Spatial Vision

SECCCA Residential Case Study

# Methods and Findings Report

6th March, 2023

## About this Document

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# Executive Summary

The South East Councils Climate Change Alliance (SECCCA) has been working with the Insurance Council of Australia (ICA) as part of understanding Member Council's responsibilities to its environmental sustainability of the municipal district, including mitigation and planning for climate change risks.

This has led to an opportunity to build upon the existing SECCCA Asset Vulnerability Assessment to determine climate impacts on residential dwellings, the vulnerability hotspots, likely damage and loss scenarios and identify adaptation actions. From this study, these participating councils will gain an understanding of the likely risks and impacts on the most exposed and vulnerable residential dwellings in the community.

The focus for this project is on flood events.  Climate impacts such as bushfire and heatwaves could be addressed as a potential future piece of analysis.

Key deliverables that have been generated for this project include:

- A Generic framework for the categorisation of residential properties
- A working set of documented residential archetypes for the agreed study area, and
- Spatial and tabular outputs of the assessment on housing stock in the region

The project workflow applied broadly followed these four key steps:

1. Spatial Definition and Exposure Assessment
2. Housing Archetype and Attribution
3. Vulnerability Profiling and Damage Curve Assessment
4. Model Processing and Analysis

To undertake the analysis, there were a number of key datasets required.  However, integral were flood modelling data inputs – either available through 1 in 100-year extent products or flood depth models – and housing rates data for archetype setting.

The Flood Extent data product is flooding extent only to a 1 in 100-year level, or a 1% Annual Exceedance Probability (AEP) level. Flood Depth data is a modelled product for a climate change future, set to 2100, and is a coupled inundation and flooding scenario.

Central to the formation of housing archetypes for the study region is a record of housing valuation data to the address level. Key housing attributes sourced from this included building age and construction type.  Other necessary data such as floor height and renovation date were not available region wide, so provided a limitation in the analysis.

Through the application of the data there were several data limitations that added to a list of modelling assumptions and caveats.  These have included;

- Missing Floor height for archetypes, where for all archetypes there is an assumed floor height range
- There is no provision of building footprint location within a parcel.  Therefore, analysis on flood impact is at the parcel level, not to the building location.
- For each archetype, there was a significant amount of properties that have had renovations. Therefore, an archetype can fall within a standard archetype and a renovated variant archetype that are updated to new building standards.
- Flood depth modelling was only available for certain water basins and is seen to not cover the full coverage of the 1 in 100-year flood extent layer as provided by Melbourne Water.
- To account for incomplete flood depth coverage, flood extent was used as a proxy to set a range of flood depth scenarios at 25cm, 45cm, 65cm and 100cm

In the assessment of housing rates databases to create housing archetypes, the following seven 'default' housing archetypes have been created:

- Pre-War
- Mid-Century Brick Veneer
- Modern Brick Veneer
- Mid-Century Weatherboard
- Modern Weatherboard
- Contemporary House
- Beach Shack

These archetypes have been applied to the parcel and then aggregated back up into a SA1 geography. This allows for de-identification of potential impacts to the parcel level and presents outputs at a larger scale SECCCA wide. For each council the most common archetypes in a given SA1 that has an intersection with the 1/100-year flood extent are listed below:

- Bass Coast: Beach Shack
- Bayside: Modern Brick Veneer
- Frankston: Mid Century Brick Veneer
- Kingston: Mid Century Brick Veneer
- Mornington Peninsula: Modern Brick Veneer

The most common by SA1 for each LGA are the Brick Veneer type houses, either Mid-Century or Modern. This trend continues in an assessment of the second most common archetype, which over most Councils are Modern Brick Veneers.

There is also a noted dominance of archetypes by location, for example Beach Shack archetypes are more commonly seen in coastal areas. Another unique clustering is in older established inner urban areas where Pre-War archetypes are more dominant, alluding to older housing stock and a lack of recent in-fill development.

Following the creation of housing archetypes by parcel, determination of parcels that may potentially be impacted by a flood and then aggregation of parcel counts to the SA1, the next stage is application of flood depth, either actual or assumed scenario depth. This involves applying an archetype damage curve that has been assigned to each archetype.

A damage curve is a representation of relative damage to a dwelling at a given flood depth. In the majority of housing archetypes and associated damage curves, significant damage can occur with only a small volume of water above floor height. This can be essentially the same amount of damage through to a flood depth of 1 - 1.2m above floor height.

This observation into damage curves does extend in the application of flood depths to housing archetypes. Although there is a small variation between Council area and housing archetype, from the analysis it is noted that for the majority of housing archetypes in a SA1, any flood above 25cm floor height presents a large increase in potential damage to a house.

After this there is a plateauing of potential damage index values. This is particularly seen in Brick Veneer type houses and less so in Beach Shack type houses. Due to the low floor height range in most Veneer types, damage can be seen to increase sharply at the 45cm mark. Whereas Beach Shacks and Weatherboards have a lower damage index due their higher floor height, hence less inundation and flood damage.

Further the Mid-Century Brick Veneer archetype exhibits the greatest increase in damage index values from a 25cm to 45cm flood depth scenario. The archetype that has the highest potential damage index by a high point of 100cm is the Contemporary House.

Therefore, it can be the case where it doesn't matter if the flood is 20cm or 100cm, the damage will be principally the same. However, above these heights the potential damage can potentially increase significantly.

On this basis, local mitigation efforts that minimise the potential damage to properties to withstand a depth of 1.2m will limit the loss in the event of a flood. Mitigation efforts include for example concrete floors, epoxy tiles or raised power sockets. Further, more general mitigation to prevent the flood height from reaching above 1.2m will better protect the property from significant damage.

This project has identified a number of limitations on the data and potential assumptions. This is extended into the application of the data and the scenarios developed. Due to the aggregation to SA1 scales and the setting of depth scenarios to extent modelling, the analysis is largely scenario based only and is more so relevant for planning and intel purposes as opposed to detailed parcel level disclosure of climate risk.

# 1. Introduction and Deliverables

The SECCCA region is particularly vulnerable to climate change. Hazards may come from coastal inundation, sea level rise and storm tides in the Port Phillip Bay or Westernport Bay regions, bushfire risks in the various parks and forested regions, including Bunyip National Park, or overland flooding in the various rivers and catchments flowing into either bay.

Previous analysis conducted for the region involved an Asset Vulnerability Assessment (AVA) to identify the vulnerability of public infrastructure in relation to exposure to these hazards in light of climate change influences.

The South East Councils Climate Change Alliance (SECCCA) has been working with the Insurance Council of Australia (ICA) as part of understanding Member Council's climate change risks relating to privately owned assets, particularly homes.

This collaboration has led to an opportunity to build upon the existing SECCCA AVA project to determine climate impacts on residential dwellings, the vulnerability hotspots, likely damage and loss scenarios and identify adaptation actions. The focus for this project is on flood events, with other climate impacts such as bushfire and heatwaves to be addressed as a likely separate piece of analysis.

Within the SECCCA regions, participating Councils include;

- Mornington Peninsula
- Bass Coast
- Frankston
- Kingston
- Bayside

From this study, these participating councils will gain an understanding of the likely risks and impacts on the most exposed and vulnerable residential dwellings in the community and potential protection options. This analysis is to then be used by SECCCA to identify and prioritise adaptation actions that can be taken in the region to strengthen the resilience of communities across both the public and private realm.

A key understanding of this project is the classification of housing stock in each of the participating Council region, which allows for a systematic classification and analysis. These archetypes draw on previous studies and material provided by the ICA. They are based on typical designs and materials, age of home relating to building codes and standards etc. The ICA have also contributed insurance industry hazard data, such as flood inundation data extent and depth, damage curve verification based on depth, based on different build types, and loss information to assist.

Key Project Deliverables

Key project deliverables are:

- Generic framework for the categorisation of residential properties in relation to associated climate related risk parameters (specifically in this study, flood). The categorisation draws on key studies undertaken to date and aims to have potential national application. The framework allows for scalability and repeatability across differing jurisdictions.
- A working set of documented residential archetypes for the agreed study area, based on an initial categorisation, to be applied in the SECCCA council study.

- Spatial and tabular outputs of the assessment on housing stock in the SECCCA region, incorporating the identification of focal areas, application of housing archetypes, and supporting the application of damage curves to determine risk.

This document outlines the methods and framework established for this assessment and which can be replicated in other regions or jurisdictions. The report presents the project workflow, list of stages undertaken, description of the key data inputs used and key caveats, considerations and recommendations.  Results from application of the analysis process for selected areas are presented, although full results for the five contributing LGA's are not presented.

# 2. Project Workflow and Methodology

The overall approach framework and workflow are structured in line with the understanding of key aspects in the deliverables. Details on the workflow and associated methods are described in this section.

As noted, the focus of this project is on five councils within the SECCCA region;

- Mornington Peninsula
- Bass Coast
- Frankston
- Kingston
- Bayside

The initial framework and testing outlined below is largely based on the Mornington Peninsula area due to availability of data. Hence, views of data inputs and some limited outputs are focused on this Council. This framework was extended into the other four Council areas as more data became available.

The following sections present the framework and workflow, and the subsequent chapter presents a more detailed description of key data inputs.

## 2.1. Project Workflow and Method

The project workflow broadly is as follows:

1. Spatial Definition and Exposure Assessment
2. Housing Archetype and Attribution
3. Vulnerability Profiling and Damage Curve Assessment
4. Model Processing and Analysis

The below diagram in Figure 1 depicts the overall framework applied in this project. It incorporates four of the key stages in the project method and the workflows that are critical between each stage.

Outputs and methods in the following section are to focus on the Mornington Peninsula Council within the SECCCA region. All initial testing of methods and outputs has been undertaken for this LGA due to data provision and acquisition timeframes (and permission provided by Mornington Peninsula Shire for this purpose).

Using the refined focal areas and exposure data (Stage 2), housing archetypes and attributions (Stage 3) and cost damage curves (Stage 4), an assessment has been undertaken on the housing stock in the SECCCA region.

Each of the individual components are processed in succession and each output is reviewed and put through a validation process to ensure logical consistency and validity of outputs. The starting point has been the process as outlined in Stage 2. Using exposure data layers, focal areas are created that centre on regions impacted by a given hazard exposure, or combinations of.

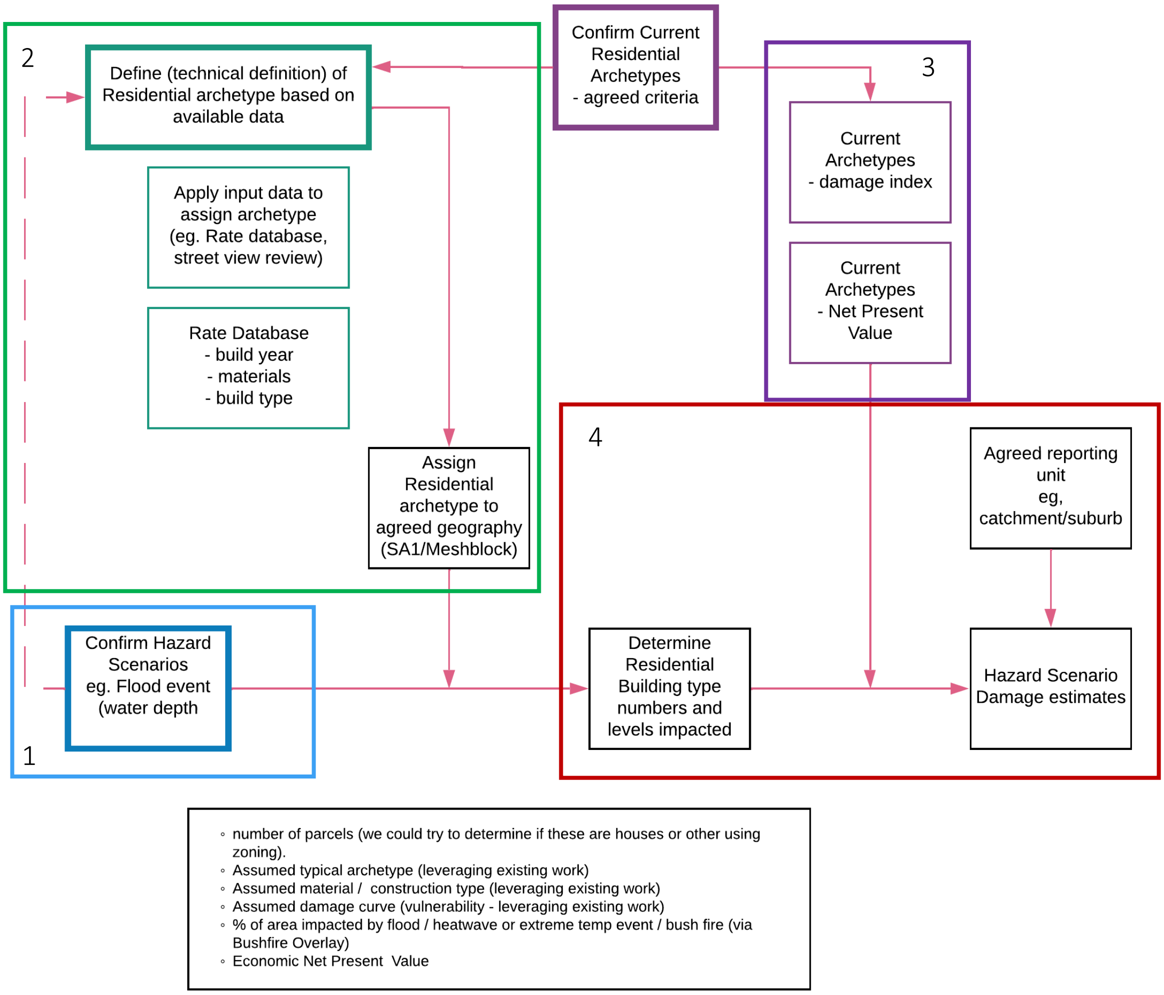


Figure 1. High-level framework of the workflow undertaken in each of the six stages

For these focal regions, the housing archetypes, as created in Stage 3, have been applied and summarised back into a given geographic unit (SA1). This will not only profile a general archetype for a given area, but also provide context into materials, housing formation and other key attributes required for analysis.

The exposure data, such as flood depth, is then combined back against these housing archetypes and the relevant damage costs or damage curves, as developed from Stage 4. Using assumed costs, replacement values, or other valuation metrics, these damage estimates can then be summarised per geographic unit and overall costs be calculated.

This project and its outputs are to act as an investigation piece into a range of scenarios and will not have impacts on real-world implications to residential housing stock.

The following chapter will provide context on data considerations in relation to climate hazards and levels of exposure, as well as key data inputs used in the framework. The chapter after this provides more detail on each of the stages outlined above, application of the data, and the proposed methodological approach in detail.

# 3. Key Considerations of Project and Data Inputs

## 3.1. Housing Classifications Literature and Asset Information

Each participating member council in this project have a variety of private residential dwelling types. This housing stock will have varying construction dates, be constructed with differing materials and be built to varying standards. For this project, private residential dwellings for an LGA have been assigned into a 'housing archetype'. This in turn has been used to support a broad risk assessment. This classification allows for a systematic analysis of housing stock in each council region.

The archetype classification has been designed to be accommodating of variations in type, such as renovations and alterations to housing stock that can modify its risk profile to a particular hazard. Upgrades to an existing older housing stock require defects that do not meet current standards to be addressed. This alters a housing archetype in relation to its internal structure and properties, but may not alter its physical appearance. Council records and rate data can indicate these changes and have been referenced where applicable, to reflect any changes in standardised house archetype.

As part of this house archetype structure there is accompanying attributes describing housing age range, estimated floor height, construction material for walls and roof, foundation formation and other such variables. These attributes contribute to describing an archetype and are used in analysis of potential damage, costs and vulnerability to climate exposures.

Archetypes and accompanying attributes have been established in several previous projects and these are leveraged for use in this project. These projects include, but are not limited to;

1. Where we Build, What we Build[1]
    a. South Australian study enabling assessment of the climate risk exposure of homes and encouraging better climate risk mitigation decisions. The final report details the archetyping methodology and attribution
2. Severe Wind Hazard Assessment - Queensland Fire and Emergency Service (QFES)
3. Geoscience Australia building vulnerability functions and Residential Flood Vulnerability Categorisation Schema
    a. Collection of housing archetypes and corresponding vulnerability damage curves in relation to flooding exposures and depth of flood
4. Launceston Flood Risk Mitigation
    a. Flood risk assessment for Launceston that combines residential archetypes, flooding vulnerability and Cost Benefit Analysis (CBA) for flood prone houses.

Each of these projects makes use of and builds upon the housing archetype system. However, each time there is a level of tailoring to ensure that archetypes fit within the geographic region being assessed.

For this project these archetypes have been used as a base and built upon for the study region.

