EXPERIMENTATION AND FRAMEWORK DEVELOPMENT FOR MULTI-VOLCANIC HAZARD IMPACT ASSESSMENT

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GNS SCIENCE TE PŪ AO
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MULTI-VOLCANIC HAZARDS IN THE AUCKLAND VOLCANIC FIELD (AVF)

- AVF eruptions are intrinsically multi-hazard events
- Multi-hazard relationships are complex and hazards can cascade or compound during an eruption
- Multi-volcanic hazard impacts are under-researched, particularly in relation to New Zealand assets
- The production of detailed AVF scenarios allows for the development of multi-volcanic hazard impact assessment framework

RESEARCH AIMS

- Develop a multi-volcanic hazard impact assessment framework, which includes impact cumulation, to improve our ability at assess multi-hazards.
- Conduct experiments and develop multi-hazard vulnerability functions to reduce assumptions and improve the robustness of the impact assessment framework
- Common building typology, timber-framed residential with sheet metal roof cladding - 36% of buildings in Auckland
- Common multi-hazard – tephra fall and volcanic ballistic projectiles occur concurrently and all DEVORA AVF scenarios

TEPHRA LOADING EXPERIMENT OBJECTIVES

- Lack of experimental assessments of tephra loading impacts
- What performance can we expect from New Zealand buildings? – Hypothesis DS4 will occur around 10-15kPa
- Comparison of experimental damage with Global Risk Assessment (GAR15) Regional Vulnerability Functions, and damage state descriptions (Hayes et. al, 2019)

