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# COST-EFFECTIVE MITIGATION STRATEGY DEVELOPMENT FOR FLOOD PRONE BUILDINGS

**Dr Tariq Maqsood, Mr Martin Wehner, Dr Ken Dale**
Geoscience Australia, ACT

An Australian Government Initiative

CRC AUSTRALIA

Australian Government
Geoscience Australia

# PROJECT MANAGEMENT TEAM

| | |
|---|---|
| Lead User Rep: | Leesa Carson, GA<br>Ralph Smith, WA DFES |
| Lead Researcher: | Michael Griffith, Uni. of Adelaide |
| Project Leader: | Tariq Maqsood, GA |
| Research Team: | Martin Wehner, GA<br>Ken Dale, GA |
| End User: | Duncan McLuckie, NSW OEH<br>Greg Howard, SA MFS<br>Elliott Simmons, NSW SES<br>Jacqueline Frizenschaff, SA Water<br>Myles Fairbairn, Qld LVRC<br>Corey Shackleton, NSW RFS<br>Greg Buckley, NSW Fire |

# PROBLEM STATEMENT

- Australia has experienced floods on a regular basis and some communities have been impacted repeatedly over a period of few years due to inappropriate urban development in flood plain areas.

- The flood events have resulted in significant logistics for emergency management and disruption to communities. They have also resulted in considerable costs to all levels of government to repair damage and enable community recovery.

# PROBLEM STATEMENT

Some recent floods in Australia

- 2005 Lismore flood
- 2010 Victorian flood
- 2010-11 Queensland flood
- 2011 Victorian flood
- 2013 Queensland/NSW flood



# RESEARCH OBJECTIVE

- To develop cost-effective strategies to mitigate damage to residential buildings from riverine floods.

- To provide the evidence base for decisions concerning the buildings having the greatest vulnerability in Australian communities by providing strategies for retrofit.

# MITIGATION OPTIONS

- Structural/non-structural options
  - Dams, levees
  - Flood gates, retarding basins
  - Land use planning
  - Flood forecasting and warning
  - Flood awareness, community readiness
  - Evacuation arrangements

- Addressing the housing ← Project's focus
  - Retirement and relocation <1%
  - Raising floor levels (elevation) 5%
  - Rebuild with revised ground floor use 12%
  - Repair with more flood resistant material 19%
  - Raising electrical outlets and hardware 8%
  - Repair as previously* *60%

Responses from the postal survey after the 2011 Queensland flood

# TASKS

- Classification of residential building stock
- Literature survey of existing mitigation options
- Australian specific mitigation options and costing, experimental testing of selected building materials
- Vulnerability assessment of current and retrofitted buildings
- Benefit verses cost analysis of retrofit and new construction options
- Identification of optimal retrofit strategies
- Stakeholder workshops

# BUILDING STOCK CLASSIFICATION (COMPLETED)

- Classification of residential building stock: review
  - HAZUS (USA): 11, structural system, storey class
  - Riskscape (New Zealand): structural system, wall and roof material, storeys, usage etc.
  - EDAC (Germany), 6, structural system, based on EMS-98, vulnerability classes
  - UPD (The Philippines): 15, structural system, storey class, wall material
  - UNISDR (Asia-Pacific): 27, structural system, 1, 2 or 3 storey, elevated/non-elevated, water susceptibility, usage
  - NSW Office for Environment and Heritage (NSW): 3, 1 or 2 storey, elevated/non-elevated
  - Geoscience Australia (QLD and NSW): 19, 1 or 2 storey, elevate/non-elevated, external and internal wall material, garage

# BUILDING STOCK CLASSIFICATION (COMPLETED)

- Classification of residential building stock: adopted

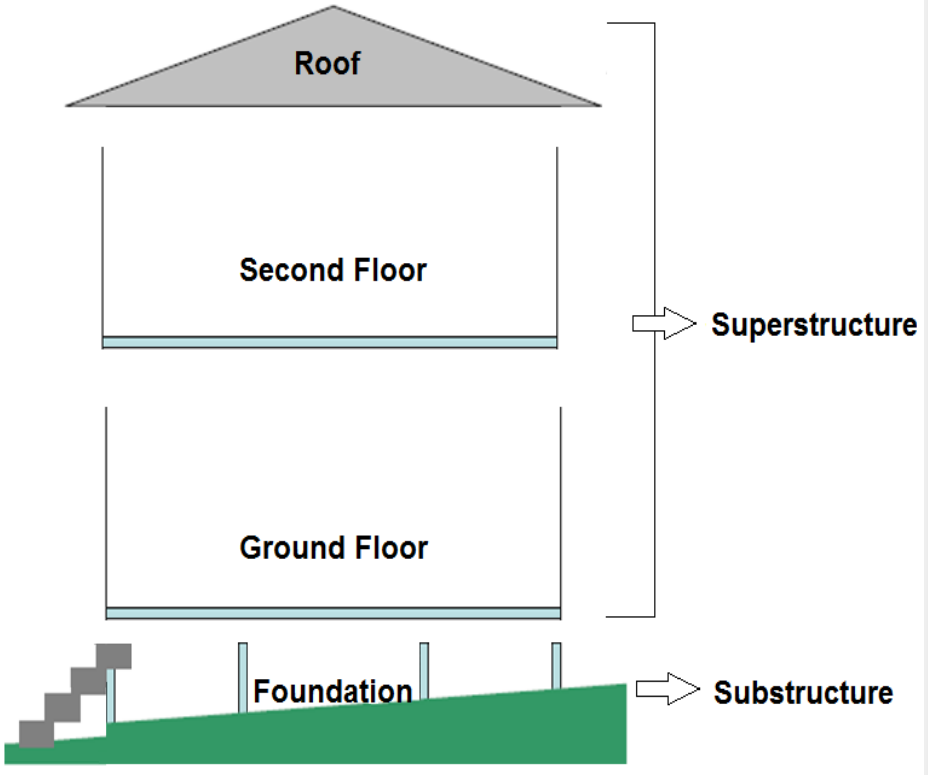
***Floor level attributes:***

- *Construction Period*
- *Fit-out Quality*
- *Storey Height*
- *Bottom Floor System*
- *Internal Wall Material*
- *External Wall Material*