## 3.2. Climate Exposure Data Considerations

Each of the outlined projects above, as well as others utilising a housing archetype system, explores residential housing stock and exposure to climatic influences. The majority look at exposure to flooding damage, but others do assess exposure to wind, extreme heat and fire.

[1] Existing resources found at https://www.lga.sa.gov.au/southern-and-hills-lga/reports-and-publications/regional-climate-adaptation/where-we-build,-what-we-build

The overarching SECCCA Asset Vulnerability Assessment project assessed council assets and their exposure to climate exposures both in a baseline period and into likely climate futures. Variables not assessed directly or at all into a climate future included wind, fire and flooding/inundation. In relation to fire and flood, what was assessed was levels of known risk and extent and recurrence intervals for event extents.

In assessing the likely impacts of climate change on residential properties in the SECCCA region, the following three areas have been identified by councils to be of particular concern:

- Flooding extent and depth to recurrence intervals
- Extreme heat related to summer maximum temperatures or heatwaves
- Fire risk related to Bushfire Management Overlays

The degree to which these climate related changes is explored in this project will vary in terms of scope. However, there is a clear focus on flood events. This document therefore outlines how flood events in particular have been explored using the method outlined in this document. The framework can be used at a more conceptual level to explore its application to the other two exposure types.

## Flooding and Inundation

Flooding and inundation impacts were considered in the SECCCA project, but were not directly incorporated or assigned to likely climate futures. During the project, the available datasets detailed flooding extent for a number of year recurrence intervals, such as 1 in 100-year recurrences or 1% Annual Exceedance Probabilities (AEP). These were sourced either from State Government or Water authorities. In-house council modelling was not included in the model ensemble.

These datasets outlined the estimated flood extent; however, depth was not available from these readily available sources. The ICA National Flood Information Database (NFID), which does contain flood depth information, was assessed for use in assessment of Council held assets for localised case study purposes. It is understood that NFID is focused on flooding that has occurred in private settings. Since the SECCCA AVA was focused on council areas and not private locations, depth information was not readily available. Future projections were also not available.

Future climate projections of flooding extent and depth can be problematic to model. Factors such as local terrain and flow restriction points, localised landscape weak points and landslip areas prone to increase flow velocity, river flow velocities and other hydrological factors need to be accounted for if modelling future scenarios. During the SECCCA project, these models were not available, and a decision was made to not roughly expand extents and fill out impact areas.

More so, there was a focus on recurrence intervals, in particular for case studies focussed on flooding and inundation. It is widely accepted that even with likely decreased annual rainfall, flooding and inundation will become more frequent and severe due to increased sea levels and altered rainfall patterns. Therefore, using recurrence intervals can act as likely future scenario points. However, to what extent recurrence intervals will change for flood in Victoria is highly uncertain.

The application of historical recurrence intervals in combination with future climate projections requires expert guidance. Hence, for this project, decisions concerning the use of recurrence intervals as likely future scenario points have been developed jointly with councils and input from the ICA expert panel representation. As output, a series of options have been considered and used to provide a range of values to support scenario setting.

However, obtaining flooding extent and depth data to a range of recurrence intervals has proven to be difficult. As noted, the NFID provides current flood depths to known occurrences. Also, existing Melbourne Water and Council held data are more for extents rather than depths.

### Bushfire

Fire was not assessed in the SECCCA AVA as a direct measure, such as through accepted measures including the MacArthur Forest Fire Degree Index. However, by investigating typical weather indicators that could contribute to fire weather, this line could be taken at a detailed localised assessment if required. Further, exploring existing systems that provide an indication of fire risk, such as Bushfire Management Overlays (BMO), can also assist identify areas of potential risk. While the BMO does not account for likely climate futures, it does identify current fire hotspots which will likely become more vulnerable into any future climate scenario.

### Wind

For the region wind data was available, but not as a meaningful measurement. Only available at time of project initiation was average wind speed in future climate scenarios. For a full assessment maximum wind speed or wind gusts is required. Hence, for this residential assessment, wind will not be covered., noting that excluding wind from this project may impact overall outcomes (i.e. due to the exclusion of factors such as wind-driven rain/water).

### Heat and Extreme Temperatures

Exposure to heat related events can be explored through the use of the original SECCCA climate data leveraged for the AVA. This can either be as heatwave events for the region or as extreme summer temperatures above a certain threshold. Any variable can be explored in a current baseline and into likely future scenarios.

## 3.3. Key Data Sources

### Rates Valuation Data

Central to the formation of housing archetypes for the study region is a record of housing rates valuation data to the address level. Detail that is required for this project will not relate to actual housing, values or any other sensitive address level detail. This is non-critical to the current project. However, from this database critical data points include;

- Building Age
- Build construction type or key materials
- Renovation date and type (if available)
- Floor Height (if available)
- Footprint area or location (if available)

Of the five data points listed, two are critical to formation of housing archetypes – age and construction type/material. These two points of data allow for a generic house archetype to be put together for an address point. How this is done ais outlined in detail in Section 4.2.

The last three points are all optional to the house archetype process and can be assumed to a generic level for a complete archetype.

*Building Renovations*

Renovation data has been sourced for one of the participating council areas and has been assessed for use in the application of this project. As noted, renovations will potentially modify housing stock by addressing defects and issues to bring a house up to current housing standards. As of 2005, any house that has a major renovation and is built before a certain date will require major upgrades to new building standards.

Hence, original house age may not reflect the current standard of the building. A renovation will alter a housing archetype in relation to its internal structure and properties, but may not alter its physical appearance. Council records and rate data may indicate these changes and will need to be reflected in any standardised house archetype.

This data, as provided has been explored in relation to housing archetypes and, if applicable, the archetype is set to have a 'variant' type or standard.

*Floor Height*

Floor height for a parcel is required for impact calculations against flood depth. Depending on the floor height in relation to the flood depth will detail the level of impact and risk a house may have.

However, this data for participating councils is either not present or extremely hard to obtain. As an alternative, floor height ranges for a particular housing archetype have been determined from a collection of Google Street View images.

This method is outlined below in Section 4.3

*Footprint Area*

For an impacted parcel, a potential flood will cross the parcel boundary. But it may not reach to actual house. Hence, for a full analysis, footprint data is of particular use. This can either be in relation to actual house location in a parcel or area of house for full valuation of potential damages.

This data, for both aspects, is not available in full for all participating council areas.

### Flooding Data

For use in this project, two flooding products form Melbourne Water have been sourced for use in impact assessment. These include;

- Flood Extent, and
- Flood Depth

No flood mitigation structures, or adaptation strategies have been incorporated into these layers, unless initially considered by Melbourne Water during the time of creation of the flooding data. This does not recognise any Council led strategies that can potentially limit or moderate likely flood damage in a given area.

*Flood Extent*

The Flood Extent data product is flooding extent only to a 1 in 100-year level, or a 1% Annual Exceedance Probability (AEP) level[2]. The extent has been determined by historical flood levels from past events as well as modelled extents based off likely rainfalls and inflows to a current climate scenario.

[2] Flood Extent spatial datasets have been sourced directly from Melbourne Water under a data license agreement. These are available upon request from Melbourne Water.

This product is seen to largely inform the Land Subject to Inundation Overlay as part of the Victorian Government planning overlays. Alternate flood extent products can also be sourced from in-house Council modelling. But this has not been used for this project.

*Flood Depth*

Flood Depth data is a modelled product for a climate change future, set to 2100. There are two products available for use in this project and include;

- Sea Level Rise only and
- Increased rainfall intensity and SLR.

For use in the project the second coupled inundation and flooding scenario is more consistently available in terms of spatial coverage, hence this is used.

This climate future is not set to a known General Circulation Model (GCM) climate change model or using any RCP emissions scenario. It is a set forcing scenario created for a given catchment basin using the Australian rainfall and Runoff guidelines projected to 2100. No other yearly scenario is currently available.

The scenario used is based off the known current modelled 1 in 100-year recurrence extent which is then forced to a new extent. The increased rainfall intensity used in the flood depth climate future in Melbourne Waters current technical specification is 18.5% for climate change. This is a forcing on top of current rainfall intensities for a given location. This means that for certain regions, intensities will differ and from the data identified are likely to vary as follow;

- Cardinia: 18.4%
- Casey: 19.5% to 18.4%
- Frankston: 18.4%
- Mornington: 19.5% to 18.4%

This data product is not available to a full coverage across the five participating council areas (and was not supplied for Bayside Council). It is seen to only be for a select few river and creek basins and does to cover the full flood extent as outlined by the extent only data product.

For each participating Council, this data set is only seen to cover the Water Basins of;

- Cardinia
    - Pakenham Township
- Casey
    - Edrington, Rodds and Ti Tree
    - Christies
- Frankston:
    - Upper Boggy
    - Baxter West
    - Carrum Downs
    - Ballarto Road
- Mornington:
    - Murray Anderson and Rosebud

- Sunshine, Finlayson and Hearn
- Coburn Creek

## Other Data

Several other open data platforms have been leveraged for detailing various aspects of this project. Initial residential parcel setting has used various Victorian Government data products from Vicmap suite of products and other products from the open data platform (data.vic.gov.au). These include;

- Council Boundaries[3]
- Parcel Boundaries[4]
- Planning Zones[5]
- Planning Overlays[6]
- Victorian Land Use Information System (VLUIS)[7]

These products in combination have been processed in order to determine where residential lots are located. This method is explored below in Section 3.2.

Other data sources include the Australian Bureau of Statistics (ABS) Statistical Area level 1 (SA1) boundaries for the current 2021 census[8].

All products listed are available on open data platforms and a data cut was done at project start to ensure consistent currency of all data products.

## Gaps and Considerations

As noted in the previous sections, there are several gaps in relation to data inputs that are necessary to be addressed or acknowledged. These include;

- Incomplete or missing renovation dates or details
- Incomplete or missing floor height measurements
- Incomplete or missing building footprint location or area
- Incomplete flood depth coverage across study region

Each of these gaps can be infilled via secondary data sources or a more generalised methodological approach. Or, for some, they need to be acknowledged as an assumed gap in the analysis. These are detailed in turn in the following methods sections.

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3 Vicmap Admin - State Council Polygon 2022 (https://discover.data.vic.gov.au/dataset/vicmap-admin-state-council-polygon-2022)
4 Vicmap Property - Parcel Polygon with Parcel Detail (https://discover.data.vic.gov.au/dataset/vicmap-property-parcel-polygon-with-parcel-detail1)
5 Vicmap Planning - Planning Scheme Zone Polygon (https://discover.data.vic.gov.au/dataset/vicmap-planning-planning-scheme-zone-polygon)
6 Vicmap Planning - Planning Scheme Overlay Polygon (https://discover.data.vic.gov.au/dataset/vicmap-planning-planning-scheme-overlay-polygon1)
7 Victorian Land Use Information System 2016-2017 (https://discover.data.vic.gov.au/dataset/victorian-land-use-information-system-2016-20171)
8 ABS Digital boundary files (https://www.abs.gov.au/statistics/standards/australian-statistical-geography-standard-asgs-edition-3/jul2021-jun2026/access-and-downloads/digital-boundary-files)

# 4. Project Application

## 4.1. Spatial Definition and Exposure Assessment

The first stage of the workflow involves detailing the impacted area in relation to the hazards and then identifying which residential parcels are potentially impacted by the hazard in question. These impacted parcels are then related back to a SA1 geographic boundary.

This process and framework, to a large extent, is a desktop analysis. It leverages freely available datasets, some proprietary models obtained through secondary organisations, and prior knowledge and literature undertaken in similar applications to detail new knowledge for the SECCCA region. It joins together several prior workflows into a larger framework that is intended to be scalable and repeatable for regions outside the SECCCA area

The following chapter focuses on the Mornington Peninsula as a case study in the application of the process and the Rosebud locale for more detailed analysis using depth flood data.

### Assessment of Flooding Exposure data

Flooding exposure data provided a basis for the spatial definition of the project area. In the initial assessment, two datasets were used. The first was the Melbourne Water 1 in 100-year flood extent polygons, as shown in Figure 2, is a publicly available dataset covering all of Melbourne Water's jurisdiction, and only provides flood extent data, not projected flood depth.

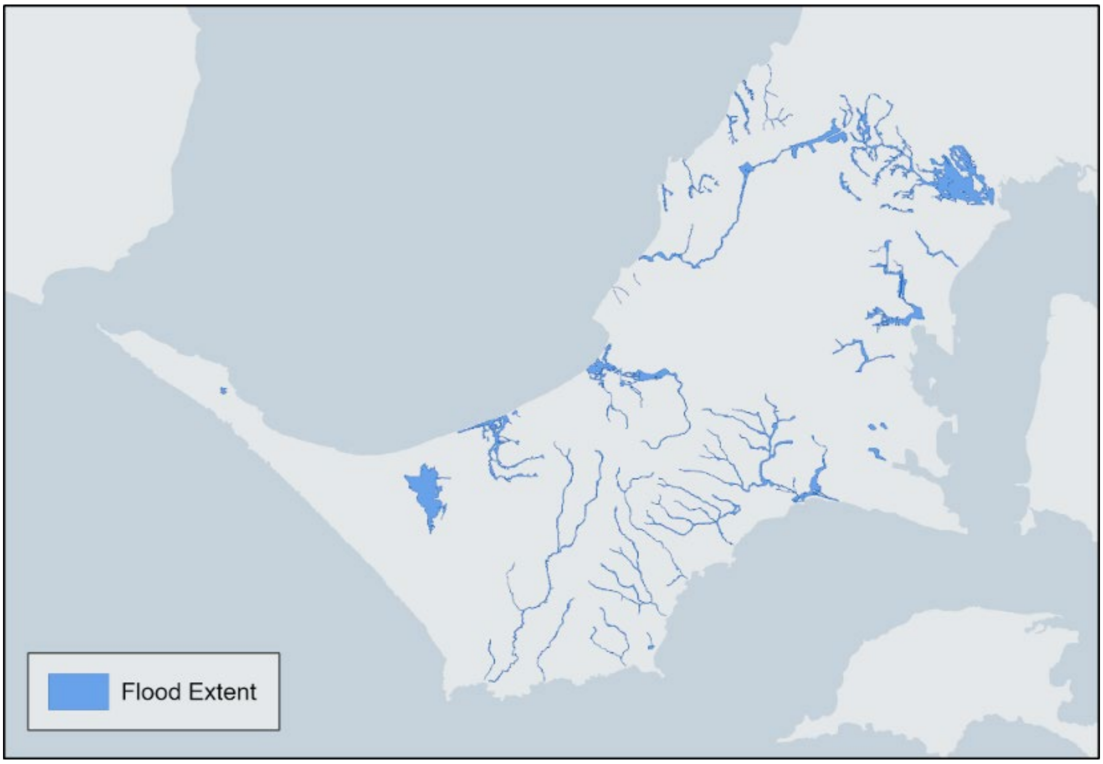



Figure 2. Melbourne Water Flood Extent for Mornington Peninsula Area at a 1 in 100-year recurrence interval

Melbourne Water also provided data for hydrological modelling done for selected catchments in the region, in a gridded point dataset which could be converted to raster, with attributes including projected flood depth, as shown in Figure 3.

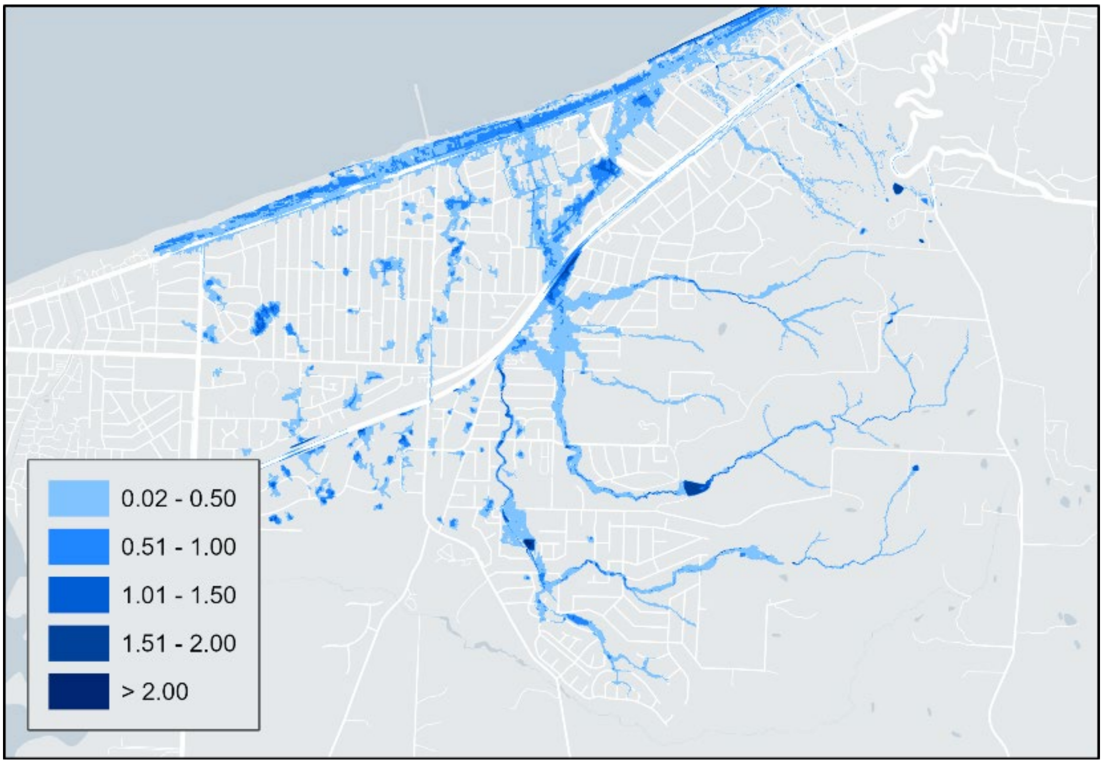



Figure 3. Melbourne Water Flood Depth output for Rosebud area in Mornington Peninsula in 2100 using a 18.5% forcing on current rainfall intensities

For both extent and depth data inputs, council led and managed flood mitigation structures and strategies are not accounted for in the data product. Unless this has been initially accounted for and modelled in the data layer, there may be uncertainty in areas where localised actions are mitigating likely flood damage.

