a case for investing in resilient building due to the partial mitigation of indirect and intangible costs that are not quantitatively included in our modelling.

Methodology

Different flood frequencies were considered including:

- 10% AEP (1 in 10)
- 5% AEP (1 in 20)
- 2% AEP (1 in 50)
- 1% AEP (1 in 100)
- 0.5% AEP (1 in 200).

Different climate change scenarios were also considered as outlined in Table 3.

Table 3 - Future climate scenarios used in economic assessment

Scenario - modelling reference	Conditions description	Rainfall increase	Sea level rise
High impact scenario – CC4	RCP 8.5 conditions at 2090	20%	0.80m
Moderate impact scenario – CC5	RCP 4.5 conditions at 2090	10%	0.63m

[13] Over 130 CBA analyses were undertaken. For each of the 3 building types, CBA's were undertaken for 3 types of benefit (internal, external and structural) and any combination of risks, 5 AEPs (10, 20, 50, 100, 200 years), and with/without climate change (moderate and extreme). Within each of the models, sensitivity analysis was undertaken for the key cost variables and key benefit variables (20,000 runs of the model for each variable).

It should be noted that these results differ from some earlier results based on a smaller and more narrowly-based sample of property data from the BRSFMP.

5.1 Economic viability of flood resilient homes - results

Perspective 5 - fully detached house on stumps

The following two options were assessed

- resilient retrofit
- raising the house.

Resilient retrofit

Economic viability of the resilient retrofit option is detailed in Table 4. Key observations include:

- For current climate conditions, between a 5% (1 in 20) AEP to a 1% (1 in 100) AEPs;
    - resilient homes are economically viable under current and future climate conditions
    - average BCRs range from 7.4 to 1.9.
    - the average payback periods range from three years to 12 years, depending on the range of flood risks, costs of resilient building and avoided future flood costs.
- For current climate conditions, resilient homes are not viable for the 0.5% (1 in 200) AEP, noting that these estimates do not include indirect or intangible benefits and should therefore be considered underestimates.
- Under moderate and high climate change scenarios, resilient homes are economically viable under all circumstances.

Table 4. Results of Cost Benefit Analysis to retrofit a fully detached, single storey home on stumps

Flood frequency	10% (1 in 10) AEP	5% (1 in 20) AEP	2% (1 in 50) AEP	1% (1 in 100) AEP	0.5% (1 in 200) AEP
current climate					
Average Benefit-cost ratio	-	7.4	3.8	1.9	0.8
Average payback period	-	3 years	5 years	12 years	Never
moderate climate impacts – CC5 (refer Table 1)					
Average Benefit-cost ratio	-	9.3	5.2	2.6	1.7
Average payback period	-	2 years	4 years	8 years	14 years
high climate impacts – CC4 (refer Table 1)					
Average Benefit-cost ratio	-	10.4	6.5	3.5	2.1
Average payback period	-	2 years	3 years	5 years	10 years

House raising

The economic viability of raising the floor level of a house on stumps is detailed in Table 5. Key observations include:

- the economic benefits are stronger for smaller and more frequent flooding up to a 1% (1 in 100) AEP
- under current climate conditions, for a 2% (1 in 50) AEP to a 1% (1 in 100) AEP;
    - resilient homes are economically viable under all circumstances
    - average BCRs range from 5.0 to 2.1
    - the average payback periods range from four to ten years, depending on the range of flood risks, costs of resilient building and avoided future flood costs.
- under current climate conditions, the economic benefits of a resilient home are marginal for a 5% (1 in 200)
- under moderate and high climate impact scenarios, there is an economic case for resilient building under all scenarios modelled.
- due to the higher initial investment cost of house raising, this option is not as economically viable as other retrofitting options.

Note: a common assumption was used to estimate internal flood damages mitigated by resilient homes (Refer **Table 2**) Therefore the benefits of house raising have been underestimated. Further research in this area is required.

Table 5. Results of Cost Benefit Analysis to raise the height of a fully detached, single storey home on stumps

Flood frequency	10% (1 in 10) AEP	5% (1 in 20) AEP	2% (1 in 50) AEP	1% (1 in 100) AEP	0.5% (1 in 200) AEP
current climate					
Average Benefit-cost ratio	-	-	5.0	2.1	1.1
Average payback period	-	-	4	10	37
moderate climate impacts – CC5 (refer Table 1)					
Average Benefit-cost ratio	-	-	6.0	2.9	1.7
Average payback period	-	-	3	7	14
high climate impacts – CC4 (refer Table 1)					
Average Benefit-cost ratio	-	-	7.5	3.8	2.5
Average payback period	-	-	2	5	8

Perspective 6 - fully detached home with slab-on-ground

The opportunities for resilient building differs for slab-on-ground buildings, as do the costs. Both single and double storey properties are assessed below.