***60 possible combination of floor system***

***Roof attributes:***

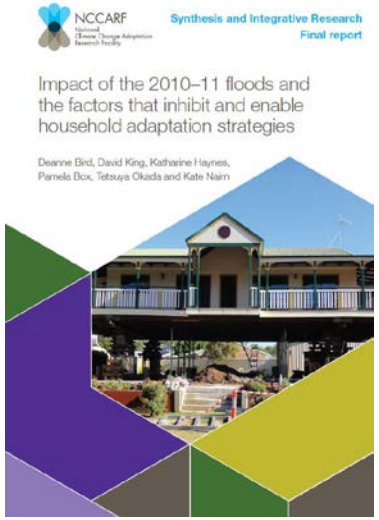
- *Pitch*
- *Material*



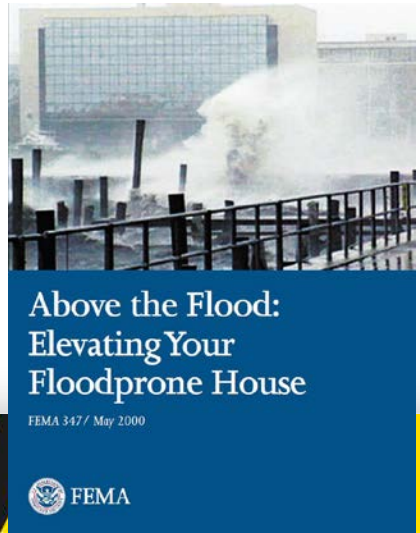
# REVIEW OF MITIGATION OPTIONS (COMPLETED)

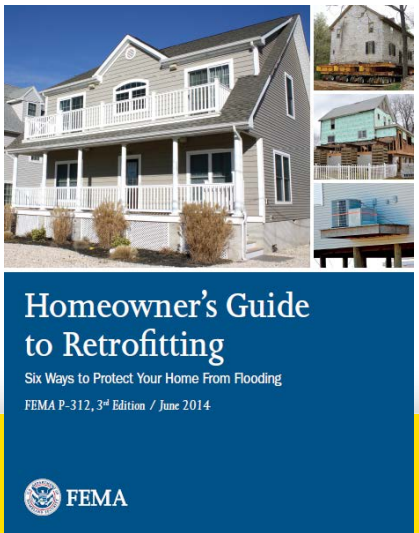
- Sources

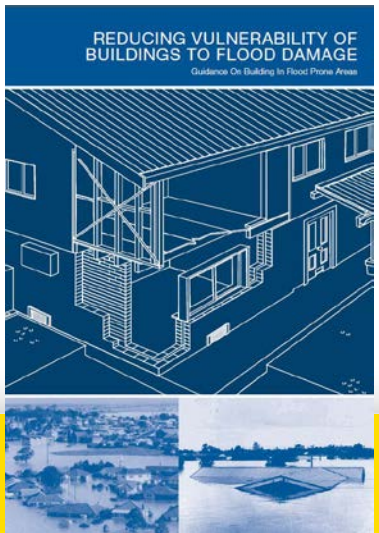
o Building standards
o Guidelines
o Project reports
o Conference papers
o Journal articles

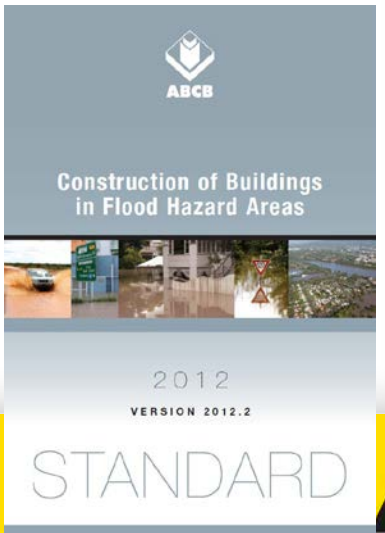







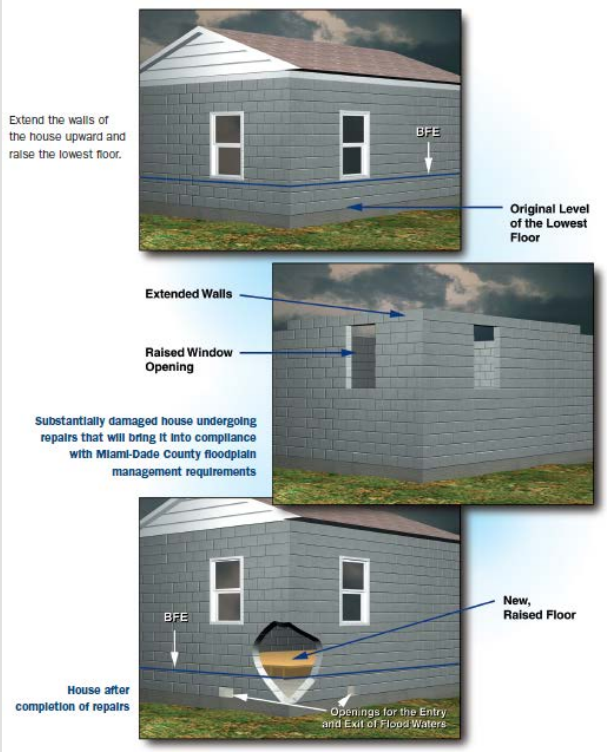
# REVIEW OF MITIGATION OPTIONS (COMPLETED)

- Raising floor level: elevating the house
- Relocation: moving to higher ground
- Demolition: tearing down damaged house
- Wet flood proofing: allowing water to enter
- Dry flood proofing: sealing a house
- Barriers: flood wall or levee around a house

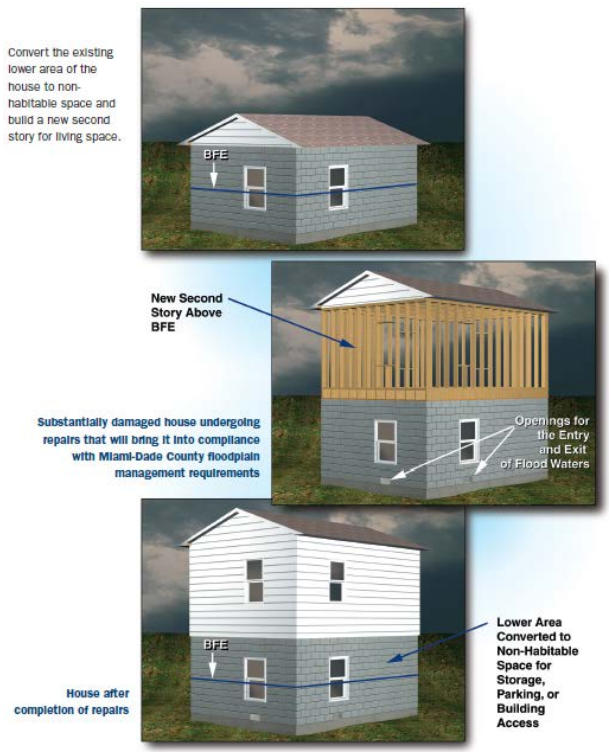
# REVIEW OF MITIGATION OPTIONS (COMPLETED)