## Defining Residential areas

The main focus of this project is to identify the likely impact of flooding on residential housing stock. There are residences which will not be affected by flooding, and conversely there are properties affected by flooding which are not residential. The initial phase of this project is to confine the focus area to these relevant residential areas and inundation zones, reducing the number of houses that are assessed.

Without access to building footprints, housing archetypes and the flood damage were estimated at a parcel level. Due to data sensitivity and uncertainty in archetype assignation, the final results presented are summarised to an SA1 level.

*Residential areas* within the AOI are defined by creating a residential overlay comprised Planning Zone data, as well as the Victorian Land Use Information System (VLUIS), to account for housing in rural areas, on farms or large lots which aren't accounted for in the Planning Schemes, which mostly identify Residential as more built up areas. Table 1 outlines the categories used to create the residential overlay and Figure 4 spatially represents this in the project area.

Table 1. Zone Codes and Land use Codes used to determine Residential Areas

[1] VLUIS makes use of a three-tier hierarchy, for residential, the top tier for all residential lots was used

| Data Source | Code | Description |
|---|---|---|
| Vicmap Planning Zones | ACZ | Activity Centre Zone |
| | GRZ | General Residential Zone |
| | LDRZ | Low Density Residential Zone |
| | MUZ | Mixed Use Zone |
| | NRZ | Neighbourhood Residential Zone |
| | RLZ | Rural Living Zone |
| VLUIS [1] | 1 | Residential |

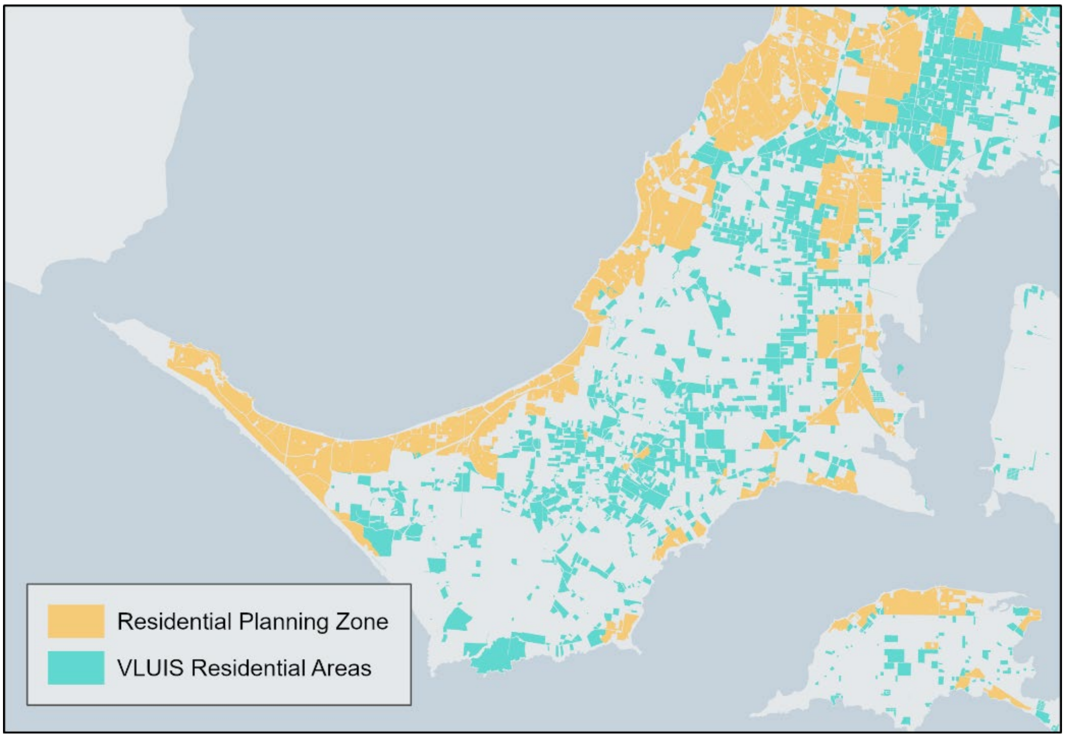



Figure 4. Designated residential areas in the Mornington Peninsula area

Property parcel boundaries were used as the minimum unit to assess housing archetypes and flood damage. A complete set of *Residential parcels* were derived by selecting all parcels within the residential overlay. The to derive impacted residential parcels, parcel that intersected with the flood extent are extracted into a secondary dataset, as seen in Figure 5.

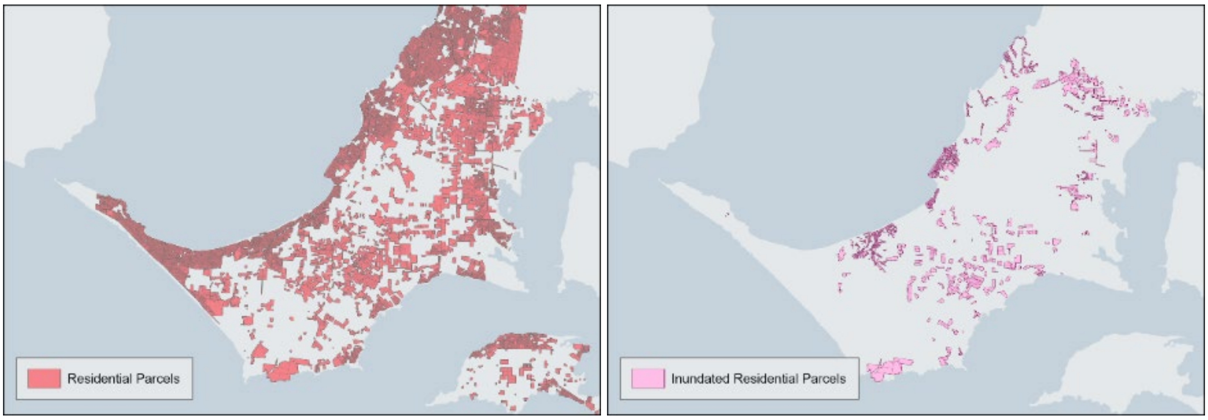



Figure 5. Selected residential parcels (left panel) and parcels that intersect with flood extent (right panel)

SA1s which contained inundated residential parcels were also produced, defining the focus area for further analysis. These SA1s are divided into two analysis areas; one where flood depth modelling data is present, and an estimation could be made of the actual flood damage inflicted upon properties. In areas without flood depth information, the simple flood extent polygon is used. These separations are shown in Figure 6. Both areas follow the same basic framework of analysis, especially in terms of determining housing archetypes. The distinction between the two is outlined in section 3.3.

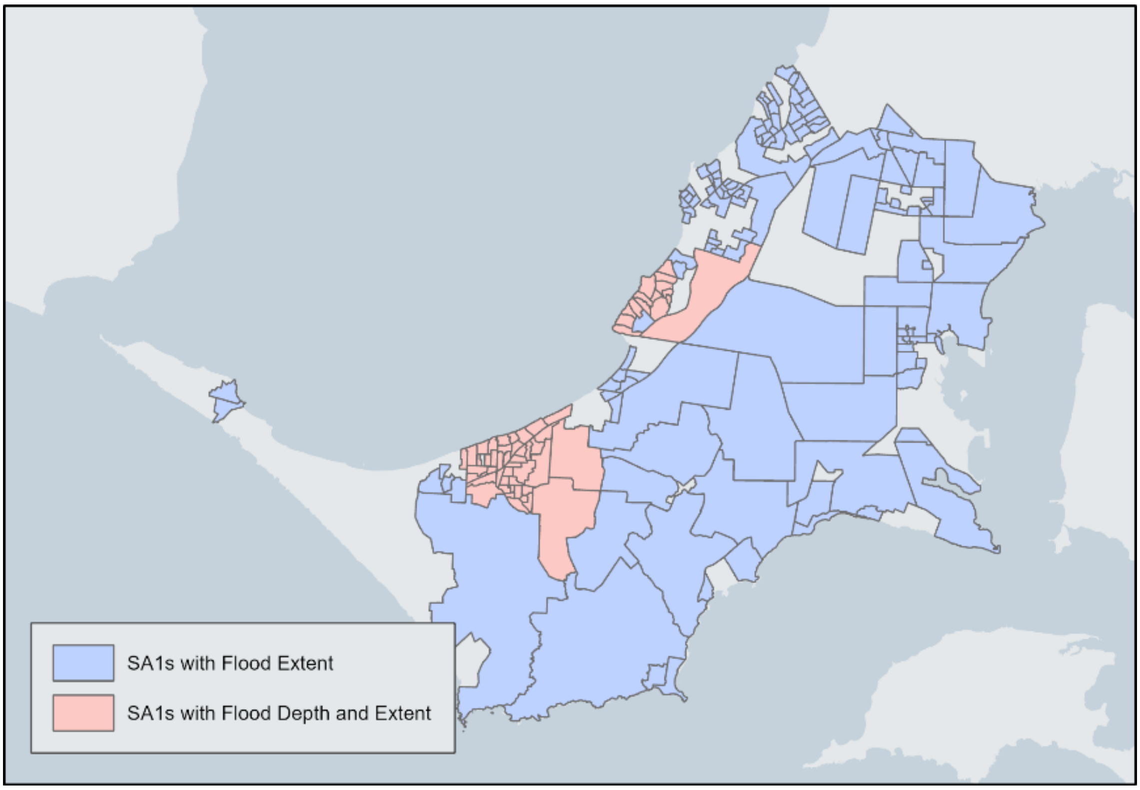



Figure 6. SA1 regions in Mornington Peninsula and availability of flooding data for analysis

## 4.2. Housing Archetype and Attribution

Building on the review from Stage 1, relevant housing archetypes are shortlisted for the SECCCA area. It is noted that the already constructed archetypes are for non-Victorian regions, but there can be similarities that can be applied in the SECCCA area.

The full archetype list and details are provided in Appendix 1

Key resources used in determining base level housing archetypes are from previous work undertaken by Geoscience Australia and other consultancies, as noted in Section 2. These include;

- Geoscience Australia building vulnerability functions and Residential Flood Vulnerability Categorisation Schema
- What We Build, Where We Build

Other resources were also used to gain a deeper understanding of trends in residential architecture in Victoria over time, such as *What House Is That?* (Heritage Council Victoria).

### Random sampling of housing stock

Archetypal trends in the region were determined by recording Street View images for a random sample of residences in the focus area and corresponding these with information from local council rates databases such as year of build, and build materials.

In order to gain an understand of the general trends of the housing stock within the focus area, a random sample of residences was taken (Figure 7).

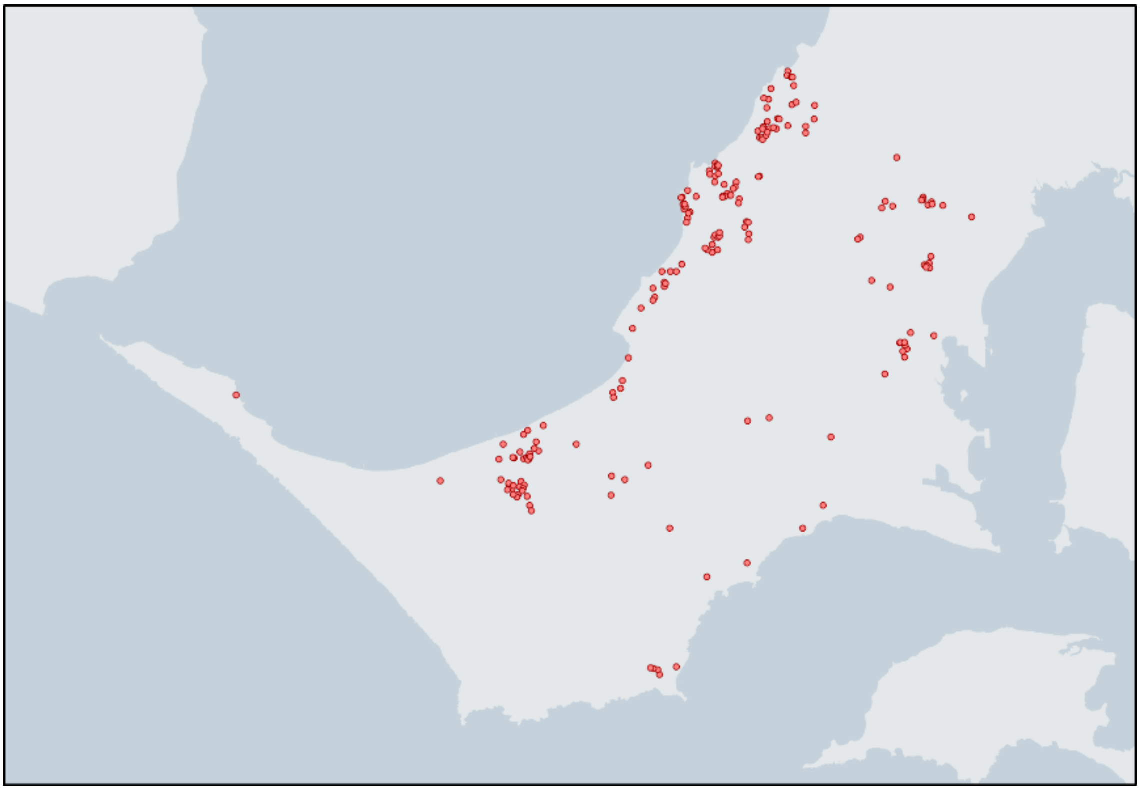


Figure 7. Random sample of housing residential parcels in Mornington Peninsula

100 random points were generated per SA1 within the focus area, and a random subset of 1000 points was taken from that and ordered randomly. This sample of points was used to build a sample of residences. A field containing a Google Maps link was generated using the latitude and longitude of these points, and each location in the dataset was visited in the GIS environment and on Google Maps. If the nearest property appeared to be residential then an image from Street View was recorded in a spreadsheet. This is demonstrated below in Figure 8.