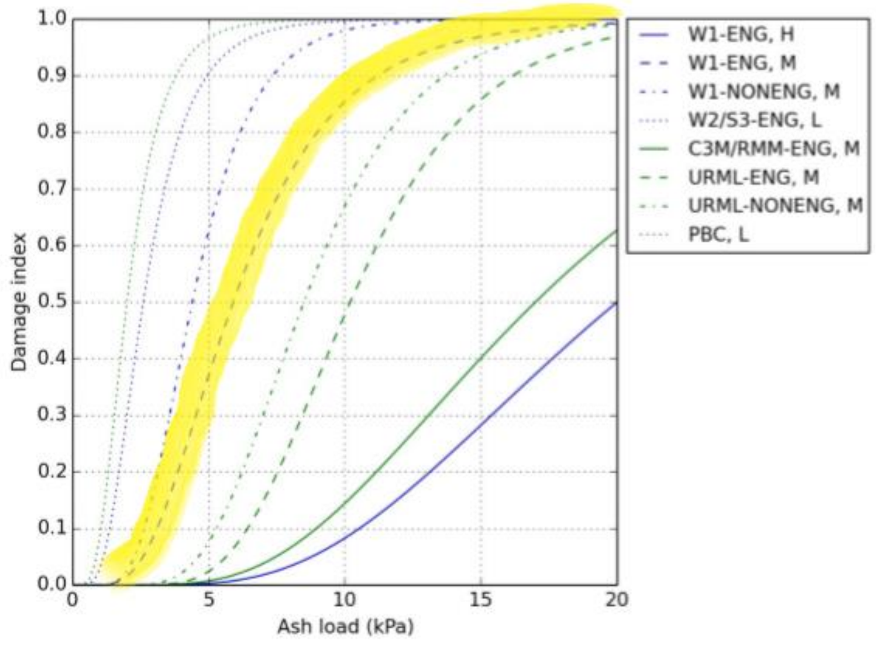


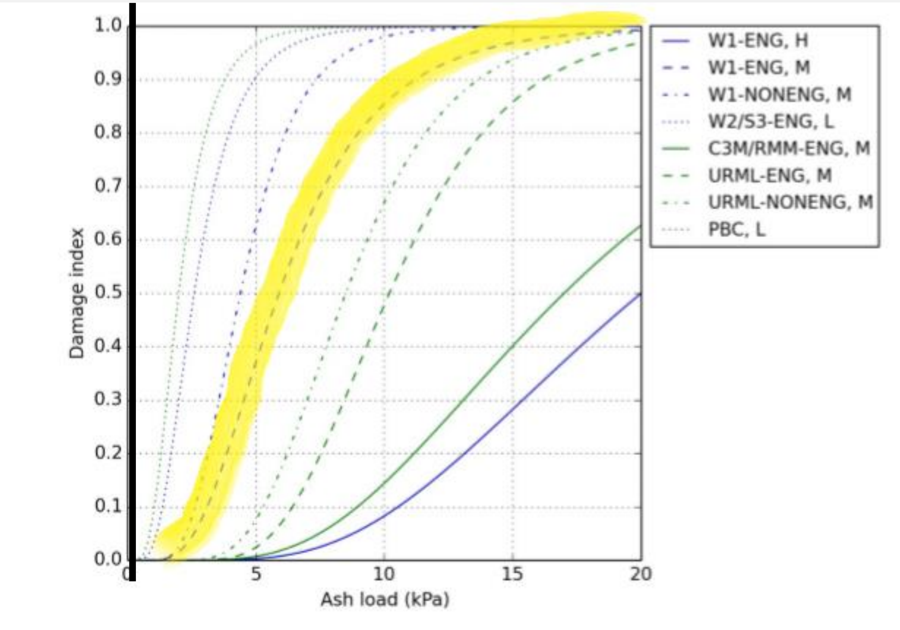
Figure 7.1 Benchmark curves developed during the volcanic ash sub-workshop. (Maqsood et. al, 2014)

DS0	No damage
DS1	Minor damage to non-structural elements
DS2	Moderate damage but vertical structure and roof supports intact
DS3	Severe damage to the roof and supports
DS4	Partial or total collapse of the roof and supports
DS5	Building collapse

(Hayes et. al, 2019)

TEPHRA LOAD EXPERIMENTATION

- Built to New Zealand building code NZS3604
- Rafter span – 2.6m, Rafter spacing – 600mm
- The building standard incorporates a 2kPa snow load (approximately 12cm of tephra)



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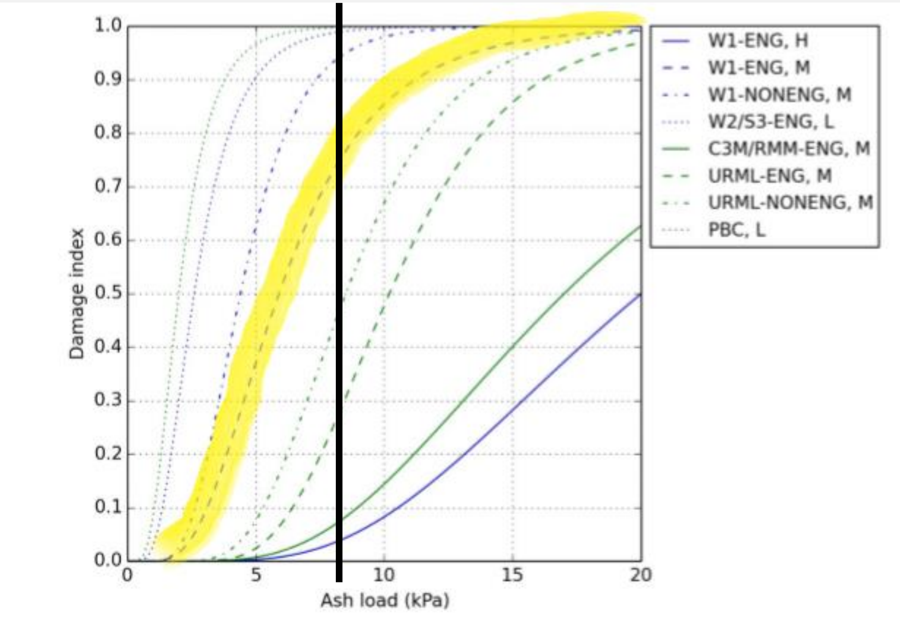
(Hayes et. al, 2019)