- Raising floor levels: elevation

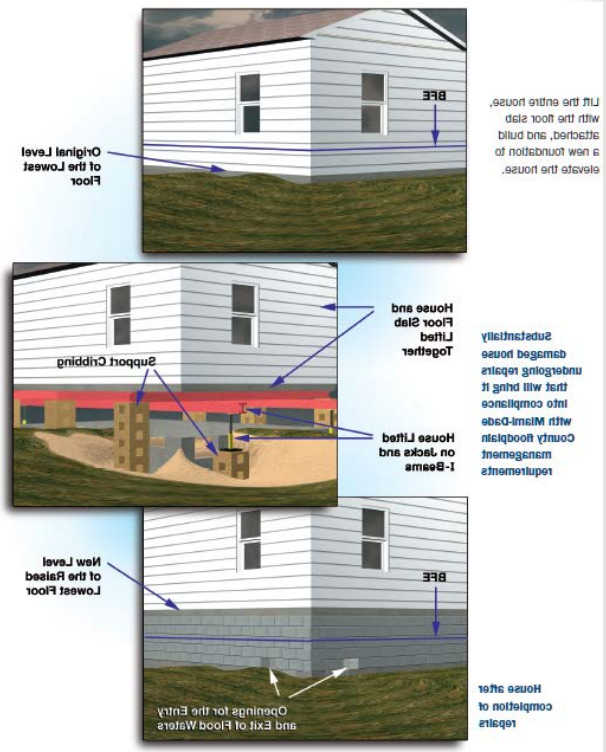
Option 1




Option 2




Option 3




Source: FEMA 347 (2008)

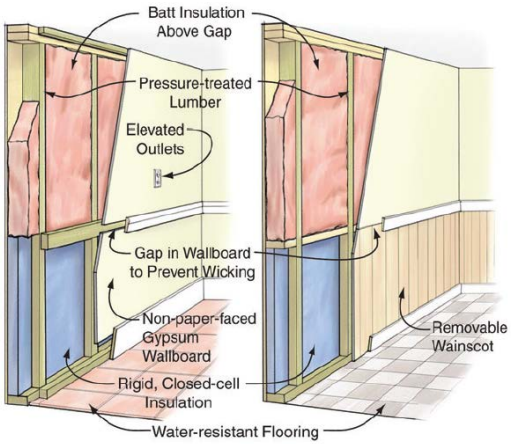
# REVIEW OF MITIGATION OPTIONS (COMPLETED)

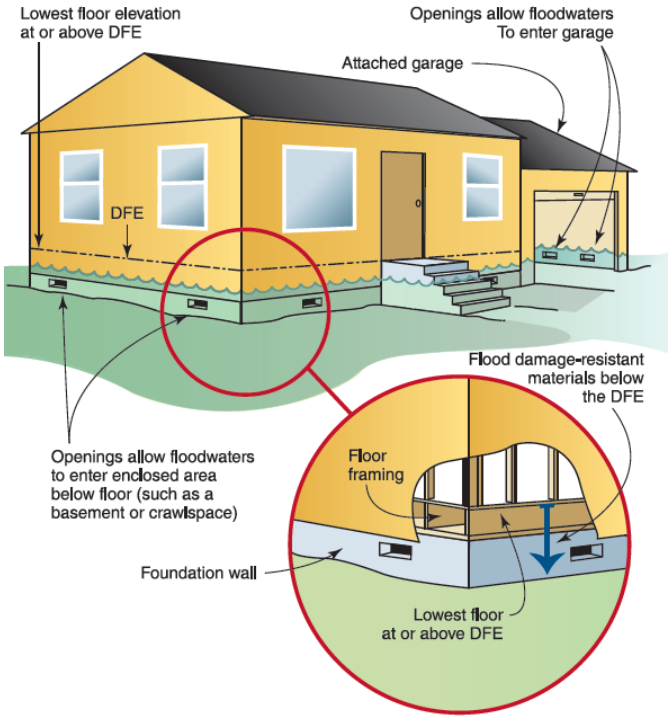
- Relocation

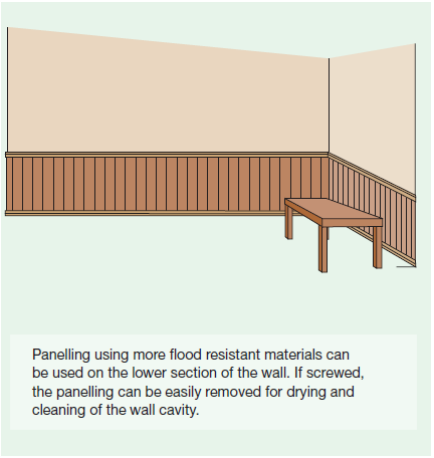
Source: FEMA P-259 (2012)

# REVIEW OF MITIGATION OPTIONS (COMPLETED)

- Wet flood proofing



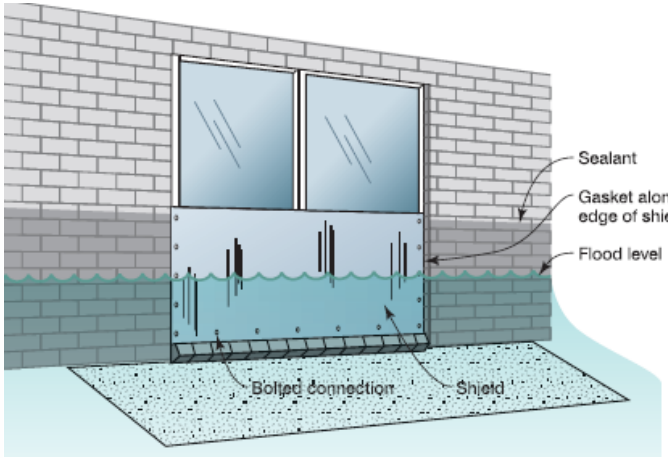

Source: FEMA P-259 (2012)