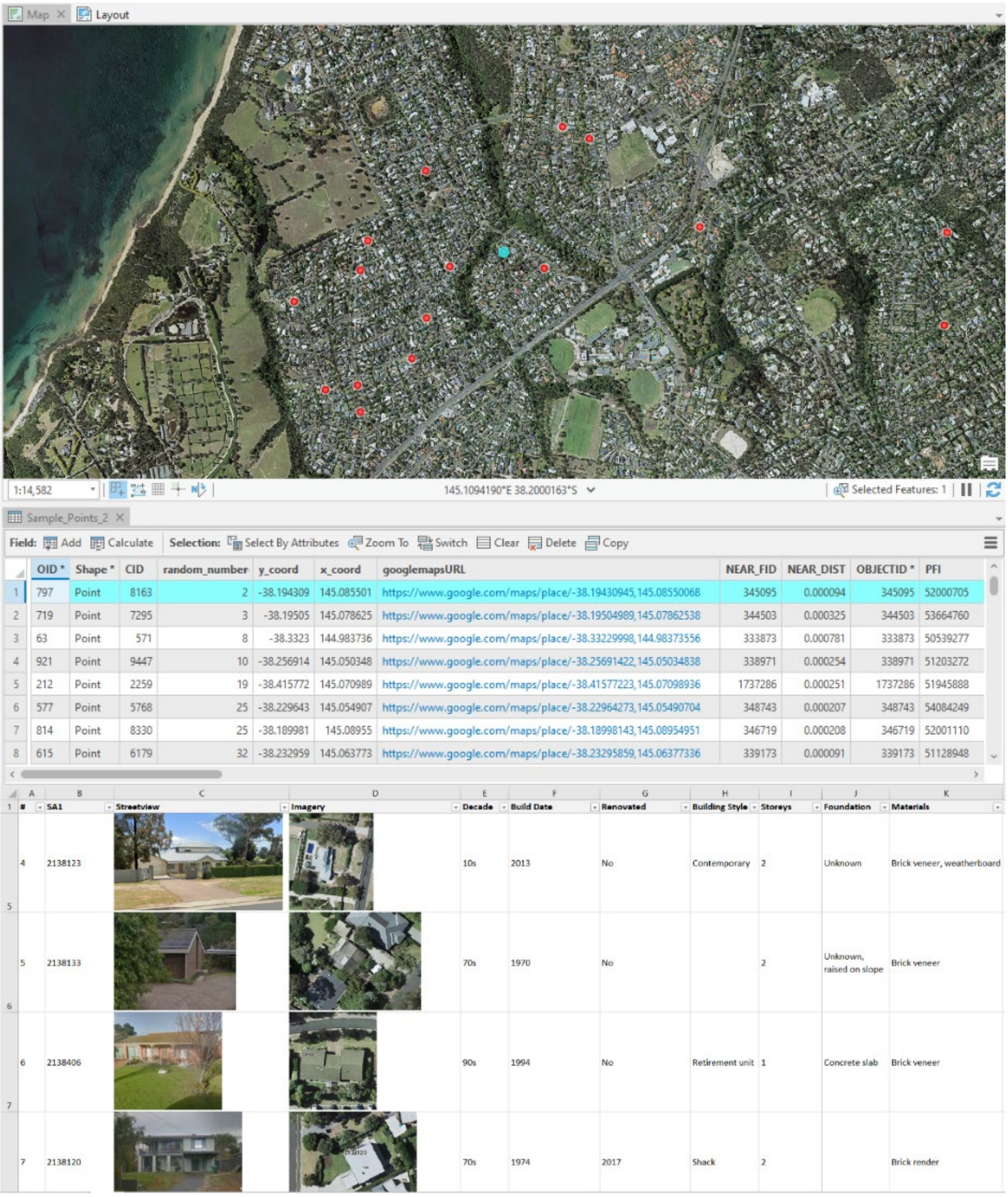



Figure 8. Example of randomised points and corresponding Google Street View for those points

## Application of Council Rates to Determine Archetype

These house images were then joined back to and attributed with council rates valuation information such as Build Year and Build Materials, as well as informal observations such as number of storeys, house style and foundation type/floor height estimation where possible.

These observations were used to identify patterns between visual style, build year and materials, allowing a shortlist of archetypes to be generated. The archetypes derived for the Mornington Peninsula flood affected area are shown in Figure 9.

| Name | Description | Year Built | Materials |
|---|---|---|---|
| Mid-Century Brick Veneer | Standard brick veneer house | 1960 - 1989 | Brick Veneer |
| Modern Brick Veneer | Standard brick veneer house | 1990 - Current | Brick Veneer |
| Modern House | Modern house that appears slightly more modern and contemporary than brick veneer, less prefabricated | 1990 - Current | Brick Render |
| Contemporary House | Architecturally designed modern house | 1990 - Current | Concrete Render, Concrete, mixed materials? |
| Beach Shack | Prefabricated or made form cheap materials such as fibre cement, sometimes weatherboards. Can be 2 storey, usually slightly raised off the ground if single storey. Floor to ceiling windows | 1940 - 1999 | Fibre Cement; Hardiplank; Cladding; Weatherboard (sometimes) |
| Pre-War | Anything made 1939 or previous. Obviously there is a diverse range of architectural styles in this time frame, but there are so few in the study area that it is not worth categorising. | Pre 1940 | Varies. Weatherboard; Stone; Brick etc. |
| Modern Weatherboard | | 1990 - Current | Weatherboard |
| Mid-Century Modern | Similar to contemporary house, but built pre 1990. Mainly following design trends of 1950s-70s. Geometric shapes, mixed materials and floor to ceiling windows are common. | 1950 - 1989 | Varies? Usually a mixed materials |
| Mid-Century Weatherboard/Bungalow | | 1940 - 1989 | Weatherboard |

Figure 9. Shortlist of housing archetypes

In order to apply these archetypes to flood affected housing stock, council rates information for all inundated residences was compiled to a pivoted spreadsheet. This data was then grouped into totals for each possible combination of build materials and build decade, as shown in Figure 10. This figure provides an example of determining the most common impacted archetypes within a given SA1. Not only does this allow for easier summation back to the SA1 geographic boundary, but it also provides a quick snapshot of impacted housing types across a region.

Once sorted into the most prevalent combinations in the region, these combinations could be assigned to a particular archetype.

This is straightforward to apply for the most common categories – for example 'Brick Veneer, 1970s' is clearly *Mid-Century Brick Veneer*. However, the further down the list the more uncertain combinations become, especially in multi-material housing stock. For uncertain categories, these have been reviewed by visiting a random sample of ten or so properties with these attributes on Google Street View, to determine if an archetypal trend could be identified.

For example, the combination 'Brick Veneer, Weatherboard, 2000s' led to confusion as to whether this might more fit the general build style of a weatherboard house or a brick veneer house, or a totally different archetype. Within a GIS environment, a selection was used to identify the houses in the region with these properties. From that selection, 10 houses were randomly chosen, and examined on Google Street View. Eventually enough of a sample was built up to say relatively confidently, that most houses with this combination appear to fit more into the *Modern Brick Veneer* archetype.

| SA1 by Archetype | Count |
|---|---|
| **2137702** | **165** |
| Brick Veneer; 1990s | 93 |
| Brick Veneer; 2000s | 33 |
| Brick Render; 1990s | 10 |
| Brick Render; 2000s | 7 |
| Brick Veneer; 2010s | 6 |
| Weatherboard; 2000s | 2 |
| Hardiplank; 2000s | 2 |
| **2137703** | **46** |
| Brick Veneer; 1990s | 17 |
| Brick Render; 2000s | 15 |
| Brick Veneer; 2000s | 12 |
| Brick Render; 1990s | 2 |
| **2137704** | **320** |
| Brick Veneer; 1980s | 53 |
| Fibre Cement; 1970s | 27 |
| Fibre Cement; 1960s | 26 |
| Brick Veneer; 1970s | 21 |
| Brick Veneer; 2010s | 19 |
| Brick Veneer; 1990s | 18 |
| Brick Render; 2000s | 12 |
| **2137708** | **195** |
| Brick Veneer; 2010s | 44 |
| Brick Veneer; 1980s | 17 |
| Brick Render; 2010s | 16 |
| Brick Render, Brick Veneer; 2020s | 11 |
| Brick Veneer, Weatherboard; 2010s | 10 |
| Brick Veneer; 2000s | 9 |
| Concrete Block; 2000s | 9 |
| **2137711** | **45** |
| Brick Veneer; 1980s | 7 |
| Cladding; 2010s | 5 |
| Brick Render; 2010s | 3 |
| Brick Veneer; 1990s | 3 |
| Brick Veneer; 1970s | 2 |
| Brick Render; 1990s | 2 |
| Weatherboard; 1980s | 2 |
| **2137714** | **2** |
| Weatherboard; 2000s | 1 |
| Brick Veneer; 1970s | 1 |
| **2137716** | **357** |
| Brick Veneer; 2000s | 101 |
| Brick Veneer; 2010s | 64 |
| Brick Render; 2010s | 41 |
| Brick Veneer; 1980s | 24 |
| Brick Veneer; 1990s | 22 |
| Brick Veneer; 1970s | 16 |
| Concrete Block; 2000s | 10 |
| Brick Render; 2000s | 9 |

| SA1 by Archetype | Count |
|---|---|
| **2137717** | **16** |
| Brick Veneer; 1980s | 3 |
| Weatherboard; 1990s | 2 |
| Brick Veneer, Weatherboard; 2010s | 2 |
| Weatherboard; 1980s | 2 |
| Brick, Weatherboard; 1980s | 1 |
| Hardiplank; 2000s | 1 |
| **2137801** | **59** |
| Timber; 2010s | 6 |
| Weatherboard; 2000s | 5 |
| Weatherboard; 1980s | 5 |
| Brick Veneer; 1970s | 4 |
| Brick Veneer; 2010s | 4 |
| Cladding; 2010s | 4 |
| Weatherboard; 2010s | 3 |
| Brick Render; 2010s | 2 |
| Brick Veneer; 1980s | 2 |
| Weatherboard; 1970s | 2 |
| Weatherboard; 1990s | 2 |
| Brick Render; 1970s | 2 |
| Brick Veneer, Weatherboard; 1980s | 2 |
| **2137802** | **39** |
| Brick Veneer; 1990s | 6 |
| Stone; 2000s | 3 |
| Weatherboard; 1990s | 3 |
| Weatherboard; 2000s | 3 |
| **2137803** | **108** |
| Brick Veneer; 1980s | 7 |
| Weatherboard; 1970s | 7 |
| Brick Veneer; 1990s | 6 |
| Weatherboard; 1990s | 4 |
| Weatherboard; 1950s | 4 |
| Weatherboard; 2010s | 4 |
| Brick Veneer; 1970s | 4 |
| **2137804** | **13** |
| Brick Veneer; 1980s | 2 |
| Weatherboard; 1990s | 2 |
| Brick Veneer; 2010s | 1 |
| Fibre Cement; 2000s | 1 |
| Fibre Cement, Weatherboard; 1950s | 1 |
| Brick, Concrete, Timber; 2020s | 1 |
| **2137808** | **2** |
| Weatherboard; 1940s | 1 |
| Brick Veneer; 1970s | 1 |
| **2137810** | **10** |
| Brick Veneer; 1980s | 3 |
| Weatherboard; 2000s | 2 |
| Weatherboard; 1890s | 1 |

Figure 10. Example application of archetypes back to housing stock

Sometimes, it is not possible to confidently apply an archetype to a build type, due to inconsistency in visual appearance. In this case, they can be marked as ‘No Archetype’.

As this data is at a parcel level and results would be aggregated up to an SA1 level, it is also important divide combinations by SA1 and filter to the most common 5 archetypes, in order to ensure that the most common combinations within each SA1 are accounted for.

Once a sufficient number of combinations of build materials and decade have been assigned an archetype, the archetypes can be applied back to the GIS environment. Figure 11 shows the result of inundated residential parcels by their most likely housing archetype in the Rosebud and McRae area in Mornington Peninsula.

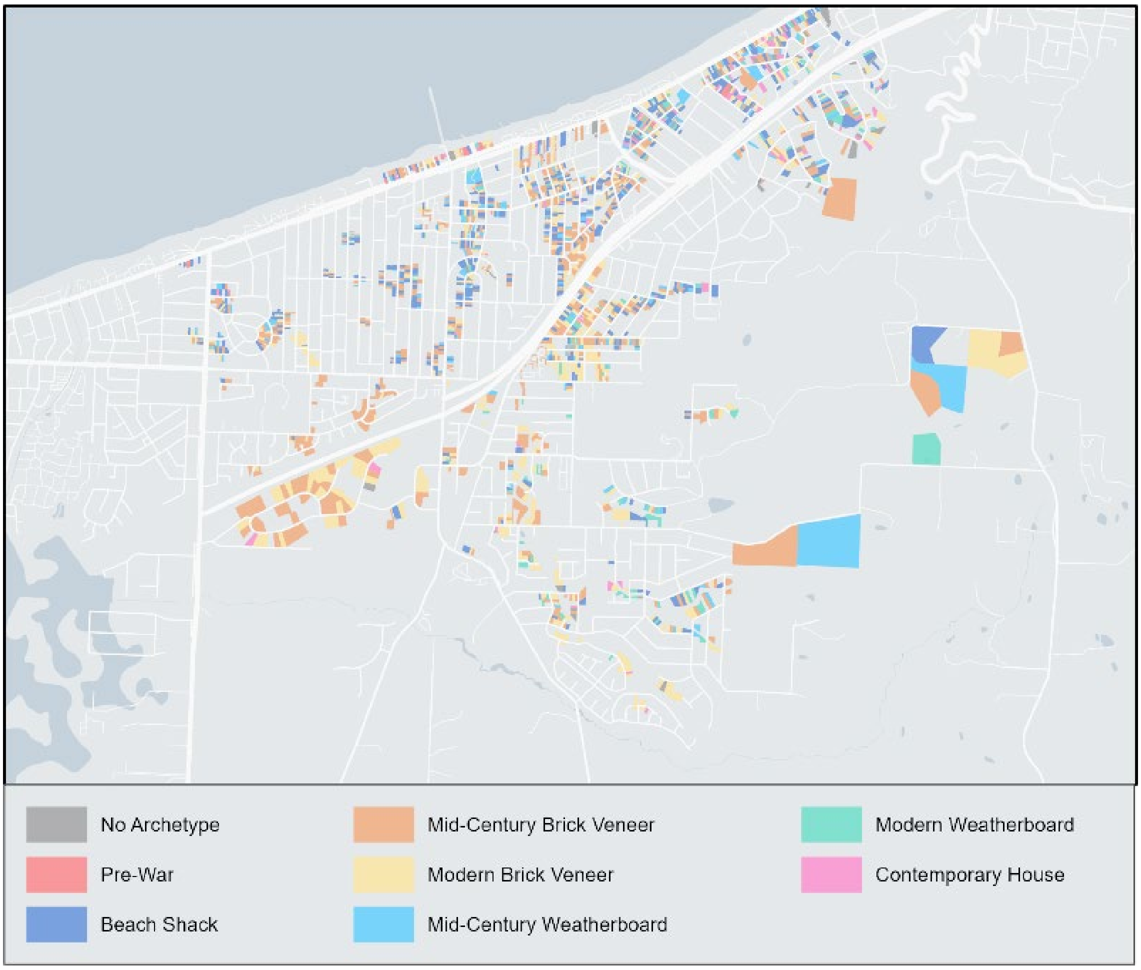



Figure 11. Hosing archetypes as applied back to parcel in the Rosebud region

### Floor Height

One notable gap in the council rates database was floor height. In the assessment of the supplied Mornington Peninsula Rates Database, there was no value for floor height.

To infill this and provide an estimation, for each archetype an estimated range was determined (refer to table 2 and appendix 1 for details). This was assessed via the Street View archive built during the previous steps and estimated from visible properties where a floor height could be seen. From this image archive, a random selection was assessed where the front, or a side, of the house was visible and then height was estimated.

It is noted that the triangulation and height estimation process can be an approximation at best.

The outcome for each archetype is an estimated range of heights that a house is likely to have. There may be outliers, but it is hoped that the majority of property types will fall within the range.

The assumption in this process of using a random sample of Google Street View images to assess floor height is that;

- All houses in the archetype grouping will fall within the floor height range
- There is no variation in a given property of floor height, i.e., there is no varied or multi-height slab

- There is no slope or elevational difference in the property that may alter floor height in relation to ground

### Building Footprint

In relation to the building footprint, two key points of data is potentially required for a full analysis. This includes;

- Floor area
- Building location in a parcel

The floor area for parcels was available for a range of parcels within the rates database. But this was not consistently provided for all impacted properties. Floor area is a useful point of information once an impact assessment and damage values are determined. It is required to calculate damage values in terms of dollars cost.

Similar to floor height, a range of floor areas, per archetype can be determined. This will allow for a scenario setting exercise to be done per archetype. Also, this can be done against the range of floor heights as well.

Also, as noted, building location can also be used in the full analysis. As indicated, the flood extent is used against a property parcel to select out impacted parcels. However, this selection is arbitrary in that a potential flood may cross a parcel boundary but never actually reach a building. This is particularly true of large parcels in rural settings or parcels that back onto a creek or river line.

To cover the analysis outputs based on this assumption, the process can be done to a range of values and calculations for potential flood damage. Application of flood depth to potential damage are outlined below in the following section. But broadly, using flood depth as input, we can process damage values to either a maximum, minimum or average flood depth per parcel.

Alternately, to simulate a building location, the analysis can be applied to a parcel centre. That is, if a flood extent crosses a parcel centre, then the full analysis is to be run.

Lastly, within a parcel the slope of the land is not taken into consideration. When running the analysis, a parcel is considered flat. Hence, two comparable impacted parcels of similar size, archetypes and with similar flood depths will have similar damage values. But if one parcel is on the side of a hill, or has a slight lean, its analysis output should be different. This is also further compounded if the actual building location is on a slope within a relatively flat parcel.

For a more accurate assessment slope should be considered within a parcel. However, it is noted that both flood extent and depth products have been built upon hydrological understandings. Therefore, slope as a link to drainage and flow would potentially be incorporated into the products.

### Renovation Outcomes

Within the rates database, renovation details and dates were explored. This was in order to provide assessment of houses renovated post 2005 that must be upgraded in total to new building standards.

It has been put forward that for each housing archetype, post 2005, that a ‘variant’ status can be applied where renovations are applicable. This, in relation to impact assessments on flood, fire and storm, can apply a new building or material standard that can mitigate certain impacts.