TEPHRA LOAD EXPERIMENTATION

- Load – 7.7kPa (dry load), 9.5kPa (wet load)
- Approximately 4 tonnes



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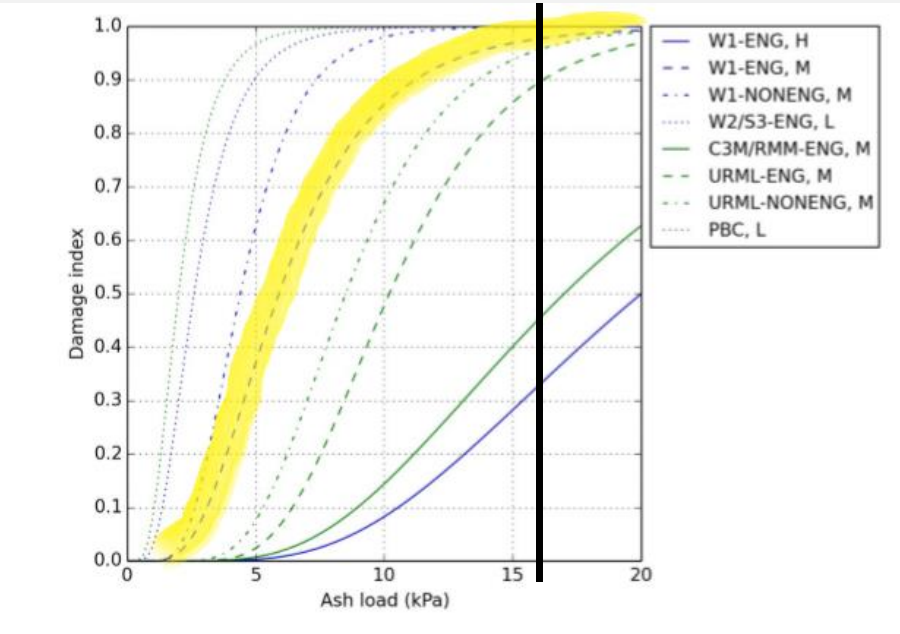
TEPHRA LOAD EXPERIMENTATION

- Initial structural damage occurred at the fixings where the rafters connect to the ridge beam.
- Initial structural damage – 13.4kPa (dry load), 16.8kPa (wet load)



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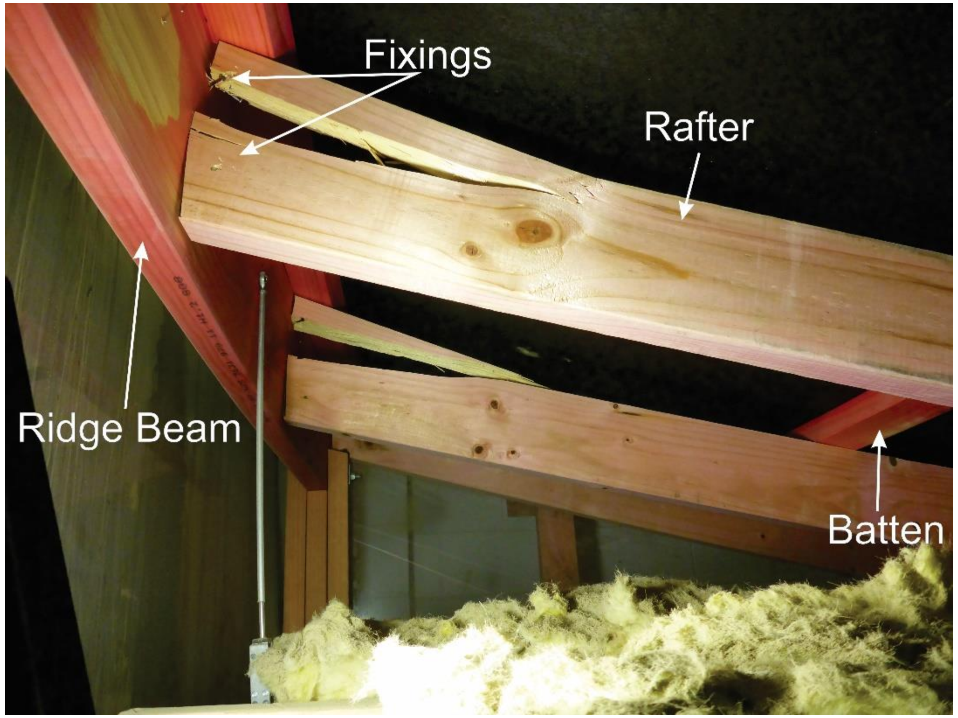