Single storey

Economic viability of this option is detailed in **Table 6**. Key observations include:

Current climate conditions

- for floods up to a 1% (1 in 100) AEP;
    - resilient homes are economically viable under all circumstances
    - average BCRs range from 19.6 to 2.3
    - the average payback periods range from one to nine years, depending on the range of flood risks, costs of resilient building and avoided future flood costs
- for floods under a 0.5% (1 in 200) AEP, the economic benefits are marginal
- the economic benefits are very strong for smaller and more frequent flooding.

Future climate impact scenarios

- there is an economic case for resilient homes under all scenarios modelled.

Table 6 - Results of Cost Benefit Analysis for a single storey flood resilient slab on ground

Flood frequency	10% (1 in 10) AEP	5% (1 in 20) AEP	2% (1 in 50) AEP	1% (1 in 100) AEP	0.5% (1 in 200) AEP
current climate					
Average Benefit-cost ratio	19.6	9.7	4.4	2.3	1.0
Average payback period	1	2	4	9	Never
moderate climate impacts – CC5 (refer Table 1)					
Average Benefit-cost ratio	27.3	11.2	7.9	3.2	2.1
Average payback period	1	2	2	6	10
high climate impacts – CC4 (refer Table 1)					
Average Benefit-cost ratio	28.9	15.8	9.9	4.2	2.6
Average payback period	1	1	2	4	8

Double storey homes

Economic viability of this option is detailed in **Table 7**. Key observations include:

Current climate conditions

- the economic benefits are very strong for smaller and more frequent flooding up to a 2% (1 in 50) AEP
- for floods up to a 0.5% (1 in 200) AEP;
    - resilient homes are economically viable under all circumstances, although the case is relatively marginal under some assumptions where the AEP is 1 in 200 (0.5%).
    - average BCRs range from 16.6 to 1.4
    - the average payback periods ranges from one year to 18 years, depending on the range of flood risks, costs of resilient building avoided future flood costs.

Future climate change scenarios

- resilient building is economically viable under all circumstances
- all BCRs increase, particularly under higher climate impacts
- the economic case for resilient building is greater than under current climate conditions.

Table 7 - Results of Cost Benefit Analysis for a double storey flood resilient slab on ground

Flood frequency	10% (1 in 10) AEP	5% (1 in 20) AEP	2% (1 in 50) AEP	1% (1 in 100) AEP	0.5% (1 in 200) AEP
current climate					
Average Benefit-cost ratio	-	16.6	7.0	3.4	1.4
Average payback period	-	1	3	6	18
moderate climate impacts – CC5 (refer Table 1)					
Average Benefit-cost ratio	-	18.8	9.8	6.0	7.6
Average payback period	-	1	2	3	3
high climate impacts – CC4 (refer Table 1)					
Average Benefit-cost ratio	-	22.2	14.0	8.1	9.0
Average payback period	-	1	2	2	2

Appendix C
Literature Review

C1 - Flood Resilience Guidance Precedents

1.1 The Flood Standard and Flood Handbook

Australian Building Code Board (ABCB), Construction of Buildings in Flood Hazard Areas Standard, 2012. Australian Building Code Board (ABCB), Construction of Buildings in Flood Hazard Areas Handbook, 2012.

The National Construction Code (NCC) contains requirements for buildings and structures within flood hazard areas to reduce the risk of structural collapse during a flood. Both the NCC and The Flood Standard focuses on solutions to mitigating community safety risks from flooding. The Flood Standard contains basic design requirements, including requirements for materials, and provisions. However, it does not contain provisions for resilient materials that are non-structural, or design solutions. It calls for designers to use professional judgement in order to develop designs that comply with the NCC performance requirement and therefore identifies an area which could benefit from further guidance material.

The Flood Handbook is a supporting non-mandatory document to be read in conjunction with The Flood Standard. This document only contains limited information on non-structural flood resilient design.

1.2 Reducing Vulnerability of Buildings to Flood Damage (NSW)

New South Wales, Department of Natural Resources, Reducing Vulnerability of Buildings to Flood Damage: Guidance on Building in Flood Prone Areas, Hawkesbury-Nepean Valley Flood Risk Management Strategy, Hawkesbury Nepean Flood plain Management Steering Committee, 2006.

These guidelines have been produced within the Floodplain Management Study component of the Hawkesbury-Nepean Floodplain Management Strategy. It is one of three guidelines spanning land use planning, building construction (this guideline) and subdivision design for development on flood prone land. This guideline identifies common problems as related to forms of house construction affected by floods and illustrates the highest priority and most cost-effective strategies including resilient building elements and appropriate selection of construction materials. The testing undertaken for this guideline was carried out by the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

1.3 SMAReST Six Step Guide to Flood Resilience (UK)

White, I. et al., Six steps to flood resilience – guidance for local authorities and professionals, Manchester, 2013.