In assessment of renovation details against archetypes, all non-structural upgrades (e.g., decks or sheds) were excluded. The remaining properties with an applicable renovation were then split into pre and post 2005. What was discovered, for the Mornington Peninsula Council area data, that each archetype had a significant amount of properties that could be found in either category.

Hence, the concept of a variant archetype can be applied against each of the established archetypes. For the application in this study, this is to be noted but it will not be reapplied. For further impact assessments and finding reports into risk, this finding should be noted and applied into any outcomes where necessary.

## 4.3. Vulnerability Profiling and Damage Curve Assessment

This stage involves investigation of vulnerability profiles for each of the defined housing archetypes. This, as with Stage 3, is leveraged from prior studies, building on these using the defined housing archetypes for this area of study. This was again calculated to the parcel level, and would by summarised by SA1 in a later stage.

The overall workflow of determining a damage value for a parcel is outlined in Figure 12.

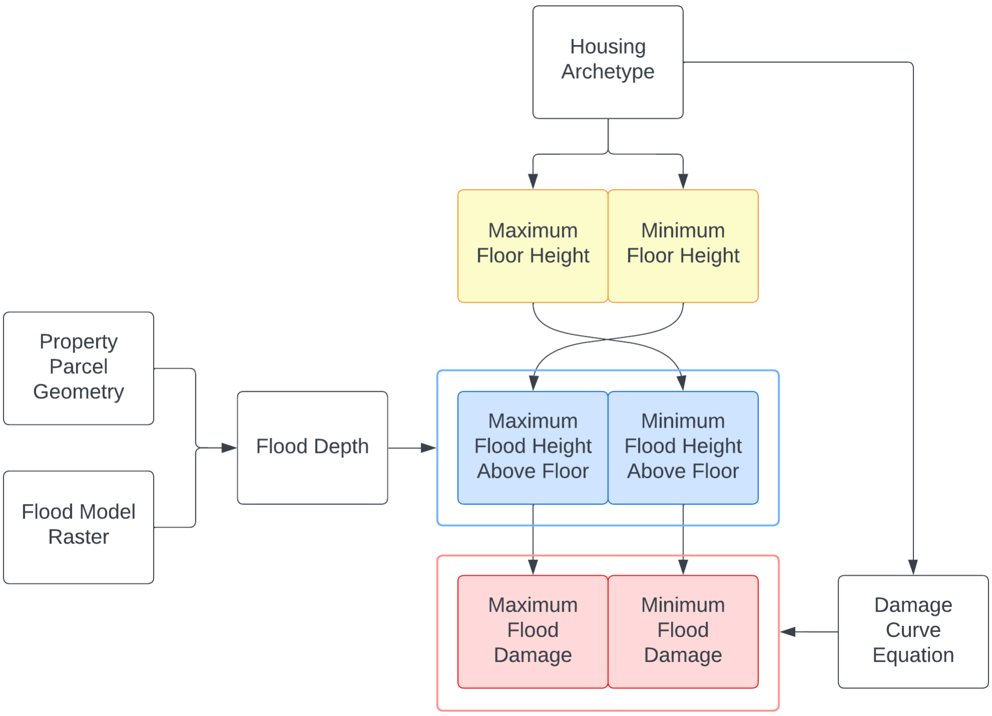



Figure 12. Damage curve assessment application workflow

Without the resources to build a reliable damage curve for the defined archetypes from scratch, the Geoscience Australia Flood Vulnerability Models was used as a guide. Each of our archetypes for our area of study was matched up to the most similar archetype outlined by Geoscience Australia (GA). The damage curve for that matched archetype was applied to our SECCCA-based archetype. The linking and mapping of the SECCCA archetypes to the GA damage curves has been verified by the project knowledge committee for use in this analysis.

All damage curves initially have been sourced from Geoscience Australia's "*Building vulnerability functions and Residential Flood Vulnerability Categorisation Schema – Flood Vulnerability Models for*

*Australian Buildings"* (Geoscience Australia, 2019). This is a collection of housing archetypes and corresponding vulnerability damage curves in relation to flooding exposures and depth of flood.

An example curve for one of the developed archetypes is seen in Figure 13.

These damage curves, per archetype are detailed in Appendix 1 alongside each associated house archetype.

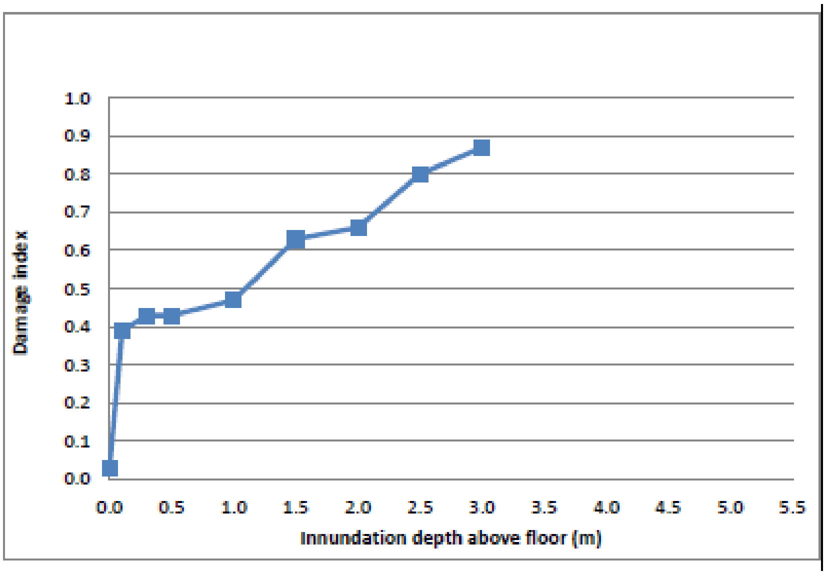



Figure 13. Damage curve example

A damage curve is a representation of relative damage to a dwelling at a given flood depth. In the diagram, significant damage, at a relativity of 0.4, occurs with only a small volume of water above floor height and it is essentially the same amount of damage through to a depth of 120cm above floor height. Therefore, it can be the case where it doesn't matter if the flood is 20cm or 120cm, the damage will be principally the same. However, above 1.2m, the potential damage does increase significantly.

The flood damage index values are a product of the flood's maximum height above floor level of a building. For our purposes, the floor height above ground of a building is required to determine this, however this data is not readily available from council property information data. An estimation of the minimum and maximum possible floor height range was made for each archetype, based on our experience from evaluating Street View images in the study area. The floor height ranges used in our analysis are shown below in Table 2.

Table 2. Default estimation floor height range per archetype

| Archetype | Minimum Floor Height (m) | Maximum Floor Height (m) |
|---|---|---|
| Pre-War | 0.5 | 0.8 |
| Mid-Century Brick Veneer | 0.3 | 0.8 |
| Modern Brick Veneer | 0.2 | 0.5 |
| Mid-Century Weatherboard | 0.4 | 0.8 |
| Modern Weatherboard | 0.4 | 1.0 |
| Contemporary House | 0.2 | 0.6 |
| Beach Shack | 0.2 | 1.0 |

Using these floor height ranges, a damage value range would be derived, based on the minimum and maximum estimated flood height above the floor.

The flood depth that would be used for each parcel was determined by using the Zonal Statistics tool to calculate the *maximum* value of the flood depth raster inside the boundaries of the parcel polygon.

The minimum and maximum flood height above floor was calculated by subtracting the min and max floor heights from the derived flood depth value. These heights were then entered into the relevant damage curve equation, resulting in a minimum and maximum Flood Damage Value for each inundated residential parcel. In Figure 14 the maximum damage index risk rating is shown for the Rosebud area in the Mornington Peninsula area.

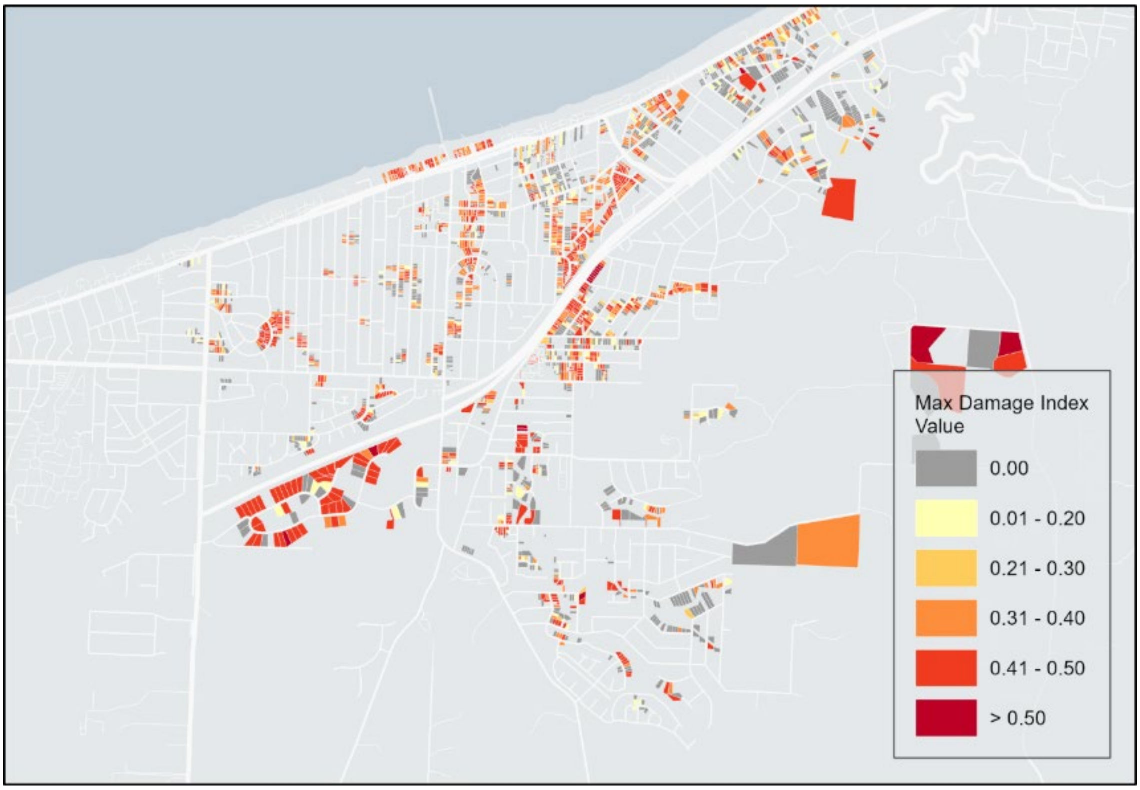



Figure 14. Application of damage curve risk rating for Rosebud area

## Assessments to Account for Building Location

As described above in Section 3.3, building location is not accounted for in the analysis. Therefore, the maximum and minimum floor heights applied back against the damage curve for the maximum and minimum flood damage index values relates back to the whole parcel.

To open the assessment up and apply a broader range of scenarios and sensitivities in the analysis outputs, various metrics can be applied. As current and as described above, a maximum value of the flood depth inside the boundaries of the parcel is presented. However, other values derived can be the average or minimum value of flood depth.

Also, to simulate a building location within a parcel, a parcel centre can be applied to capture flood depth. That is, if a flood extent crosses the parcel centre then the analysis is to be run on the relevant flood depth information.

## 4.4. Summary to SA1

In order to de-identify and protect the anonymity of sensitive property level data, the results gained from previous stages were summarised at an SA1 level for final output. Table 3 below outlines the summary statistics attributed to the SA1s.

Table 3. Summary table of SA1 statistics, including attribute values and descriptions

<table>
<tr><th>Attribute Value</th><th>Description</th></tr>
<tr><td>No Archetype</td><td>A count of how many inundated residential parcels within the SA1 could not be classified into an archetype</td></tr>
<tr><td>Beach Shack</td><td rowspan="7">A count of how many inundated residential parcels within the SA1 were classified into each archetype.</td></tr>
<tr><td>Contemporary House</td></tr>
<tr><td>Mid-Century BV</td></tr>
<tr><td>Mid-Century WB</td></tr>
<tr><td>Modern BV</td></tr>
<tr><td>Modern WB</td></tr>
<tr><td>Pre-War</td></tr>
<tr><td>Total Residential Parcels</td><td>Number of total residential parcels (both flood-affected and not flood-affected)</td></tr>
<tr><td>Total Inundated Parcels</td><td>Number of total residential parcels which intersected with the flood extent</td></tr>
<tr><td>Total Damaged Parcels</td><td>Number of total residential parcels which returned a non-zero flood damage value</td></tr>
<tr><td>Most Common 3</td><td>The top three most common archetypes in the SA1. Left as null if inapplicable.</td></tr>
<tr><td>Overall Mean Max</td><td>The average maximum flood damage value of all Inundated Residential Parcels in the SA1, not including those which returned a zero for Flood Damage</td></tr>
<tr><td>Overall Mean Min</td><td>The average minimum flood damage value of all Inundated Residential Parcels in the SA1, not including those which returned a zero for Flood Damage</td></tr>
<tr><td>Archetype (1, 2, 3)<br>Mean Max and Min</td><td>The average maximum and minimum flood damage value for the three most common archetypes, not including those which returned a zero for Flood Damage</td></tr>
</table>

Using the parcel level analysis on archetypes and damage curve application, results per parcel are summed or averaged out per SA1.

For housing archetypes, the most common 3 archetypes per SA1 have been determined per area. This is up to three per boundary, if there is only two or less per SA1, then the remaining categories are left blank. Also, this is only applied back to SA1's that have parcels that are intersected by a flood extent area. Those SA1's without any impacted parcels are not included in this analysis.

Figure 15 provides a spatial example of this by detailing the most common archetype per SA1 for the Mornington Peninsula area.

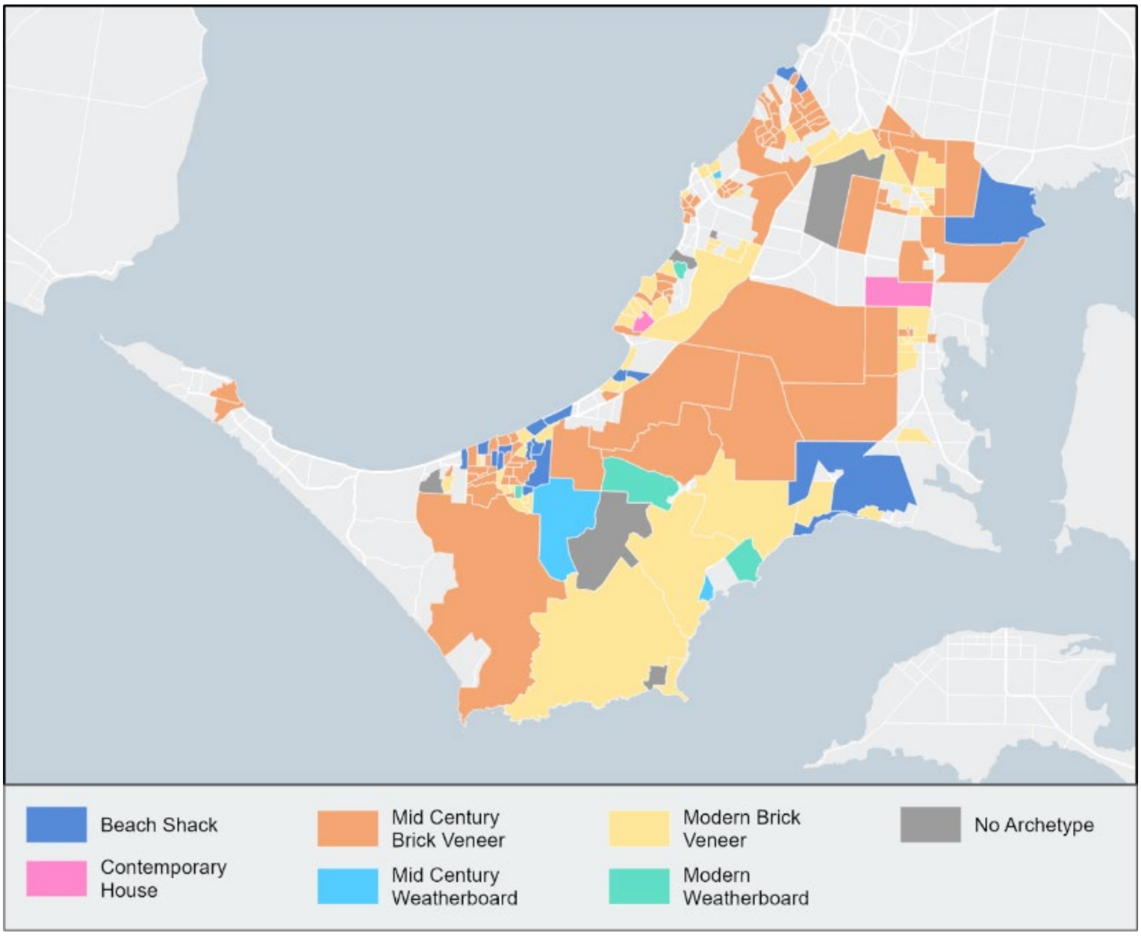



Figure 15. The most common archetype per SA1 in the Mornington Peninsula

Also included in the SA1 descriptions are :

- counts of parcels,
- counts of parcels impacted by flood, and
- counts of parcels where flood exceeds the minimum floor height.