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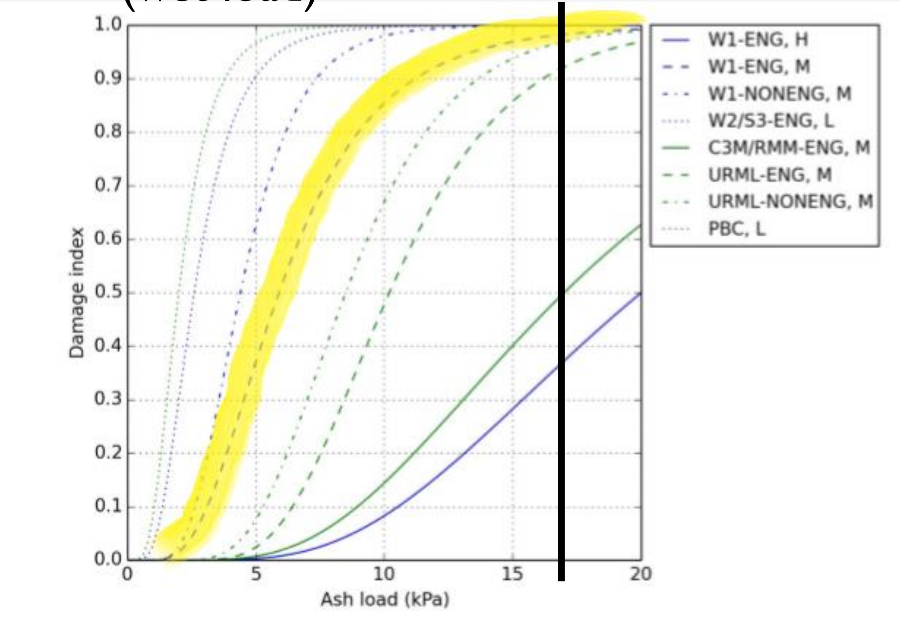
(Hayes et. al, 2019)

TEPHRA LOAD EXPERIMENTATION

- Once rafter failure occurred, batten failure occurred
- A total of 7.5 tonnes of pseudo tephra were applied to the roof
- Total load – 14.9kPa (dry load), 18.7kPa (wet load)



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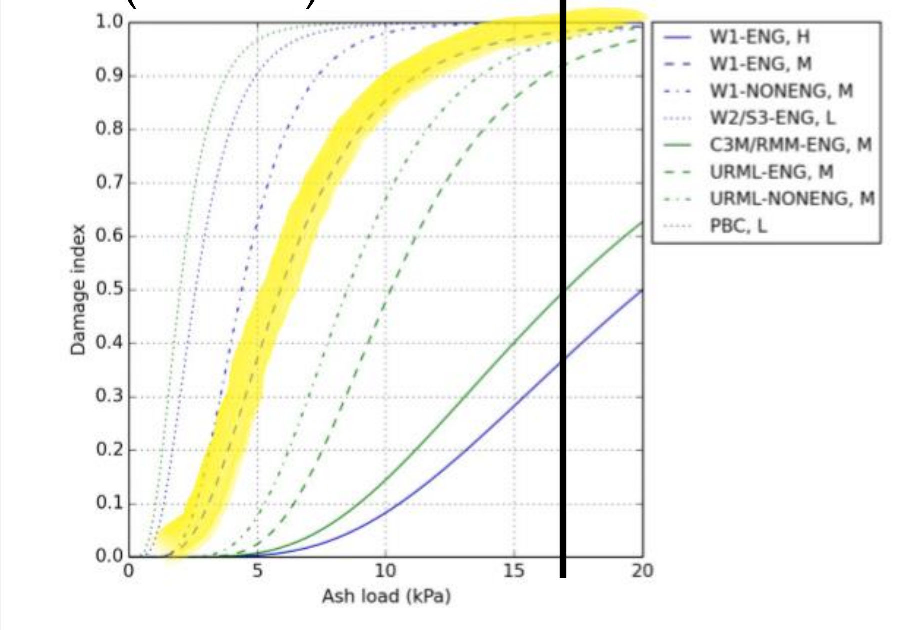