This guidance document falls under the North Sea Region Programme 2014 – 2020. The six steps guide to flood resilience includes:

1. Understanding risk
2. Planning
3. The property survey
4. Product supply
5. Product installation
6. Operation and maintenance.

1.4 The Property Flood Resilience Action Plan (UK)

Bonfield, P., The Property Flood Resilience Action Plan, Department for Environment Food and Rural Affairs, 2016.

This action plan is a part of a broader national flood resilience review. It aims to achieve property level resilience by making properties less vulnerable to flooding. Actions and recommendations to be delivered by individual task groups are outlined in the plan.

1.5 Improving the Flood Performance of New Buildings (UK)

Bowker, P, Escarameia, M and Tagg, A., Improving the Flood Performance of New Buildings: Flood Resilient Construction, RIBA Publishing, UK, 2007

This guidance document forms part of the Department for Communities and Local Government Buildings Regulations (Sanitation) Research Framework and joint Defra and Environment Agency Flood Risk Management research.

1.6 Building Resilience in Boston (U.S.)

Newman, J. et al., Building Resilience in Boston, Linnean Solutions, The Built Environment Coalition and The Resilient Design Institute, 2013.

This report by the Boston Society of Architects details international programs, initiatives, and activities for "best practice" building resilience to climate change.

1.7 Practical Guidance for Property Level Flood Protection (UK)

Bartram, D., Practical Guidance for Property Level Flood Protection, Environment Agency, 2011.

This report is a resource for the Environment Agency project managers to offer guidance based on case studies from the UK. It offers guidance on flood resistance (dry-proofing) measures rather than flood resilience measures. This resource includes information about how a property may be surveyed, suitable flood resistance measures and resources.

1.8 Guideline for Stress Testing the Climate Resilience of Urban Areas (NL)

Foundation CAS (Climate Adaption Services), The Spatial Adaptation Knowledge Portal, [website], 2014, www.ruimtelijkeadaptatie.nl/english/ (accessed May 2018).

This guideline is part of Deltaplan Spatial Adaptation. It outlines strategies for investigating climate resilience and planning measures to adapt environments. The stress test begins with a "vulnerability scan" based on existing data and knowledge, followed by "adaptation planning" for the most vulnerable areas, additional collection of data, additional stakeholder engagement and implementation.

1.9 Floodproofing Regulations (U.S.)

EP1165-2-314 Floodproofing Regulations, U.S. Army Corps of Engineers, Washington, D.C. 20314 – 1000, 15 Dec 1995

This document contains floodproofing measures (dry-proofing). It was originally published in 1972 and has since been adopted as the framework for local U.S. building codes, the National Flood Insurance Program and other national flood standards.

1.10 Elevation Design Guidelines (U.S.)

URS, The Homeowner Elevation Grant Program and Elevation Design Guidelines For Historic Homes, Mississippi Development Authority.

This guidance was developed after Hurricane Katrina in 2005 to ensure historic preservation regulations and safety were in line with flood resilience measures for rebuilding damaged structures.

1.11 FEMA Technical Bulletin

FEMA, Flood Damage-Resistant Materials Requirements, Technical Bulletin 2, 2008.

FEMA's Technical Bulletin 2, provides guidance on regulations for flood damage resistant construction materials located within special flood hazard areas.

C2 - Flood resilient design and rating tools

2.1 Resilience Rating Tool, Insurance Council of Australia

Insurance Council of Australia, Building Resilience Rating Tool, [website], 2017, www.resilient.property, (accessed May 2018).

This rating tool provides users with broad resilience and adaptation guidance concerning flood, hail, bushfire, wind and cyclone.

2.2 National Flood Forum Property Protection Advisor and Appraisal Report (UK)

JBA Consulting, Property Protection Advisor, [website], 2018, www.nationalfloodforum.org.uk/about-flooding/reducing-your-risk/property-protection-advisor/ (accessed May 2018)

This online tool is designed to raise awareness of flood resilience options and provide an initial estimate of the cost of resilience measures.

The online advisor consists of a series of questions to gain property information including:

- basic property information
- building construction information.

An Appraisal Report details the following:

- breakdown of indicative costs of resistance measures
- assumptions made based on property details provided
- benefits of the suggested resistance measures.

2.3 Flood Risk Report and Examples 1 and 2 (UK)

Environment Agency, et al., Flood Risk Report, 2012, Available from: Thomson Reuters Practical Law E-Library, (accessed May 2018).