For parcels where the likely flood depth is set to exceed the minimum floor height the potential damage curve value and applied risk is summed back into the SA1. This is either by providing the average maximum damage curve value or average minimum damage curve value. Due to the application of a floor height range, the application of flood depth to damage curves can either provide a minimum or maximum value. When applying this back to the SA1, these max and min values are averaged out.

The below map in Figure 16 details the average maximum damage value per SA1. This relates more so to the higher flood depths and damages.

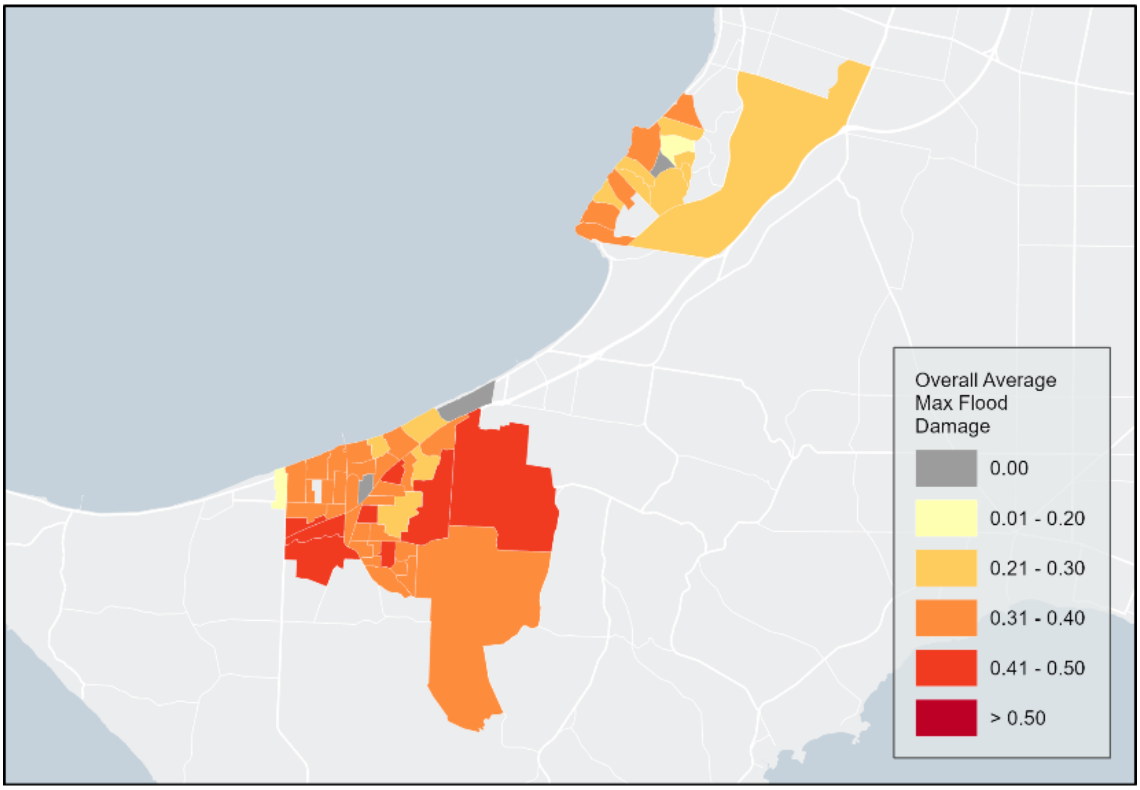



Figure 16. Average maximum flood damage per SA1 for the Rosebud and Mount Martha areas

### Missing or Incomplete Flood Depth Assessments

The above assessment methodology outlined has been formulated principally on if there is flood depth information available for a given area. Where there is no flood depth information available for an area which is likely to be impacted by a flood, a more generic approach can be applied.

As outlined in Section 3.2, there are a number of parcels that can intersect the flood extent layer, but not by the flood depth layer. To cover the areas where there is a paucity of data, flooding scenarios can be applied. That is a flood depth can be assumed for the impacted parcel and SA1 where extent is seen to impact and then run a damage value index sensitivity test on the various set flood depths to estimate a range of likely values.

Based off the various archetypes, floor heights and damage curves, it is suggested to run this to flood depths above surface level of 25cm, 45cm, 65cm and 100cm.

Outputs produced are for all SA1s that have impacted parcels, per archetype for the various floor height ranges done to each flood depth scenario.

## 4.5. Model Assumptions and Caveats

In each of the above sections each of the modelling assumptions and caveats to analysis and application have been detailed. Broadly these have covered;

**Floor height for archetypes** (Section 4.3)

- All houses in the archetype grouping are assumed fall within the floor height range

- There is no variation in a given property of floor height, i.e., there is no varied or multi-height slab
- There is no slope or elevational difference in the property that may alter floor height in relation to ground

Building location and footprint (Sections 4.3 and 4.4)

- There is no consistent application and measurement of building floor area per parcel, so it has been omitted from analysis
- There is no provision of building footprint location within a parcel. Therefore, analysis on flood impact is at the parcel level, not to the building location.
- Using flood depth as input, we can process damage values to either a maximum, minimum or average flood depth per parcel, or
- to simulate a building location, the analysis can be applied to a parcel centre.
- Within a parcel the slope of the land is not taken into consideration. When running the analysis, a parcel is considered flat

Renovation considerations (Section 4.3)

- For each archetype, there was a significant amount of properties that have had renovations.
- Therefore, an archetype can fall within a standard archetype and a renovated variant archetype that are updated to new building standards.
- In output analysis to the SA1 level, this finding should be noted and applied into any outcomes where necessary.

Incomplete flood depth data for SECCCA study region (Section 2.3 and 4.5)

- Flood depth is only available for certain water basins and is seen to not cover the full coverage of the 1 in 100-year flood extent layer as provided by Melbourne Water
- This is only available for one modelled projection of flood depth, that is not related directly to a climate change model, rather a rainfall intensity forcing per basin.
- No Council managed flood mitigation structures or overall strategies have been accounted for in these data products, unless considered during product creation. The data has been applied as supplied

Scenario setting for incomplete flood depth regions (Section 4.5)

- To account for incomplete flood depth coverage, flood extent was used as a proxy.
- A series of flood depth scenarios were set and analysed to the respective archetypes and damage curves.
    - 25cm, 45cm, 65cm, 100cm

# 5. Project Outputs

## 5.1. Housing Archetype Outputs

Across the five participating council areas for each parcel, an archetype was assigned and then aggregated backup into the SA1 geography. For each council the most common archetype in a given SA1 that has an intersection with the 1/100-year flood extent is;

- Bass Coast: Beach Shack
- Bayside: Modern Brick Veneer
- Frankston: Mid Century Brick Veneer
- Kingston: Mid Century Brick Veneer
- Mornington Peninsula: Modern Brick Veneer

A map view of this most common Archetype, by SA1, is presented in Figure 17. As noted, only SA1's that have residential parcels that may be potentially impacted by a flood extent are shown in this figure and any area denoting no archetype are those without any intersecting residential parcels.

The most common by SA1 for each LGA are the Brick Veneer type houses, either Mid-Century or Modern. This is the majority housing archetype within the Frankston LGA, with a greater mix found in the other LGAs. The dominance of archetypes by location within and across Councils can also be seen. For example, in the Mornington Peninsula, and Bass Coast to a lesser degree, Beach Shack archetypes are seen in coastal areas. Another unique clustering is found in the Bayside region where Pre-War archetypes are more dominant, alluding to more established housing types that are dominant in the area.

This trend continues in an assessment of the second most common archetype. Although not presented, the second most common over most Councils are Modern Brick Veneer.

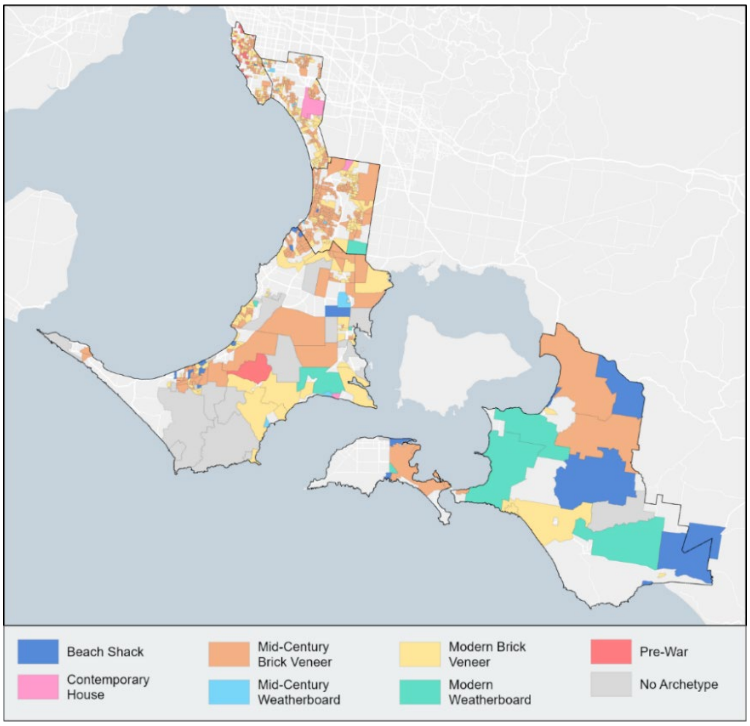



Figure 17. Most common archetype by SA1 in the participating Council areas.

## 5.2. Flood Damage Analysis

Outlined in the prior Section were a number of limitations on the data and a list of assumptions and caveats. This is extended into the application of the data and the scenarios developed. Due to the aggregation to SA1 scales and the setting of depth scenarios to extent modelling, this analysis in scenario based only and is more so relevant for planning and intel purposes as opposed to detailed parcel level disclosure of climate risk.

Following the creation of housing archetypes by parcel, determination of parcels that may potentially be impacted by a flood and then aggregation of parcel counts to the SA1, the next stage is application of flood depth, either actual or assumed scenario depth. This involves applying an archetype damage curve that has been assigned to each archetype.

As initially presented in Section 4.3, Figure 18 below shows an example of a damage curve. All damage curves have been sourced from Geoscience Australia's *"Building vulnerability functions and Residential Flood Vulnerability Categorisation Schema – Flood Vulnerability Models for Australian Buildings"* (Geoscience Australia, 2019). This is a collection of housing archetypes and corresponding vulnerability damage curves in relation to flooding exposures and depth of flood.

Damage curves by housing archetype are also seen in Appendix 1. Also presented with these archetypes are common materials associated with each type and assumed floor heights.

These attributes are what can influence the shape of a damage curve. But for each archetype, typically at the 25-30cm inundation depth above floor level, the curve damage index jumps significantly. Afterwards it is seen to plateau until about the 1m and above height.

Significant damage, at a relativity of 0.4, occurs with only a small volume of water above floor height and it's is essentially the same amount of damage through to a depth of 120cm above floor height. Therefore, it can be the case where it doesn't matter if the flood is 25cm or 120cm, the damage will be principally the same. However, above 1.2m, the potential damage does increase significantly.

On this basis, local mitigation efforts that minimise the potential damage to properties to withstand a depth of 1.2m will limit the loss in the event of a flood. Such as concrete floors or epoxy tiles or raised power sockets. Further, more general mitigation to prevent the flood height from reaching above 1.2m will better protect the property from significant damage.

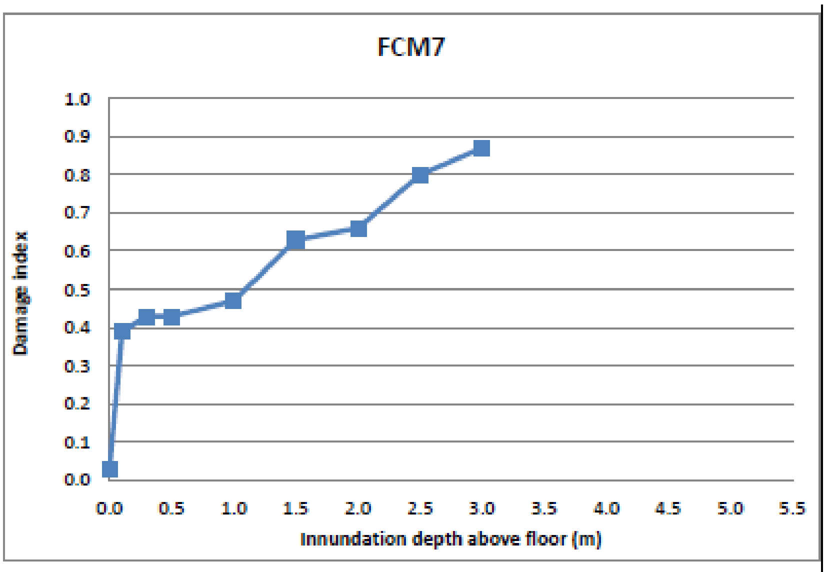



Figure 18. Damage curve example

## Flood Extent Depth Scenario Analysis

Using the housing archetypes by SA1 against the assume flood depth scenarios of 25cm, 45cm, 65cm and 100cm a summary of impacted residential areas can be prepared for each council. These findings are presented in Table 4. These scenarios are not related to a climate change related event, but make use of the 1/100-year flood extent layer as an assumed maximum flood extent in a given area.

Using the flood extent data, impacted SA1s were selected and all residential parcels were counted in the area. Those that crossed with the flooding extent were considered 'inundated' and houses that were potentially impacted by a flood depth scenario at a height above floor height were considered 'damaged'. Then using the standard damage curve, where index values range from 0 to 1, for the most common housing archetype in the SA1, an averaged damage index value was calculated.

For the columns in the table;

- The first column details the total residential parcels in the impacted SA1s that have a flood event
- The second column details the actual count of parcels that intersects a likely flood extent and potentially have an inundated parcel, but not damaged.
- The following four columns detail the total damaged parcels by assumed flood depth from surface level. These damaged parcels are those where the flood depth is seen to go above floor height and potentially cause damage to a house. This can differ per house archetype as provided through the assumed flood height range

The last four columns detail the damage index value for that given flood depth scenario applied to a housing archetype damage curve. For example, a 45cm flood applied against an archetype with a 20cm floor height will provide a 25cm inundation depth above floor height. Presented is the averaged values for the archetype in an LGA.