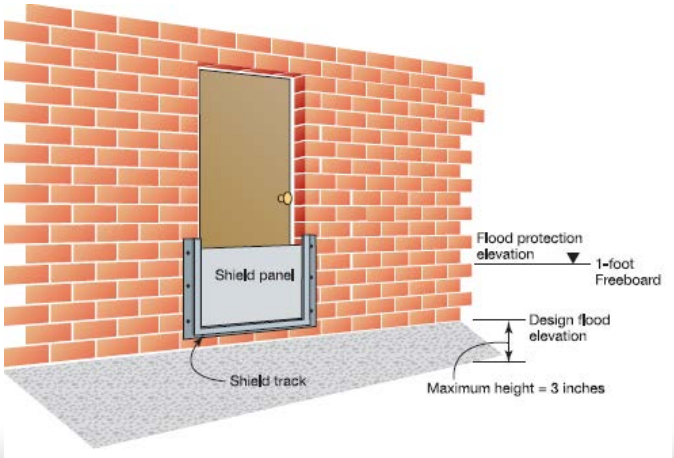
bnhcrc.com.au

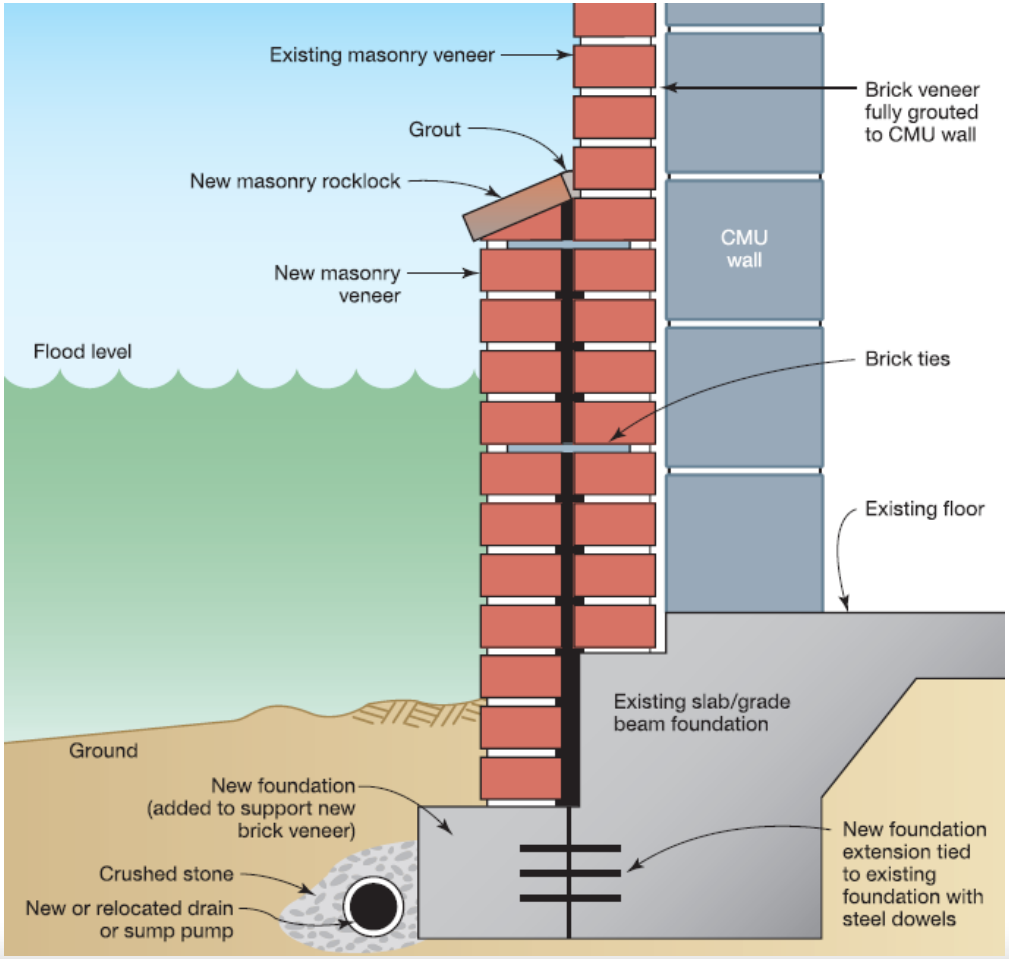
Source: Hawkesbury-Nepean Floodplain Management Steering Committee (2006)

# REVIEW OF MITIGATION OPTIONS (COMPLETED)

- Dry flood proofing



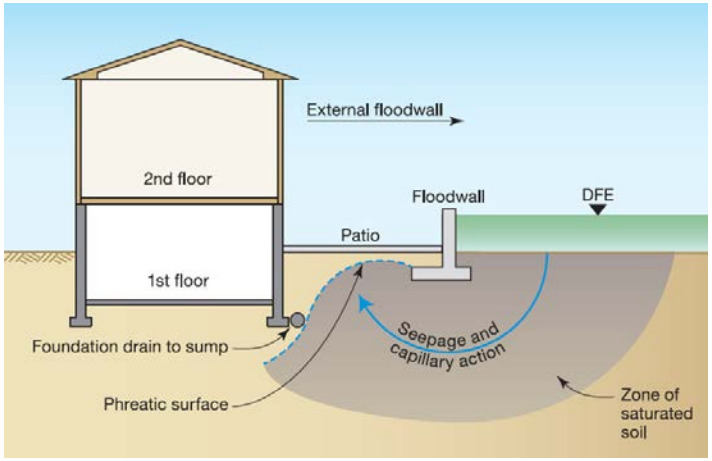



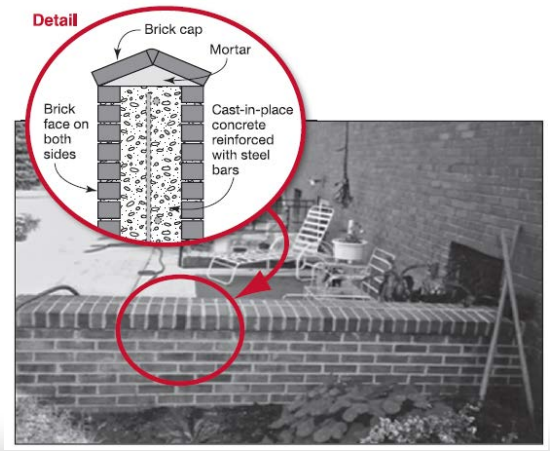




Source: FEMA P-259 (2012)

# REVIEW OF MITIGATION OPTIONS (COMPLETED)

- Barriers: flood walls




Source: FEMA P-259 (2012)

# REVIEW OF MITIGATION OPTIONS (COMPLETED)

- Raising floor levels: elevation

| Advantages | Disadvantages |
|---|---|
| • Reduces flood risk to the structure and its contents<br>• Often reduces flood insurance premiums (elevation only)<br>• Uses established techniques<br>• Can be initiated quickly<br>• Reduces the physical, financial, and emotional strains that accompany flood events | • Elevation/demolition: May be cost-prohibitive<br>• Elevation: May adversely affect the structure's appearance<br>• Elevation: May adversely affect access to the structure<br>• Relocation: Requires locating a new site<br>• Wet proofing: Usually requires a flood warning to prepare the building and contents for flooding<br>• Wet proofing: Requires human intervention to evacuate contents from the flood-prone area<br>• Dry proofing: Requires ongoing maintenance<br>• Dry proofing: Cannot be used in areas with high-velocity water flow unless special measures are taken<br>• Barriers: Only applicable to low inundation<br>• Barriers: May fail or be overtopped by large floods<br>• Barriers: Requires periodic maintenance and interior drainage |

Source: FEMA 312 (2014)

# REVIEW OF MITIGATION OPTIONS (COMPLETED)

- Making decision to retrofit

| Hazard level | Building type | Government rules | Decision |
|---|---|---|---|
| • Catchment type<br>• Flood hazard<br>• Flood levels<br>• Duration | • Age<br>• Foundation type<br>• Construction materials<br>• Fit outs<br>• Condition | • Local regulations/codes<br>• Technical assistance<br>• Financial assistance | • Available options<br>• Benefit/Cost assessment<br>• Approvals<br>• Retrofit |