This is a template report for insurers released by the Environment Agency in collaboration with the Department for Environment, Food and Rural Affairs, the British Insurance Brokers' Association, the Royal Institution of Chartered Surveyors and others. Its purpose is to record flood resilience measures and flood risk, to enable negotiations about flood cover with insurers.

2.4 The Climate Adaptation App (NL)

Bosch Slabbers, et al., The Climate Adaptation App, [website], www.climateapp.nl/, (accessed May 2018).

Developed by Bosh Slabbers, Deltares, Sweco, Witteveen+Bos and KNMI for worldwide application. This app has been tested in Ho Chi Minh City, Copenhagen and New Orleans.

2.5 Urban Green-Blue Grids for Sustainable and Resilient Cities Design Tool (NL)

Atelier Groenblauw, et al., Urban Green-Blue Grids for Sustainable and Resilinet Cities, [website], 2016, www.urbangreenbluegrids.com (accessed May 2018).

Adapted from the book, a number of filters allow the user of this web-based design tool to narrow down potential strategies at city, neighbourhood and individual building scales. The Table of solutions can also be narrowed down to apply to different types of flooding, heat and drought. It allows the user to filter land use, soil type, topography, scale and project type. The adaptation measures are then ranked according to relevance as a percentage. (In development)

Amsterdam Rainproof Toolbox (NL)

Goedbloed, D., et al., Amsterdam Rainproof, [website], 2018, https://www.rainproof.nl, (accessed May 2018).

This is a knowledge sharing network of diverse organisations concerned with 'rain-proofing' (dry-proofing) Amsterdam. These organisations include: government, educators, residents and land owners, designers and consultants and neighbourhood initiatives. Atelier Groen Blauwe developed this toolbox as a key resource for Amsterdam Rainproof.

C3 - Flood resilience program precedents

3.1 RainReady Home (U.S.)

Center for Neighborhood Technology (CNT), RainReady, [website], www.rainready.org, (accessed May 2018).

An initiative of the Center for Neighbourhood Technology (CNT) based in Chicago. This website provides information on both RainReady Home and RainReady Community services. RainReady Home provides services targeting individual properties and includes: Flood Risk Assessments and recommendations; landscaping design; construction support; grant administration; postconstruction monitoring.

3.2 FloodRepairable Trial (UK)

Lamond, J. et al., The Flood Repairable Project, [website], www.floodrepairable.wordpress.com/, (accessed May 2018).

As part of the Tewkesbury Property Support Network LAA this project focuses on cost-effective measures to creating flood resilience. Case studies may be accessed on this website which detail various resilience strategies and recommends generic types of resilient materials.

3.3 Delta Plan on Spatial Adaptation (NL)

Deltacommissaris, Delta Programme 2018, [website], www.deltaprogramma2018.deltacommissaris.nl/viewer/chapter/1/2-deltaprogramme-/ chapter/delta-plan-on-spatialadaptation# (accessed May 2018).

The Delta Plan on Spatial Adaptation aims to encourage climate resilience of new residential areas, business parks and adaptation of existing areas before 2050. This includes water, heat, drought, flood resilience. A standardised stress test of climate resilience is used to determine target areas along with the Climate Impact Atlas / Klimaateffectatlas. Atelier X will be working on the design research activities for this programme. (In development)

3.4 Marken Boven Water (NL)

Atelier GroenBlauw et al., Marken Boven Water, 2015, Ministry of Infrastructure and the Environment, Available from: Atelier GroenBlauw online publications, (accessed May 2018).

The “Marken above water” report provides guidelines for water and energy-conscious construction in the dutch town of Marken for existing historic and new buildings. It is part of a pilot project commissioned by the Delta Program Commissioner to assist in the development of a new flood risk management policy. The approach is multi-layered and looks at strategies to reinforce infrastructure, design water-robust and climateproof buildings and public spaces and develop disaster management strategies.

3.5 Flood Buyout and Elevation Program (U.S.)

Rose, R. et al., Flood Buyout and Elevation Program, [website], 2015, www.kingcounty.gov/services/environment/water-and-land/flooding/buyout.aspx (accessed May 2018).

The U.S. based King County Flood Buyout and Elevation Program involves an initial home assessment followed by voluntary sale or house elevating assistance. The buyout option is appropriate in areas of deep, fast-moving flooding or areas prone to bank erosion. The result of a buyout is the creation of permanent public open space. Houses located in areas of slower moving flood waters may be elevated to above the 100-year elevation.

Appendix D
Resource list

D1 - Publications

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Paper Node 3 – Australian Climate Change Adaptation Research Network for Settlements and Infrastructure.

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