Table 4. Results summary table for Council areas for an assumed flood depth to height above floor level. Shown are four flood depth scenarios at 25cm, 45cm, 65cm and 100cm.

| Council / Archeytpe | Total - Residental Parcels | Total - Inundated Parcels | Total - Damaged Parcels (25cm above ground level) | Total - Damaged Parcels (45cm above ground level) | Total - Damaged Parcels (65cm above ground level) | Total - Damaged Parcels (100cm above ground level) | Damage Index - Overall (25cm above ground level) | Damage Index - Overall (45cm above ground level) | Damage Index - Overall (65cm above ground level) | Damage Index - Overall (100cm above ground level) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Bass Coast** | **5,673** | **889** | **455** | **635** | **831** | **831** | **0.18** | **0.37** | **0.40** | **0.42** |
| Beach Shack | 2,142 | 705 | 379 | 517 | 656 | 656 | 0.20 | 0.36 | 0.38 | 0.41 |
| Mid Century Brick Veneer | 1,505 | 40 | 8 | 31 | 37 | 37 | 0.14 | 0.38 | 0.41 | 0.43 |
| Modern Brick Veneer | 998 | 40 | 30 | 37 | 40 | 40 | 0.21 | 0.40 | 0.42 | 0.44 |
| Modern Weather Board | 1,028 | 104 | 38 | 50 | 98 | 98 | 0.20 | 0.35 | 0.38 | 0.40 |
| **Bayside** | **21,050** | **4,088** | **1,598** | **3,269** | **3,997** | **3,997** | **0.19** | **0.40** | **0.40** | **0.42** |
| Beach Shack | 114 | 2 | 2 | 2 | 2 | 2 | 0.20 | 0.39 | 0.41 | 0.43 |
| Mid Century Brick Veneer | 8,842 | 1,642 | 532 | 1,501 | 1,615 | 1,615 | 0.19 | 0.40 | 0.42 | 0.44 |
| Modern Brick Veneer | 8,363 | 1,825 | 915 | 1,484 | 1,772 | 1,772 | 0.21 | 0.40 | 0.41 | 0.43 |
| Pre War | 3,731 | 619 | 149 | 282 | 608 | 608 | 0.18 | 0.38 | 0.33 | 0.36 |
| **Frankston** | **40,061** | **8,848** | **2,896** | **8,755** | **8,838** | **8,838** | **0.17** | **0.40** | **0.42** | **0.44** |
| Beach Shack | 243 | 3 | 1 | 3 | 3 | 3 | 0.20 | 0.32 | 0.39 | 0.41 |
| Contemporary House | 3 | 1 | 1 | 1 | 1 | 1 | 0.21 | 0.42 | 0.43 | 0.45 |
| Mid Century Brick Veneer | 25,967 | 6,823 | 1,279 | 6,754 | 6,814 | 6,814 | 0.16 | 0.39 | 0.42 | 0.44 |
| Mid Century Weather Board | 275 | 13 | 3 | 12 | 13 | 13 | 0.11 | 0.26 | 0.37 | 0.40 |
| Modern Brick Veneer | 13,301 | 2,004 | 1,611 | 1,983 | 2,003 | 2,003 | 0.21 | 0.41 | 0.43 | 0.45 |
| ModernWeather Board | 272 | 4 | 1 | 2 | 4 | 4 | 0.21 | 0.41 | 0.39 | 0.42 |
| **Kingston** | **33,921** | **10,001** | **3,721** | **9,453** | **9,715** | **9,715** | **0.18** | **0.39** | **0.42** | **0.44** |
| ContemporaryHouse | 136 | 120 | 100 | 101 | 101 | 101 | 0.21 | 0.42 | 0.43 | 0.45 |
| Mid Century Brick Veneer | 19,250 | 5,764 | 1,048 | 5,525 | 5,640 | 5,640 | 0.17 | 0.39 | 0.43 | 0.44 |
| Mid Century Weather Board | 1,172 | 239 | 75 | 230 | 236 | 236 | 0.15 | 0.29 | 0.39 | 0.41 |
| Modern Brick Veneer | 13,363 | 3,878 | 2,498 | 3,597 | 3,738 | 3,738 | 0.21 | 0.40 | 0.42 | 0.44 |
| **Mornington Peninsula** | **28,843** | **6,881** | **3,490** | **5,667** | **6,108** | **6,108** | **0.19** | **0.39** | **0.41** | **0.43** |
| Beach Shack | 3,162 | 919 | 522 | 772 | 810 | 810 | 0.20 | 0.36 | 0.40 | 0.42 |
| ContemporaryHouse | 334 | 1 | 1 | 1 | 1 | 1 | 0.21 | 0.42 | 0.43 | 0.45 |
| Mid Century Brick Veneer | 12,642 | 2,711 | 1,015 | 2,327 | 2,468 | 2,468 | 0.17 | 0.39 | 0.41 | 0.43 |
| MidCenturyWeather Board | 579 | 61 | 23 | 47 | 54 | 54 | 0.20 | 0.32 | 0.39 | 0.41 |
| Modern Brick Veneer | 11,489 | 3,155 | 1,920 | 2,507 | 2,745 | 2,745 | 0.21 | 0.40 | 0.41 | 0.44 |
| ModernWeather Board | 462 | 28 | 7 | 10 | 25 | 25 | 0.21 | 0.41 | 0.37 | 0.40 |
| PreWar | 175 | 6 | 2 | 3 | 5 | 5 | 0.21 | 0.41 | 0.37 | 0.39 |

What can be noted in these tables is that for the majority of housing archetypes in a SA1, any flood above 25cm floor height presents a large increase in potential damage to a house, after which there is a plateauing of potential damage index values. This is particularly seen in Brick Veneer type houses and less so in Beach Shack type houses.

This is not only in relation to the flood depth but the assumed floor height range and potential intersection and inundation damage. Due to the low floor height range in most Veneer types, damage can be seen to increase sharply at the 45cm mark. Whereas Beach Shacks and Weatherboards, to a lesser extent, have a lower damage index due their higher floor height, hence less inundation and flood damage.

On average, for each LGA, there is a significant increase in potential damages from the 25cm to 45cm flood depth scenario. But in a deeper analysis, for each LGA, the Mid-Century Brick Veneer archetype exhibits the greatest increase in damage index values from the 25cm to 45cm level. The archetype that has the highest potential damage index by the 100cm mark is the Contemporary House.

**Modelled Flood Depth Analysis**

Melbourne Water modelled flood depth data was provided for a number of creek and river basins across the study area. This data only covered selected residential areas within Mornington Peninsula and Frankston LGAs. Within these Council areas, this flood depth data was not available for all the river and creek basins covered by the current 1/100 year flood extent data.

In contrast to the above results for a range of assumed flood depth scenarios, this modelled flood depth data could be applied in the impacted areas for actual modelled flood depth. This, as detailed in Section 3.3, is for a likely climate change model for the year 2100.

Table 5 presents the flood depth analysis for Frankston and Mornington Peninsula for SA1s that contained the modelled flood depth data. Presented are the total residential parcels in SA1s that have a modelled flood depth and then the total inundated parcels within those SA1's, that is those parcels that intersect a flood depth.

As noted, these findings only cover two Council areas and are only available for a few basins within these Councils. Hence, the total parcel count is considerably lower, as well as the inundated and damaged parcel counts. Nonetheless, it does provide a useful exercise and contrast if actual modelled flood depth results are available rather than an assumed level.

What can be noted in contrast to the assumed flood extent is the elevated damage index values for particular housing archetypes. The majority of Brick Veneer types have larger damage curve index values than those typically seen in the 100cm flooding scenario. In contrast, Weather Boards have only a slightly higher value in the detailed modelling as compared to the 100cm flood extent result (as shown in the summary table). Lastly, the Beach Shack damage index value in Mornington Peninsula is more similar to the 45cm flood depth scenario.

This indicates that flood depth modelling can provide a more specific or localised analysis that presents a more detailed output. A flood depth model will be more aligned to elevation and flow path in the event of a flood. This is in contrast to the extent driven scenario-based modelling that can be more generalised in the approach and outputs.

In a high-level analysis, Brick Veneer housing types that have been built in areas intersecting modelled flood depth may likely exhibit a higher damage index in likely flooding events in contrast to Beach Shacks or Weather Boards.

Table 5. Results summary table for Council areas for a modelled flood depth to height above floor level.

| Council / Archeytpe | Total - Residental Parcels | Total - Inundated Parcels | Total - Damaged Parcels | Damage Index - Overall |
|---|---|---|---|---|
| **Frankston** | **18,444** | **2,620** | **771** | **0.64** |
| Mid Century Brick Veneer | 6,948 | 1,152 | 247 | 0.64 |
| Modern Brick Veneer | 11,496 | 1,468 | 524 | 0.43 |
| **Mornington Peninsula** | **14,829** | **3,807** | **1,725** | **0.60** |
| Beach Shack | 2,718 | 525 | 229 | 0.38 |
| Mid Century Brick Veneer | 5,186 | 1,356 | 643 | 0.60 |
| Mid Century Weather Board | 105 | 5 | 3 | 0.48 |
| Modern Brick Veneer | 6,001 | 1,901 | 845 | 0.53 |

However, these results in Table 4 should be tempered with the assumption that for each scenario every property is equally impacted. Typically, during a flood the edges will have the lesser depth and central locations will have a greater depth due to movement and flow of flood waters. These scenarios assume that all properties will be impacted equally regardless of their location, which in reality is false. Total damaged parcels should be lower than what has been presented.

This is where flood depth modelling is extremely useful as it can remove assumptions in flood extent only based scenarios. But in the absence of a full coverage of flood depth across all Council areas, setting a scenario can be a useful exercise to detail potential impacts.

As outlined above, due to the aggregation to SA1 scales and the setting of depth scenarios to extent modelling, the analysis can largely be a scenario-based investigation only and is more so relevant for planning and intel purposes as opposed to detailed parcel level disclosure of climate risk.

There are no local planning controls or local flood mitigation efforts accounted for in the analysis. It is an application to the data as is and although not accounted for in the main in this analysis, climate change has a potential to increase impact and increase risk in areas not currently accounted for in local strategies.

## 5.3. Spatial Distribution of Flood Damage Index Values

Presented in Figure 19 is a spatial distribution of damages in an area within the study region. This is for a 25cm and a 45cm flood depth scenario against the common housing archetype in each the selected region. The deeper the colouration indicates a higher damage index value for those residential properties in the SA1 that have an intersection with the flood extent. A white area indicates a SA1 that has no associated dame index values or an SA1 that does not contain any potentially damaged parcels.

As a general rule the distribution of higher damage index values for a given area can largely be aligned to creek and river lines as well as low-lying coastal areas prone to storm surge or inundation events.

In this presented example, flood depth to 25cm has a negligible impact and is only denoting damage index values at or below 0.2. This is potentially a reflection on housing archetypes in this area that may have a minimum floor height at or above the maximum 25cm flood depth.

In contrast, the 45cm scenario presents higher potential damage index values. Here there is more a variation in this region where damage index values range from 0.25 in one area to 0.35-0.40 and above 0.45 in the rest of the potentially impacted areas.

The SA1s that exhibit a higher damage index value may have either an archetype that has a lower minimum floor height range hence a potential to show more likely damage, or contain a damage curve that has a higher index value at a lower flood depth above floor height.

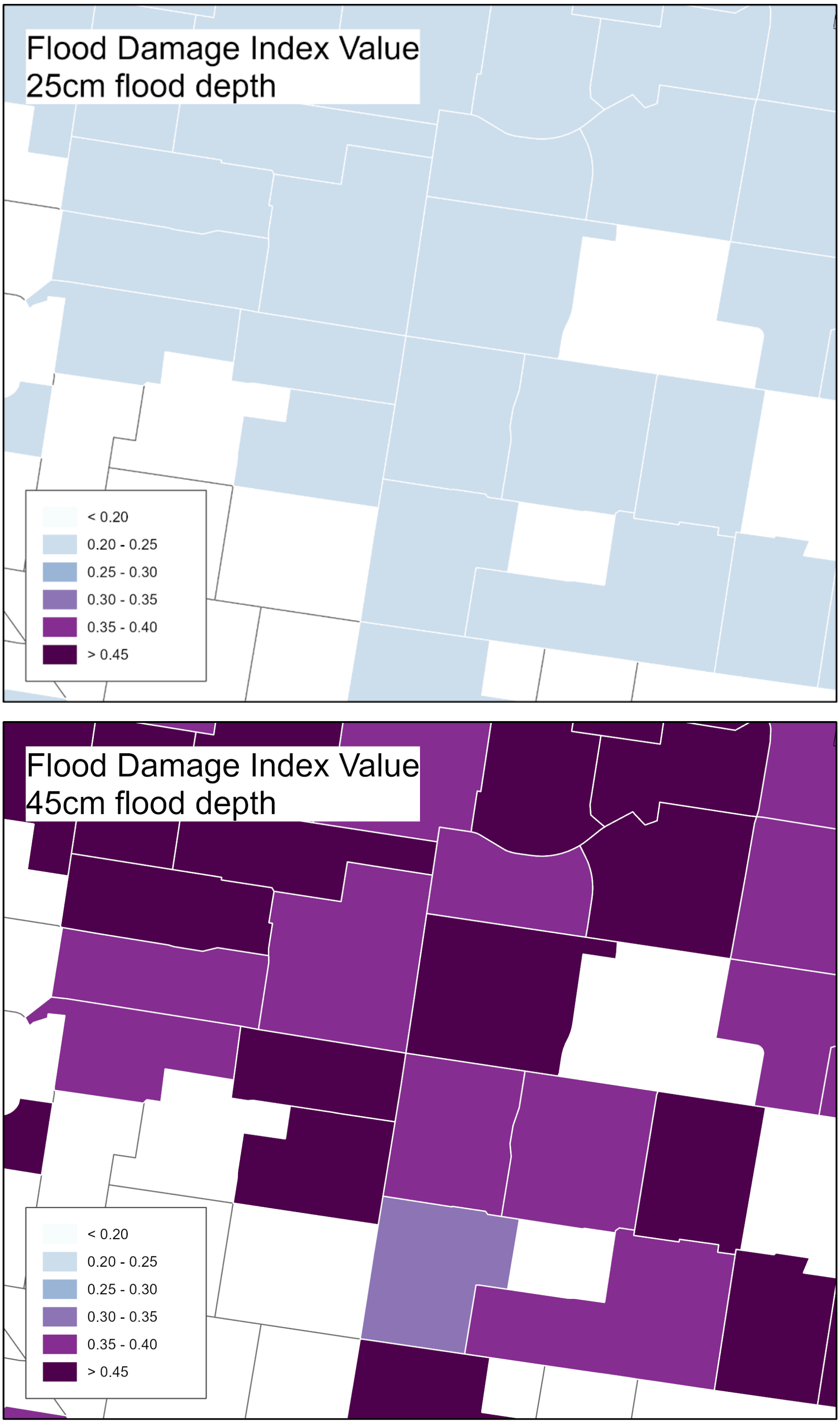



Figure 19. Distribution of flood damage index values for a given area at a 25cm and 45cm flood depth scenario

## 5.4. SA1 Analysis Tables

The following section presents the results that can be generated for a given area using the process described and assumptions outlined. This is not a discussion on the results or a presentation on any summaries or conclusions drawn from these results. The intention of this document is to present the framework and workflow, and the results outputted from this process.

The below tables 6 and 7 outline the outputs generated:

- against SA1s where there was adequate detailed flooding depth data, and
- against all SA1s impacted by the 1 in 100-year flooding to several flood depth scenarios

Each table provides SA1 level summary statistics on

- Parcels Impacted
    - Count of parcels
    - Housing Archetypes
- Summary of archetypes per SA1
    - Damage Curve Profile and Envelope of Damage
    - Per archetype
    - Minimum and Maximum damage index value

Table 6 presents the count of archetypes impacted within each SA1 and the three most common archetypes. This is for an assumed scenario flood depth of 65cm from ground level, which is applied to every SA1 where a parcel has been impacted by flood extent. Similar outputs have been generated for 25cm and 100cm flood depth scenarios. Where there are blanks in the common archetype counts, that indicates that there are no other archetypes that are within that SA1.

Table 7 presents parcel count per impacted and damaged parcel, as well as overall parcel count by SA1. This is for an assumed scenario flood depth of 65cm from ground level, which is applied to every SA1 where a parcel has been impacted by flood extent. Similar outputs have been generated for 25cm and 100cm flood depth scenarios. This result is also shown against the most common 3 archetypes. The result for the average maximum value and the average minimum value overall for each of the common archetypes is also presented.

Table 6. SA1 Summary Tables for housing archetypes at a generic 25cm flood depth scenario

| SA1 Code - Long | Area - SqKm | SA1 Code - Short | Total - Residental Parcels | Total - Inundated Parcels | Total - Damaged Parcels | Archetype - Most Common 1 | Archetype - Most Common 2 | Archetype - Most Common 3 | Archetype - None | Archetype - Beach Shack | Archetype - Contemporary House | Archetype - Mid Century Brick Veneer | Archetype - Mid Century Weather Board | Archetype - Modern Brick Veneer | Archetype - Modern Weather Board | Archetype - Pre War |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20503108912 | 84.22 | 2108912 | - | - | - | | | | - | - | - | - | - | - | - | - |
| 20503108923 | 35.19 | 2108923 | 31 | 2 | 1 | BeachShack | MidCenturyBV | | - | 1 | - | 1 | - | - | - | - |
| 20503109101 | 0.69 | 2109101 | 275 | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109103 | 0.59 | 2109103 | 449 | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109105 | 0.97 | 2109105 | 483 | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109106 | 0.71 | 2109106 | 415 | 6 | - | NoArchetype | ModernWB | | 4 | - | - | - | - | - | 2 | - |
| 20503109109 | 1.10 | 2109109 | 326 | 65 | 22 | ModernWB | BeachShack | ModernBV | 3 | 14 | 1 | 1 | 4 | 7 | 35 | - |
| 20503109110 | 2.23 | 2109110 | 482 | 430 | 225 | BeachShack | ModernWB | ModernBV | 32 | 160 | 10 | 43 | 50 | 55 | 80 | - |
| 20503109111 | 0.74 | 2109111 | 565 | 110 | 69 | BeachShack | ModernWB | MidCenturyW | 5 | 61 | 2 | 4 | 8 | 6 | 24 | - |
| 20503109114 | 24.45 | 2109114 | 66 | 6 | 1 | MidCenturyBV | ModernBV | NoArchetype | 1 | - | - | 4 | - | 1 | - | - |
| 20503109115 | 0.92 | 2109115 | 526 | 14 | 4 | MidCenturyBV | ModernWB | BeachShack | 1 | 2 | - | 4 | - | 2 | 4 | 1 |
| 20503109116 | 0.82 | 2109116 | 277 | 2 | - | MidCenturyBV | | | - | - | - | 2 | - | - | - | - |
| 20503109117 | 0.87 | 2109117 | 468 | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109118 | 0.89 | 2109118 | 487 | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109123 | 1.99 | 2109123 | 518 | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109124 | 4.17 | 2109124 | - | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109126 | 0.37 | 2109126 | - | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109127 | 0.72 | 2109127 | - | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109128 | 0.30 | 2109128 | - | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109129 | 0.40 | 2109129 | - | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109132 | 0.47 | 2109132 | - | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109134 | 0.37 | 2109134 | - | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109135 | 0.33 | 2109135 | - | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109136 | 0.45 | 2109136 | - | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109138 | 0.38 | 2109138 | - | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109139 | 1.03 | 2109139 | - | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109140 | 50.93 | 2109140 | - | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109142 | 0.40 | 2109142 | - | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109304 | 54.20 | 2109304 | 198 | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109305 | 33.58 | 2109305 | 45 | 4 | 1 | NoArchetype | MidCenturyW | ModernBV | 2 | - | - | - | 1 | 1 | - | - |
| 20503109306 | 81.64 | 2109306 | 120 | 1 | 1 | BeachShack | | | - | 1 | - | - | - | - | - | - |
| 20503109307 | 36.85 | 2109307 | 67 | - | - | | | | - | - | - | - | - | - | - | - |