Source: FEMA 312 (2014)

# MATERIAL SUSCEPTIBILITY TO WATER (CURRENT)

- Building material susceptibility to water

## Flood Damage-Resistant Materials Requirements

for Buildings Located in Special Flood Hazard Areas in accordance with the National Flood Insurance Program

*Technical Bulletin 2 / August 2008*

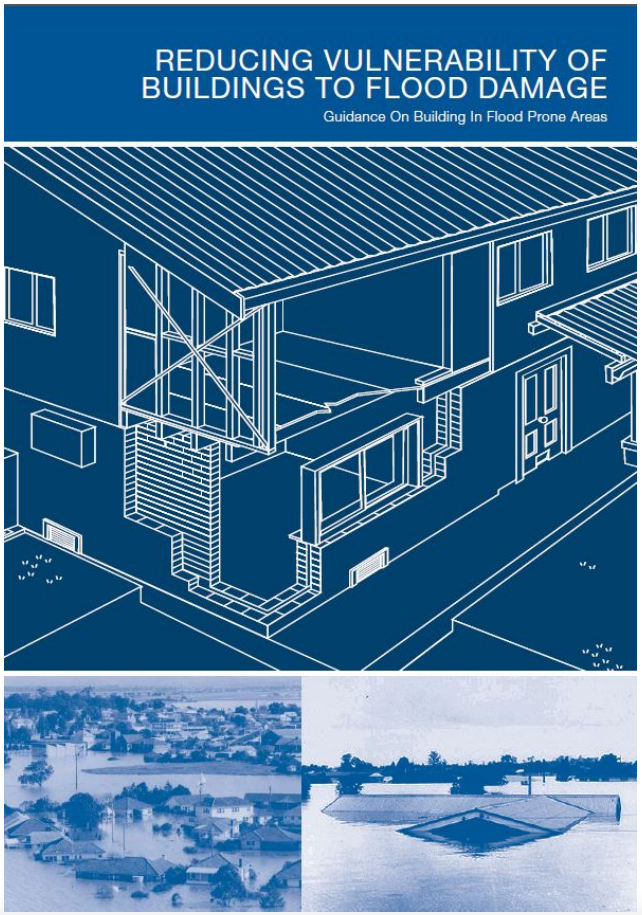
FEMA

| Types of Building Materials | Uses of Building Materials | | Classes of Building Materials | | | | |
|---|---|---|---|---|---|---|---|
| | | | Acceptable | | Unacceptable | | |
| | Floors | Walls/ Ceilings | 5 | 4 | 3 | 2 | 1 |
| **Structural Materials (floor slabs, beams, subfloors, framing, and interior/exterior sheathing)** | | | | | | | |
| Wood | | | | | | | |
| Solid, standard, structural (2x4s) | | ■ | | ■ | | | |
| Solid, standard, finish/trim | | ■ | | | ■ | | |
| Solid, decay-resistant[4] | ■ | ■ | ■ | | | | |
| Solid, preservative-treated, ACQ or C-A | | ■ | | ■ | | | |
| Solid, preservative-treated, Borate[2] | | ■ | | ■ | | | |
| **Finish Materials (floor coverings, wall and ceiling finishes, insulation, cabinets, doors, partitions, and windows)** | | | | | | | |
| Asphalt tile[5] | | | | | | | |
| With asphaltic adhesives | ■ | | | | ■ | | |
| All other types | ■ | | | | | | ■ |
| Cabinets, built-in | | | | | | | |
| Wood | | ■ | | | | ■ | |
| Particle board | | ■ | | | | | ■ |
| Metal[3] | | ■ | | ■ | | | |
| Carpeting | ■ | | | | | | ■ |
| Ceramic and porcelain tile | | | | | | | |
| With mortar set | ■ | ■ | | ■ | | | |
| With organic adhesives | ■ | ■ | | | | ■ | |
| Concrete tile, with mortar set | ■ | | ■ | | | | |
| Corkboard | | ■ | | | | ■ | |
| Doors | | | | | | | |
| Wood, hollow | | ■ | | | | ■ | |
| Wood, lightweight panel construction | | ■ | | | | ■ | |
| Wood, solid | | ■ | | | | ■ | |
| Metal, hollow[3] | | ■ | | ■ | | | |
| Metal, wood core[3] | | ■ | | ■ | | | |
| Metal, foam-filled core[3] | | ■ | | ■ | | | |
| Fiberglass, wood core | | ■ | | ■ | | | |
| Epoxy, formed-in-place | ■ | | ■ | | | | |

Source: FEMA Technical Bulletin 2 (2008)