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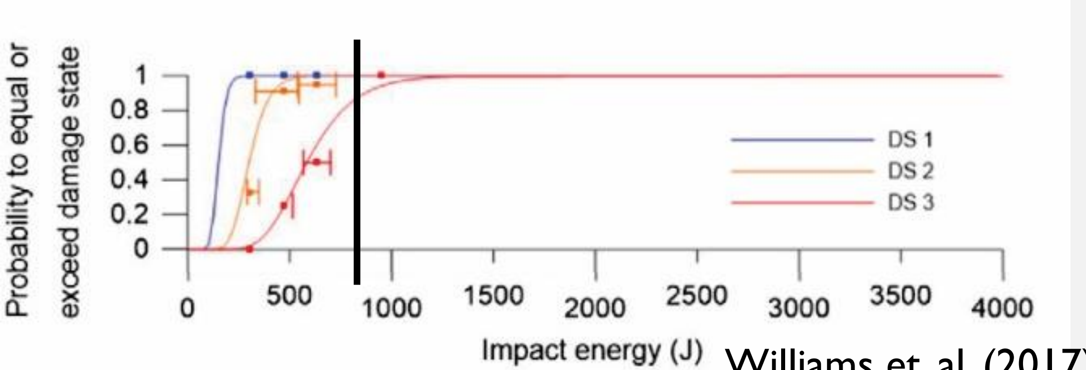
TEPHRA LOADING AND BALLISTIC PROJECTILE EXPERIMENT OBJECTIVES

- Tephra fall and Volcanic ballistics often occur concurrently
- Does the interaction of these hazards alter the impacts they produce?
- Hypothesis
  - low tephra loads will have little or no effect on ballistic impact
  - Moderate tephra loads will cushion ballistic impacts
  - Large tephra loads will lead to ballistic impacts causing structural damage
- Comparison of experimental results with damage states to sheet metal cladding from Williams et. al, 2017
  - DS1 – cosmetic denting
  - DS2 – Tearing
  - DS3 - Perforation

MULTI-HAZARD EXPERIMENTATION

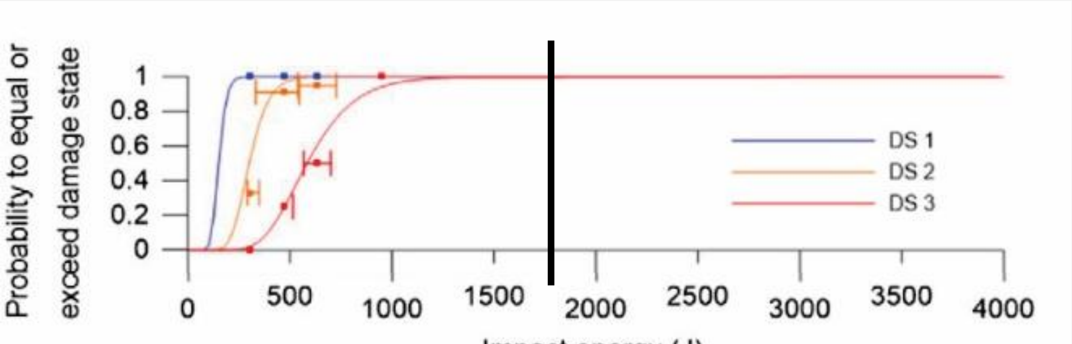
- Ash
  - Load – 2kPa
  - Thickness – 15cm
- Ballistic
  - Mass – 3.5kg
  - Velocity – 21m/s
  - Energy – 819J



Williams et. al, (2017)

MULTI-HAZARD EXPERIMENTATION

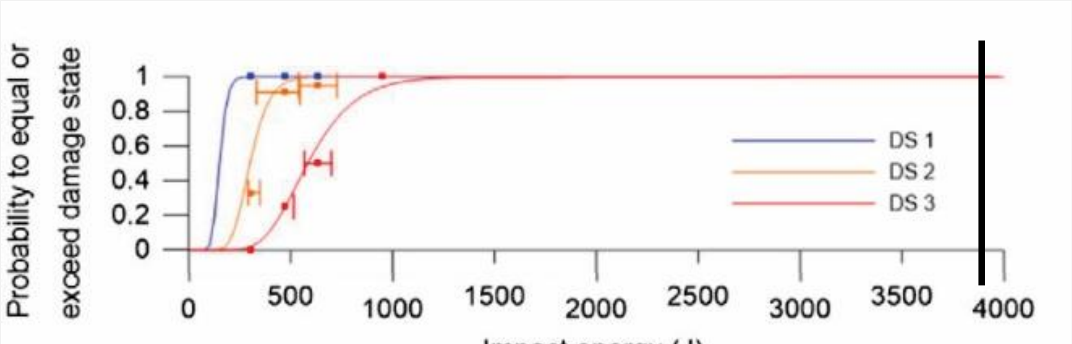
- Ash
  - Load – 2kPa
  - Thickness – 17cm
- Ballistic
  - Mass – 3.5kg
  - Velocity – 31m/s
  - Energy – 1767J