# MATERIAL SUSCEPTIBILITY TO WATER (CURRENT)

- Building material susceptibility to water



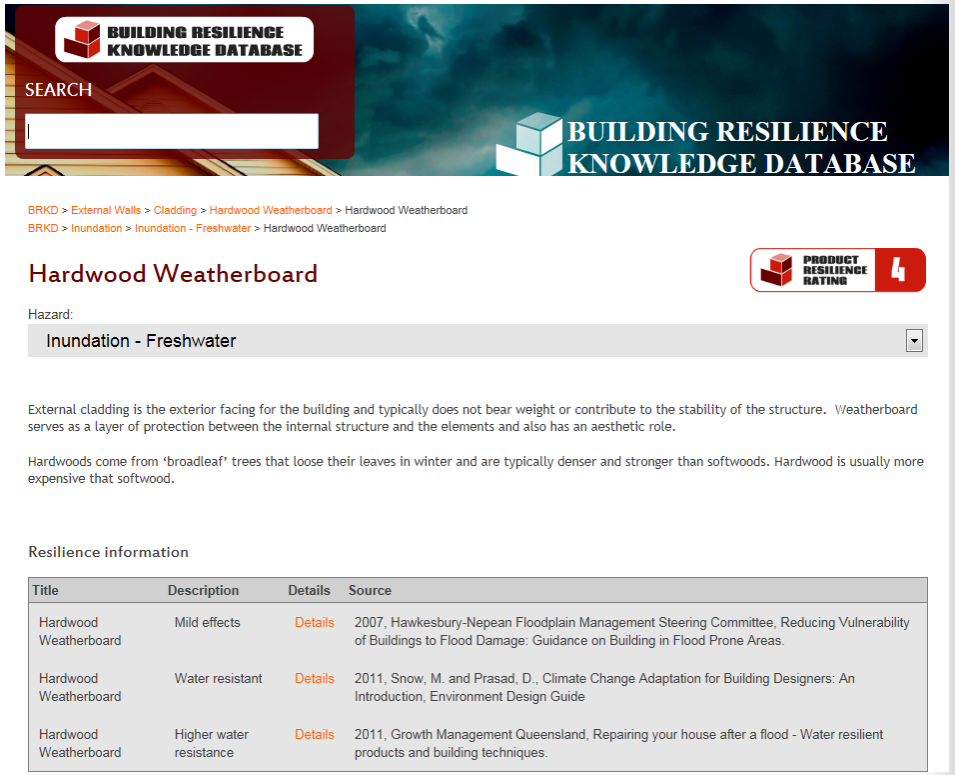

| | ABSORBENCY | | | |
|---|---|---|---|---|
| CLASS | HIGH | MODERATE | LOW | NIL |
| A | • masonry<br>• concrete | | • solvent-based neoprene adhesives<br>• two-part epoxy adhesives<br>• rubber based sealants silicone sealants | • copper<br>• brass<br>• plastic membranes and sheeting<br>• nylon fittings<br>• glass<br>• glass bricks |
| B | • plasterboard | • plywood<br>• hardwood | | |
| C | | • low durability timbers<br>• good quality adhesives<br>• low quality tiles<br>• water-based paints | • high durability timbers<br>• good quality tiles<br>• rubber-based adhesives<br>• epoxy putty sealants<br>• stone epoxy formed in place | • galvanised steel<br>• aluminium |
| D | • insulation<br>• building paper<br>• wall paper<br>• ceiling plasterboard*<br>• normal particle-board | • hardboard<br>• dry area adhesives<br>• water-based acrylic adhesives<br>• water-based urethane adhesives<br>• water-based acrylic sealants<br>• PVA emulsion cements<br>• lino, carpets, cork | • oil based paints | • bright steel |

*A minimal damage under most circumstances*
*B susceptible to physical damage when wet, otherwise no long-term damage*
*C subject to damage after prolonged immersion, but will recover when effectively dried*
*D subject to permanent damage if subjected to relatively short periods of wetness*
** plasterboard fails due to increased weight and weakened state*

Source: Hawkesbury-Nepean Floodplain Management Steering Committee (2006)

# MATERIAL SUSCEPTIBILITY TO WATER (CURRENT)

- Building Resilience Rating Tool


- Gap analysis of building resilience
- Testing and certification of building products
- Methodology for relating vulnerability to cost to determine the resilience ratings

INSURANCE COUNCIL OF AUSTRALIA

Source: http://www.buildingresilience.org.au/brrt

# DUNGOG FLOOD REPORT (COMPLETED)

- Dungog, a country town in Hunter Valley, NSW
- Impacted by flash flooding on 20-21 April 2015
- 233mm rainfall recorded at Dungog Post office
- 46 Damaged houses
- 4 houses washed away
- 3 deaths

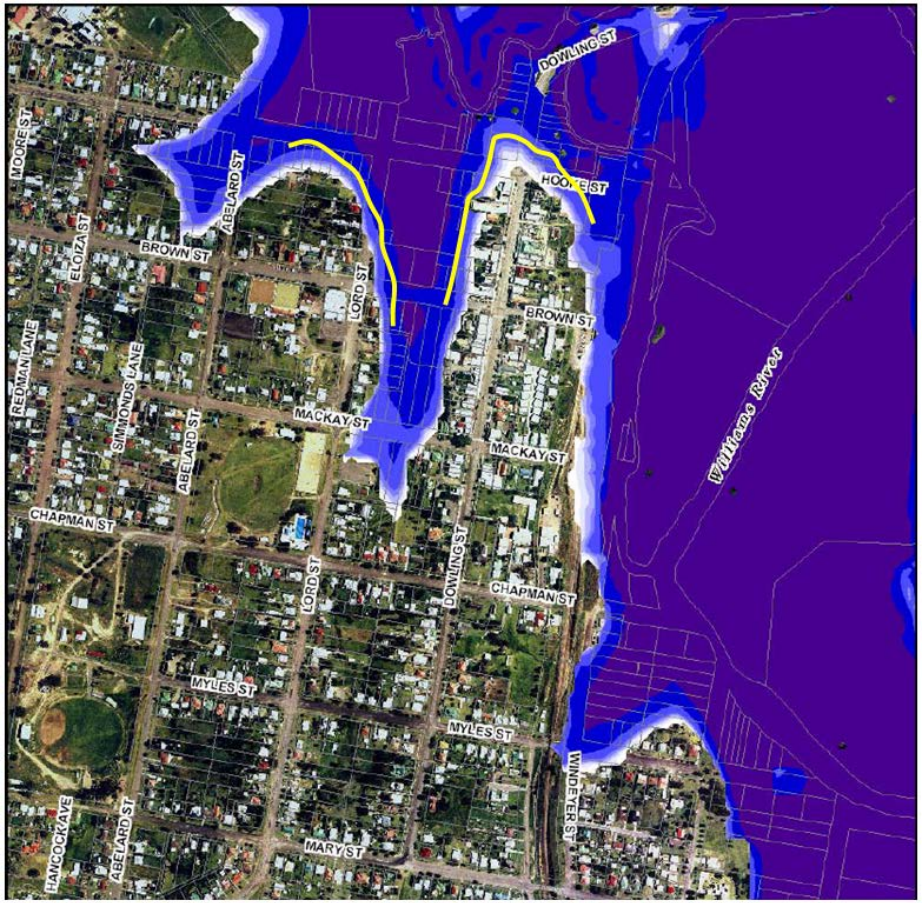
# DUNGOG FLOOD REPORT (COMPLETED)

- High water level (several metres)


# DUNGOG FLOOD REPORT (COMPLETED)

- Flood study for the William River (BMT WBM, 2009)