Williams et. al, (2017)

MULTI-HAZARD EXPERIMENTATION

- Ash
  - Load – 2kPa
  - Thickness – 17cm
- Ballistic
  - Mass – 3.5kg
  - Velocity – 45m/s
  - Energy – 3865J

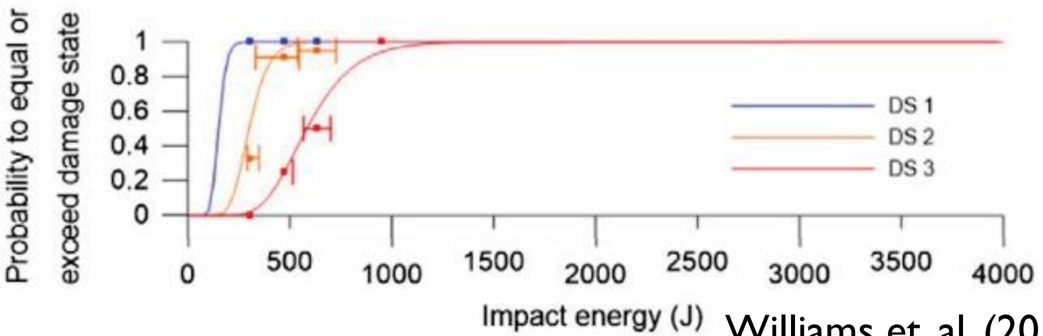


Williams et. al, (2017)

Tephra can cushion ballistic impacts, protecting cladding from perforation, but higher impacts energies can lead to structural damage

MULTI-HAZARD EXPERIMENTATION

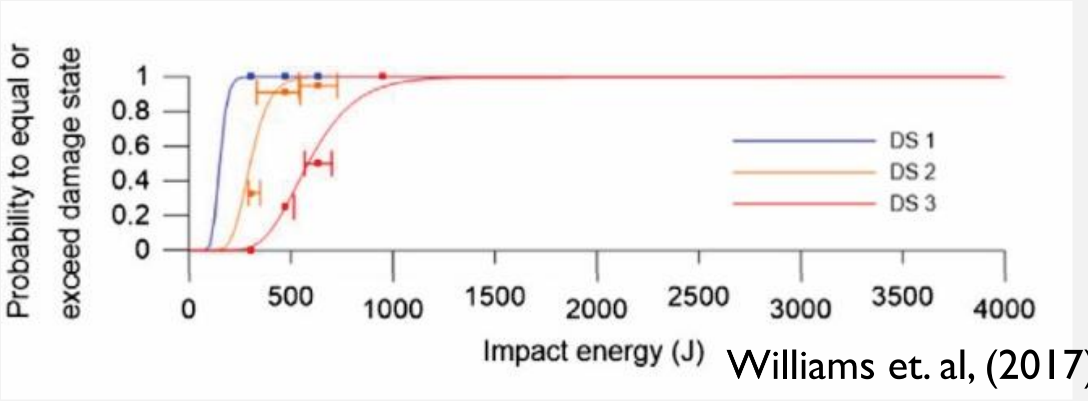
- Ash
  - Load – 7.5kPa
  - Thickness – 45cm
- Ballistic
  - Mass – 8.8kg
  - Velocity – 32m/s
  - Energy – 4505J



Williams et. al, (2017)

MULTI-HAZARD EXPERIMENTATION

- Ash
  - Load – 11kPa
  - Thickness – 61cm
- Ballistic
  - Mass – 8.8kg
  - Velocity – 32m/s
  - Energy – 4592J



Williams et. al, (2017)

Large loads of tephra can dissipate the energy of ballistics, potentially leading to no or little impact occurring

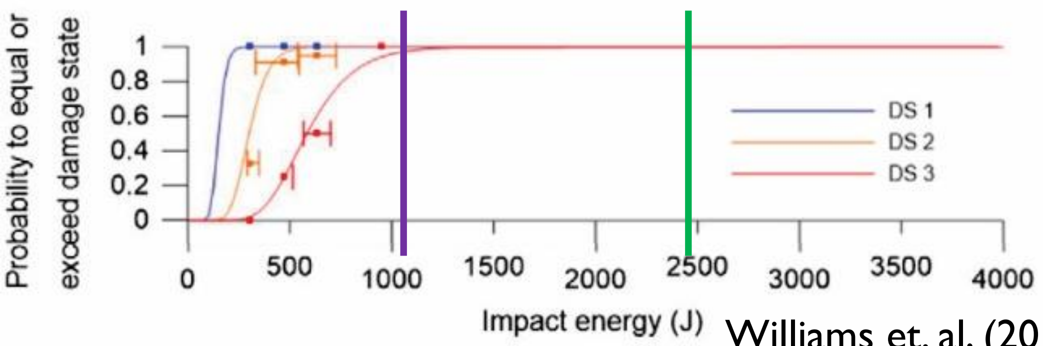
MULTI-HAZARD EXPERIMENTATION

1

- Ash
  - Load – 1kPa
  - Thickness – 7cm
- Ballistic
  - Mass – 3.5kg
  - Velocity – 36m/s
  - Energy – 2486J

2

- Ash
  - Load – 1kPa
  - Thickness – 9cm
- Ballistic
  - Mass – 1kg
  - Velocity – 47m/s
  - Energy – 1075J



Williams et. al, (2017)

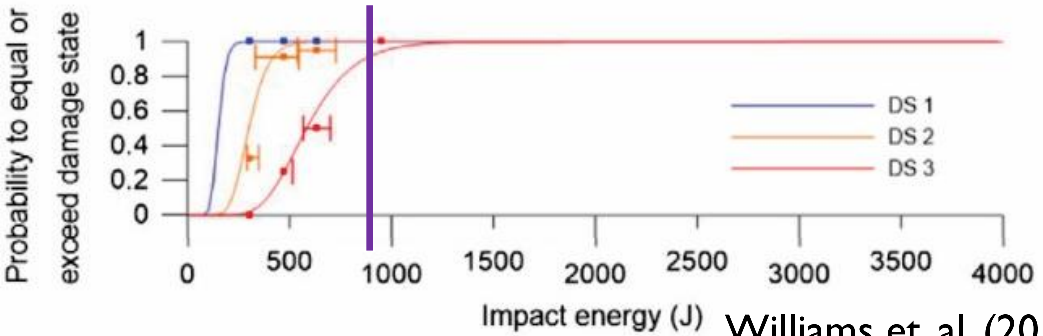
MULTI-HAZARD EXPERIMENTATION

1

- Ash
  - Load – 0.5kPa
  - Thickness – 4cm
- Ballistic
  - Mass – 3.5kg
  - Velocity – 50m/s
  - Energy – 4623J

2

- Ash
  - Load – 0.5kPa
  - Thickness – 3.5cm
- Ballistic
  - Mass – 1kg
  - Velocity – 44m/s
  - Energy – 941J



Williams et. al, (2017)

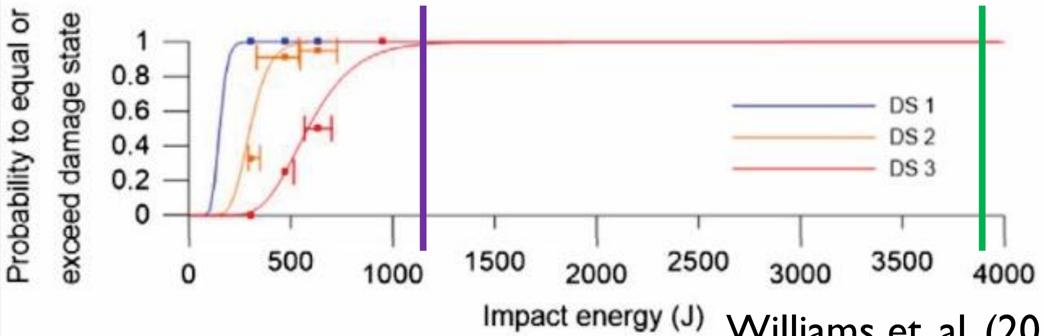
MULTI-HAZARD EXPERIMENTATION

1

- Ash
  - Load – 0.25kPa
  - Thickness – 2cm
- Ballistic
  - Mass – 3.5kg
  - Velocity – 46m/s
  - Energy – 3865J