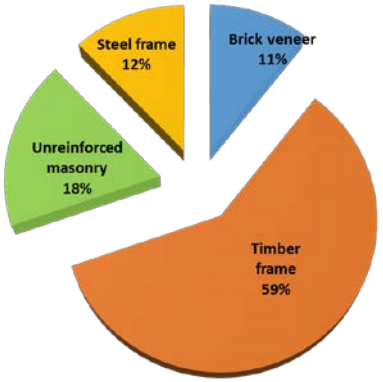

(A) 0.5% AEP Flood Event



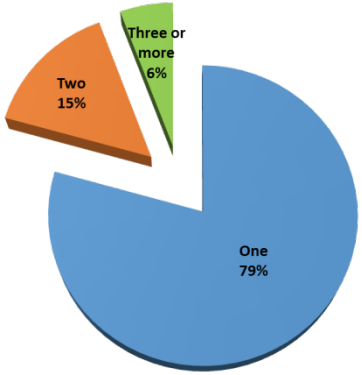

(B) Probable Maximum Flood Event

# DUNGOG FLOOD REPORT (COMPLETED)

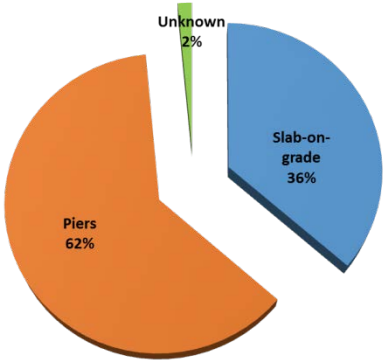
- Statistics of surveyed buildings



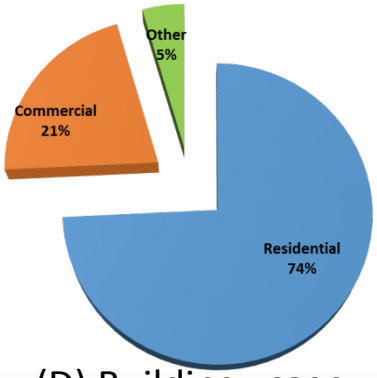

(A) Building structure



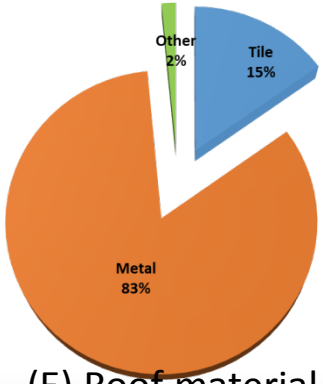

(B) Number of storeys



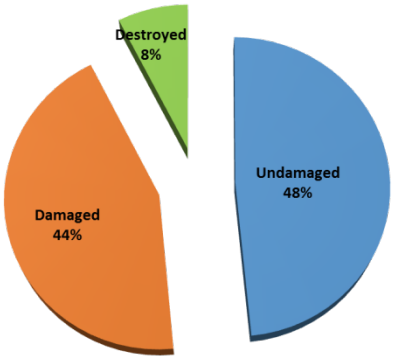

(C) Foundation type




(D) Building usage



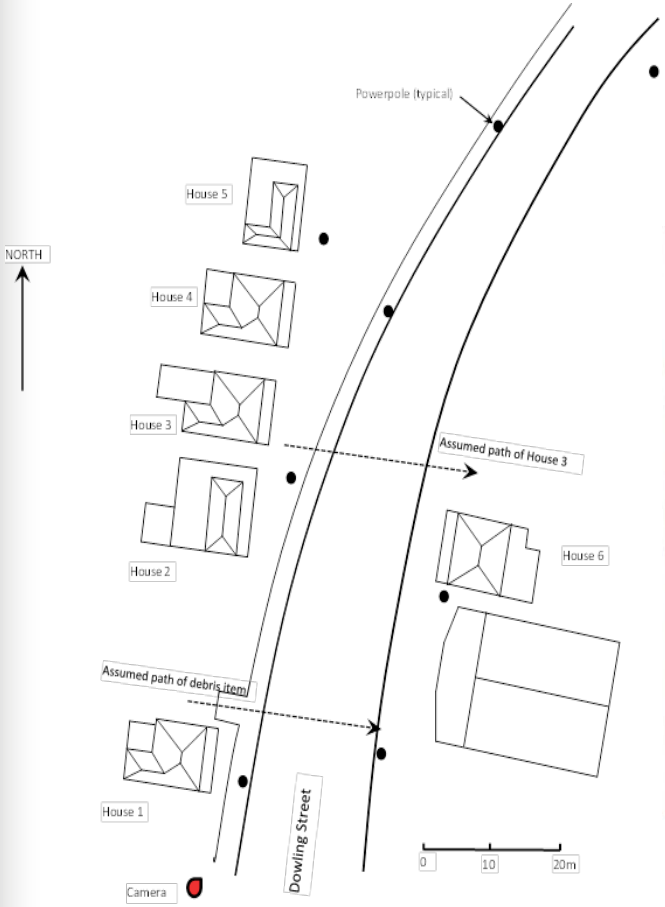

(E) Roof material




(F) Building damage

# DUNGOG FLOOD REPORT (COMPLETED)

- Observations and video to estimate flow velocity




(A) Sketch map

(B) Stills from Youtube (2015) video

# DUNGOG FLOOD REPORT (COMPLETED)

- Velocity related damage to 6 houses (Dowling st.)