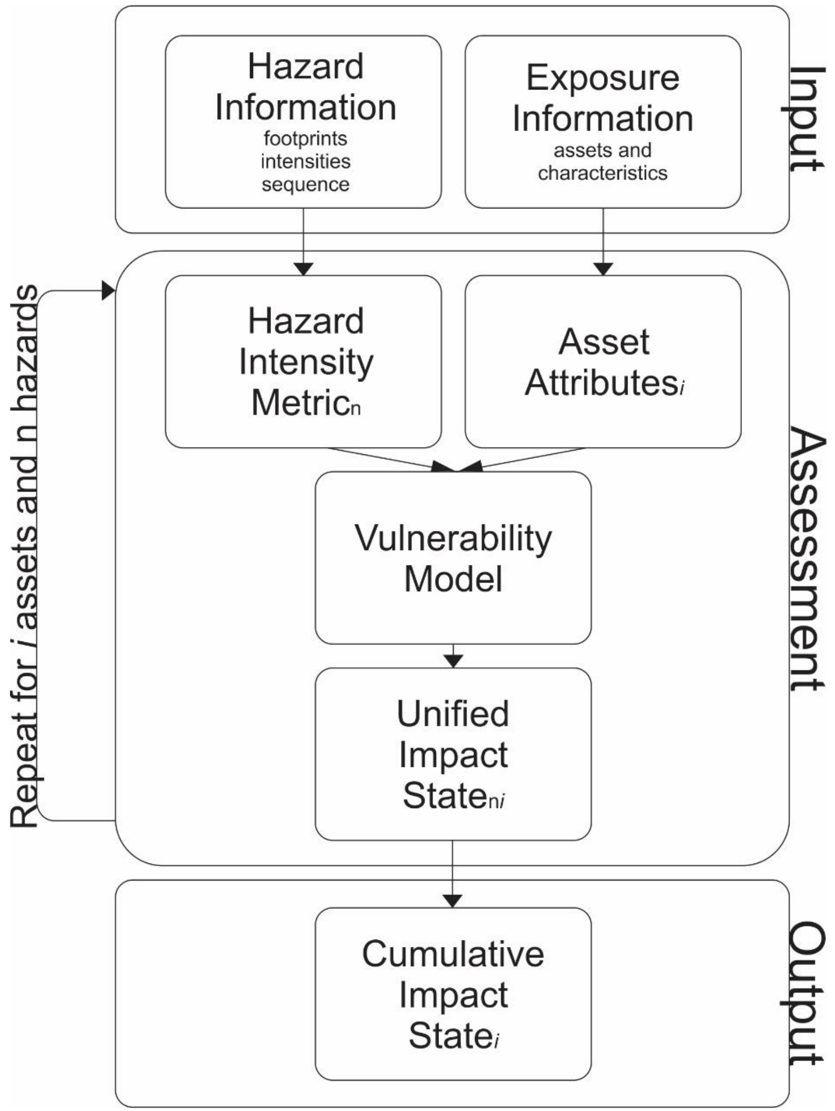
2

- Ash
  - Load – 0.25kPa
  - Thickness – 1.5cm
- Ballistic
  - Mass – 1kg
  - Velocity – 49m/s
  - Energy – 1138J



Williams et. al, (2017)

The size of the ballistic, rather than the impact energy, controls whether a ballistic can penetrate sheet metal cladding



Conceptual multi-volcanic hazard impact framework design. Where *i* is asset (building) number and *n* is hazard number.

FRAMEWORK DESIGN

- Currently hazards are represented by a hazard intensity metric
- Assumptions are needed to be made to assign unified impact state and to cumulate impacts
- The development and incorporate multi-hazard vulnerability models reduces the assumptions and increases the robustness of the framework

THANK YOU

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