(1) Intact

(3) Floated and washed away

(5) Destroyed

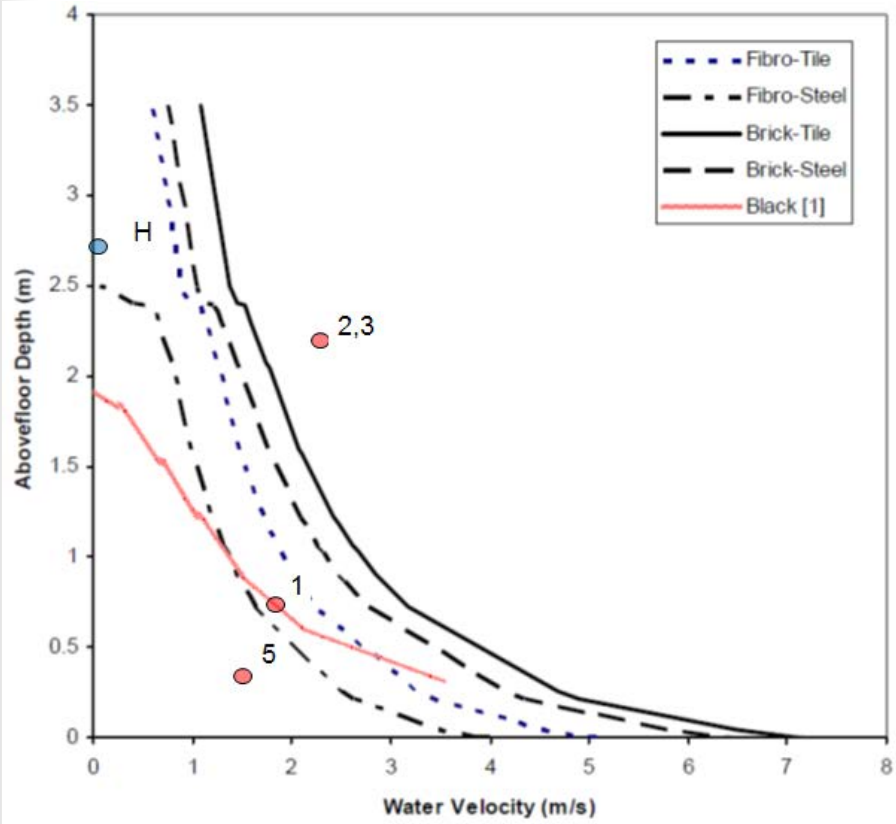
(2) Destroyed

(4) severely damaged and moved off

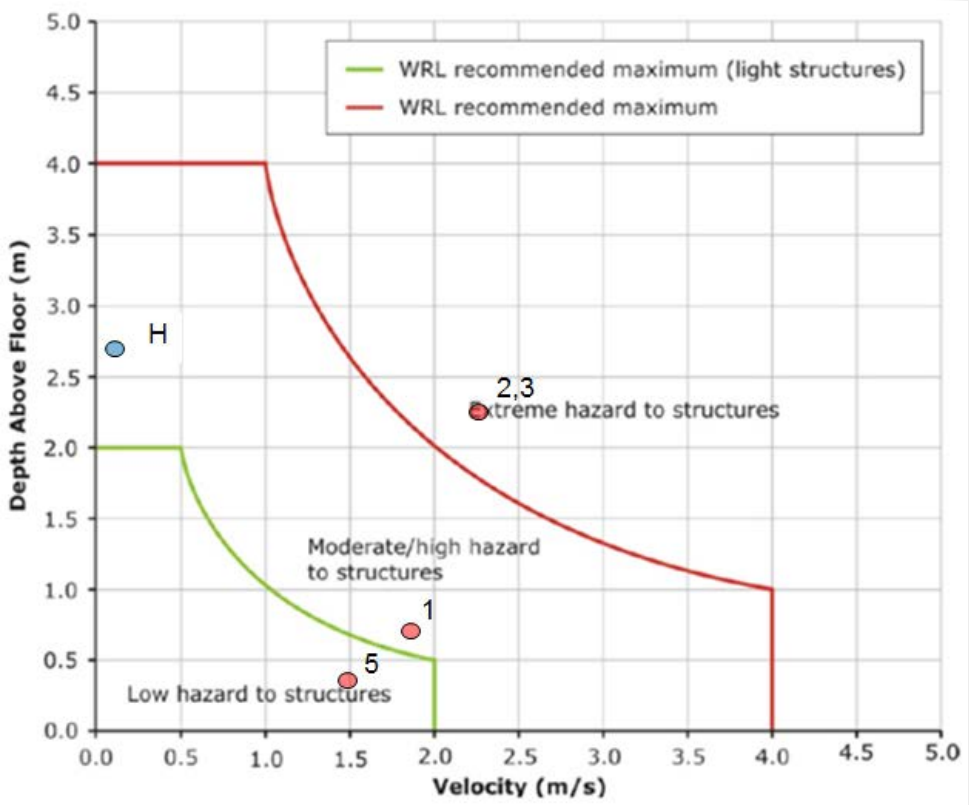

(6) Destroyed

# DUNGOG FLOOD REPORT (COMPLETED)

- Building stability and observations




(A) Thresholds for building stability (Dale et al. 2004)

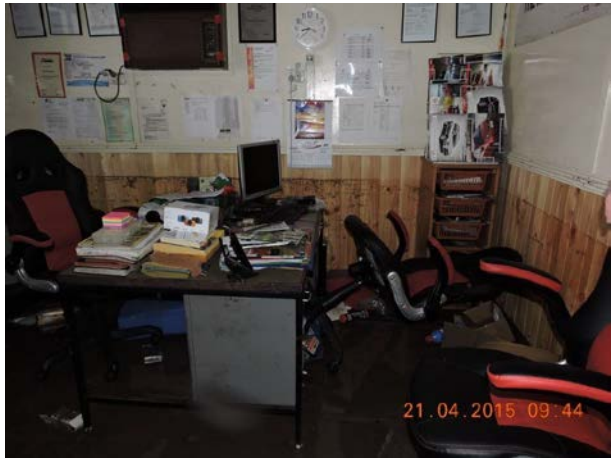



(B) Thresholds for building stability (Smith et al. 2014)

# DUNGOG FLOOD REPORT (COMPLETED)

- Commercial Buildings

(A) Glulam Factory




(B) Motor Vehicle Repair

(C) Farm Machinery Repair

# DUNGOG FLOOD REPORT (COMPLETED)

- Infrastructure: Myall Creek bridge


(A) Approach embankment


(B) Northern abutment


(C) Southern abutment

# PARALLEL ACTIVITIES

- Engagement with other projects within the cluster
- Engagement with other projects outside the cluster
- Engagement with Insurance Council Australia (ICA) and Edge Environment Consultant
- Engagement with CSIRO
- Advising South Australian Government on Flood Resilience Scorecards for Aged Care facilities

# PROJECT TIMELINES

| | Start | Mar-14 | Jun-14 | Sep-14 | Dec-14 | Mar-15 | Jun-15 | Sep-15 | Dec-15 | Mar-16 | Jun-16 | Sep-16 | Dec-16 | Mar-17 | Jun-17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Project Management - Work Plan, Communication, Collaborations*** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| ***Classification of building stock into vulnerability classes*** | | | | | | | | | | | | | | | |
| Review of literature, NEXIS and international practices | | | | | | | | | | | | | | | |
| Report on building classification | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| ***Literature survey of existing mitigation options*** | | | | | | | | | | | | | | | |
| Review of literature, national and international practices | | | | | | | | | | | | | | | |
| Publication on proposed research at AFAC and BNHCRC Conference | | | | | | | | | | | | | | | |
| Report on review of existing mitigation strategies | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| ***Development of Australian specific mitigation options and costing modules*** | | | | | | | | | | | | | | | |
| Identification of Australian specific mitigation options | | | | | | | | | | | | | | | |
| Developing costing modules of different mitigation strategies | | | | | | | | | | | | | | | |
| Publication on retrofit options and costing modules | | | | | | | | | | | | | | | |
| Report on retrofit options and developing of costing modules | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| ***Development of strategies for new construction, quantity surveying and experimental plan*** | | | | | | | | | | | | | | | |
| Strategies for new construction | | | | | | | | | | | | | | | |
| Quantity surveying | | | | | | | | | | | | | | | |
| Experimental plan for testing of materials to flood resilience | | | | | | | | | | | | | | | |
| Report on strategies for new constructions and quantity surveying | | | | | | | | | | | | | | | |

# CONCLUDING REMARKS

- The project is on track and progressing smoothly.
- The deliverables have been completed on time including:
  - Project Management Plan (April 2014)
  - Quarterly reports (FY2013-14, FY2014-15, FY2015-16)
  - Annual report FY2013-14 (June 2014)
  - Report on building schema (June 2014)
  - Poster presentation at AFAC&BNHCRC Conference Wellington (Sept 2014)
  - Paper published and oral presentation at FMA National Conference Brisbane(May 2015)
  - Report on review of mitigation strategies (June 2015)
  - Annual report FY2014-15 (June 2015)
  - Poster presentation at AFAC&BNHCRC Conference Adelaide(Sept 2015)
  - Report on Dungog Floods, NSW (Sep 2015)

# THANK YOU

**Phone:** +61 2 6249 9524
**Web:** www.ga.gov.au
**Email:** Tariq.Maqsood@ga.gov.au
**Address:** Cnr Jerrabomberra Avenue and Hindmarsh Drive, Symonston ACT 2609
**Postal Address:** GPO Box 378, Canberra ACT 2601