Table 7. SA1 Summary Tables for damage index values for the three most common archetypes at a generic flood depth of 25cm

| SA1 Code - Long | Area - SqKm | SA1 Code - Short | Total - Residental Parcels | Total - Inundated Parcels | Total - Damaged Parcels | Archetype - Most Common 1 | Archetype - Most Common 2 | Archetype - Most Common 3 | Damage Index - Overall (Mean Max) | Damage Index - Overall (Mean Min) | Damage Index - Archetype 1 - Overall (Mean Max) | Damage Index - Archetype 1 - Overall (Mean Min) | Damage Index - Archetype 2 - Overall (Mean Max) | Damage Index - Archetype 2 - Overall (Mean Min) | Damage Index - Archetype 3 - Overall (Mean Max) | Damage Index - Archetype 3 - Overall (Mean Min) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20503108912 | 84.22 | 2108912 | - | - | - | | | | - | - | - | - | - | - | - | - |
| 20503108923 | 35.19 | 2108923 | 31 | 2 | 1 | BeachShack | MidCenturyBV | | 0.20 | - | 0.20 | - | - | - | - | - |
| 20503109101 | 0.69 | 2109101 | 275 | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109103 | 0.59 | 2109103 | 449 | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109105 | 0.97 | 2109105 | 483 | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109106 | 0.71 | 2109106 | 415 | 6 | - | NoArchetype | ModernWB | | - | - | - | - | - | - | - | - |
| 20503109109 | 1.10 | 2109109 | 326 | 65 | 22 | ModernWB | BeachShack | ModernBV | 0.20 | - | - | - | 0.20 | - | 0.21 | - |
| 20503109110 | 2.23 | 2109110 | 482 | 430 | 225 | BeachShack | ModernWB | ModernBV | 0.20 | - | 0.20 | - | - | - | 0.21 | - |
| 20503109111 | 0.74 | 2109111 | 565 | 110 | 69 | BeachShack | ModernWB | MidCenturyW | 0.20 | - | 0.20 | - | - | - | - | - |
| 20503109114 | 24.45 | 2109114 | 66 | 6 | 1 | MidCenturyB\ | ModernBV | NoArchetype | 0.21 | - | - | - | 0.21 | - | - | - |
| 20503109115 | 0.92 | 2109115 | 526 | 14 | 4 | MidCenturyB\ | ModernWB | BeachShack | 0.20 | - | - | - | - | - | 0.20 | - |
| 20503109116 | 0.82 | 2109116 | 277 | 2 | - | MidCenturyBV | | | - | - | - | - | - | - | - | - |
| 20503109117 | 0.87 | 2109117 | 468 | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109118 | 0.89 | 2109118 | 487 | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109123 | 1.99 | 2109123 | 518 | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109124 | 4.17 | 2109124 | - | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109126 | 0.37 | 2109126 | - | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109127 | 0.72 | 2109127 | - | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109128 | 0.30 | 2109128 | - | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109129 | 0.40 | 2109129 | - | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109132 | 0.47 | 2109132 | - | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109134 | 0.37 | 2109134 | - | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109135 | 0.33 | 2109135 | - | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109136 | 0.45 | 2109136 | - | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109138 | 0.38 | 2109138 | - | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109139 | 1.03 | 2109139 | - | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109140 | 50.93 | 2109140 | - | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109142 | 0.40 | 2109142 | - | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109304 | 54.20 | 2109304 | 198 | - | - | | | | - | - | - | - | - | - | - | - |
| 20503109305 | 33.58 | 2109305 | 45 | 4 | 1 | NoArchetype | MidCenturyW | ModernBV | 0.21 | - | - | - | - | - | 0.21 | - |
| 20503109306 | 81.64 | 2109306 | 120 | 1 | 1 | BeachShack | | | 0.20 | - | 0.20 | - | - | - | - | - |
| 20503109307 | 36.85 | 2109307 | 67 | - | - | | | | - | - | - | - | - | - | - | - |


ROAD CLOSED
BY FLOOD

# 6. Conclusion

From application of the data certain limitations have been noted in several sections. Some of these key observations include:

- There are no porvided floor heights and as such all houses in the archetype grouping are assumed fall within the floor height range
- An archetype can fall within a standard archetype and a renovated variant archetype that are updated to new building standards.
- Flood depth only available for certain water basins and is seen to not cover the full coverage of the 1 in 100-year flood extent layer as provided by Melbourne Water
- Only available for one modelled projection of flood depth, that is not related directly to a climate change model, rather a rainfall intensity forcing per basin.
- To account for incomplete flood depth coverage, flood extent was used as a proxy and a series of flood depth scenarios were set and analysed to the respective archetypes and damage curves.

These limitations place certain limitations on the application and interpretation of the data. In particular, scenario setting with extent data can limit interpretation. This is where flood depth modelling is extremely useful as it can remove assumptions in flood extent only based scenarios. But in the absence of a full coverage of flood depth across all Council areas, setting a scenario can be a useful exercise to detail potential impacts.

In application of archetypes to flood depth and potential damage through the damage curves, potential damage at a relativity of 0.4, occurs with only a small volume of water above floor height, approximately at or above 30cm above floor height. Further, it is essentially the same amount of damage through to a depth of 100cm to 120cm above floor height.

Therefore, it can be the case where it doesn’t matter if the flood is 20cm or 120cm, the damage will be principally the same. However, above 120 cm, the potential damage does increase significantly.

On this basis, local mitigation efforts that minimise the potential damage to properties to withstand a depth of 100cm to 120cm above floor height will limit the loss in the event of a flood. Such as concrete floors or epoxy tiles or raised power sockets. Further, more general mitigation to prevent the flood height from reaching above 100cm to 120cm will better protect the property from significant damage.

As outlined in the report, due to the aggregation to SA1 scales and the setting of depth scenarios to extent modelling, the analysis can largely be a scenario-based investigation only and is more so relevant for planning and intel purposes as opposed to detailed parcel level disclosure of climate risk.

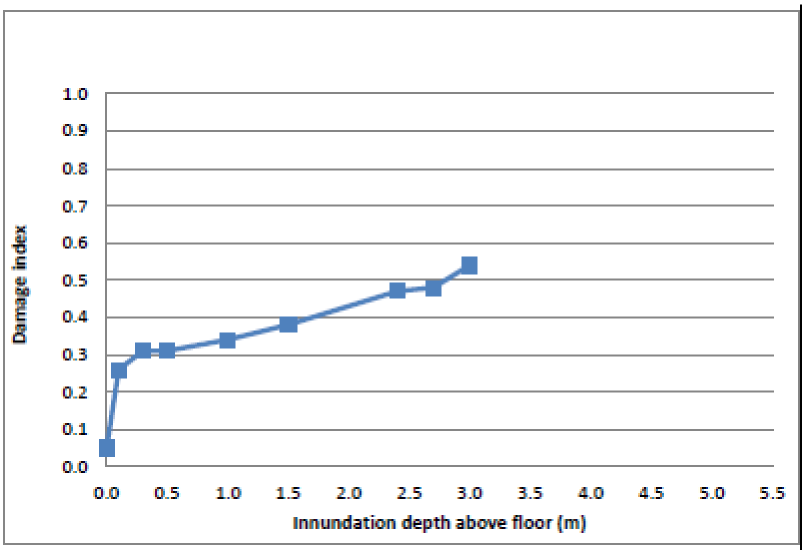
Further, there are no local planning controls or local flood mitigation efforts accounted for in the analysis. It is an application to the data as is and although not accounted for in this analysis, extreme weather events caused by climate change has a potential to increase impact and increase risk and property damage to private residences in areas not currently accounted for in local strategies.

# Appendix 1 – Housing Archetypes

| Pre-War House | |
|---|---|

Anything built before 1940. While there is still a very diverse range of house styles in this time frame, there aren't enough within this area of interest to warrant categorizing any further.

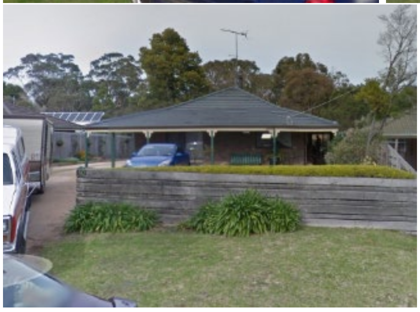
| | |
|---|---|
| **Year Built** | Pre 1940 |
| **Materials** | Varies. Commonly weatherboard, brick, stone. |
| **Typical Foundation** | Stumps |
| **Floor Height Range** | 0.5 – 0.8 |

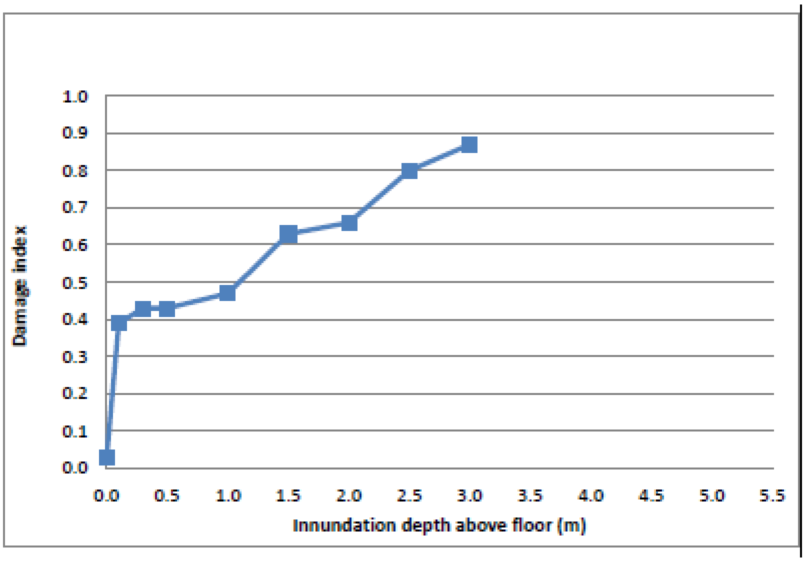


## Post-War Brick Veneer

Typical brick veneer house seen built in suburbs after WW2. Often L shaped or triple-fronted, with hipped roofs. In less dense areas on Mornington Peninsula can be more of a ranch style, long and close to the ground.

| | |
|---|---|
| **Year Built** | 1940 – 1989 |
| **Materials** | Brick veneer; brick render |
| **Typical Foundation** | Usually stumps/posts |
| **Floor Height Range** | 0.3 – 0.8 |

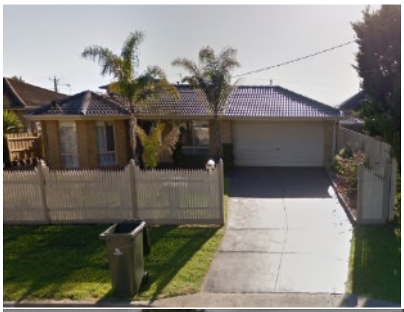
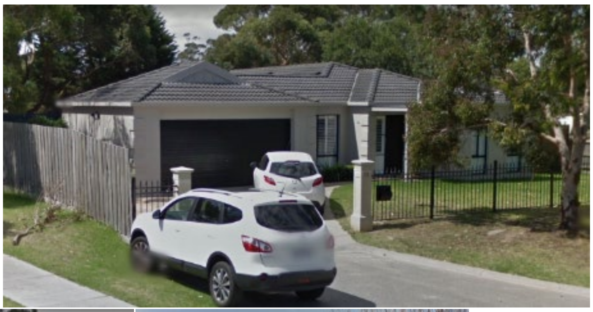
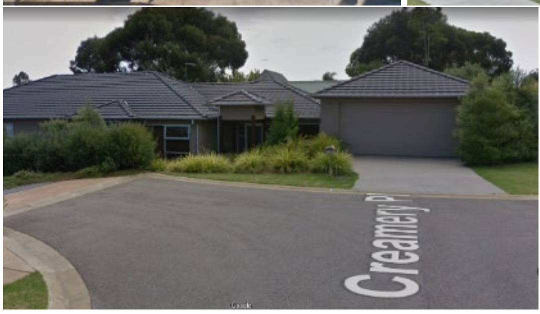
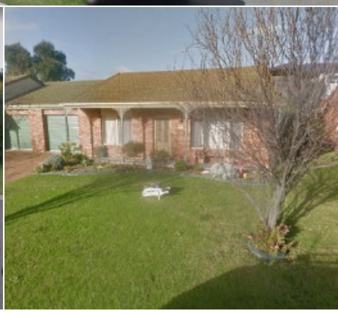


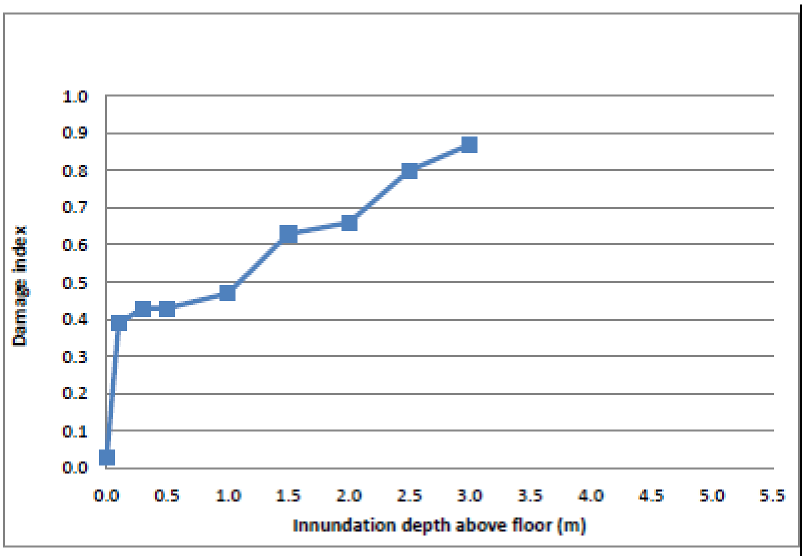


## Modern Brick Veneer

Brick veneer house built after 1990. May look similar to Post-War Brick Veneer, or may have been updated to appear more unique by adding render, paint, and external features. Concrete slab foundations are also probably more common here.

| | |
|---|---|
| **Year Built** | 1990 – present |
| **Materials** | Brick veneer; brick render; concrete block; |
| **Typical Foundation** | Slab |
| **Floor Height Range** | 0.2 – 0.5 |

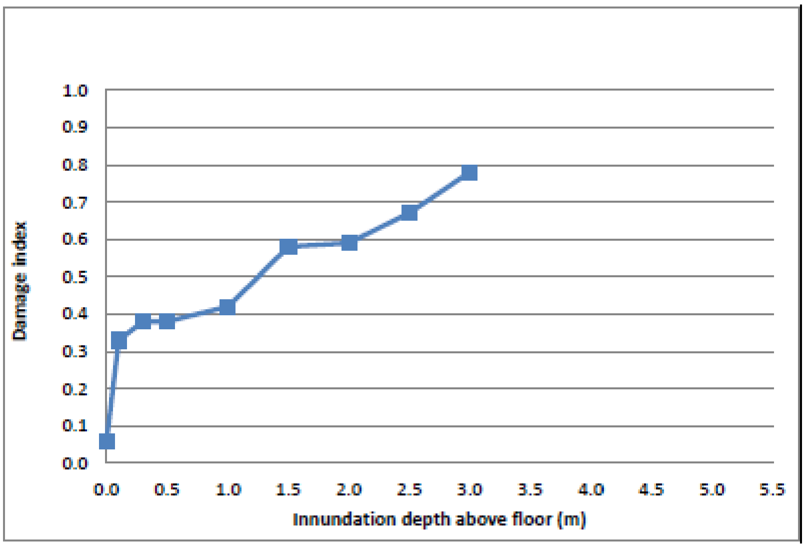







## Mid-Century Weatherboard/Bungalow

Weatherboard house built between 1940 and 1989. May be a Californian Bungalow, or beach house.

| | |
|---|---|
| **Year Built** | 1940-1989 |
| **Materials** | Weatherboard |
| **Typical Foundation** | Stumps |
| **Floor Height Range** | 0.4 – 0.8 |



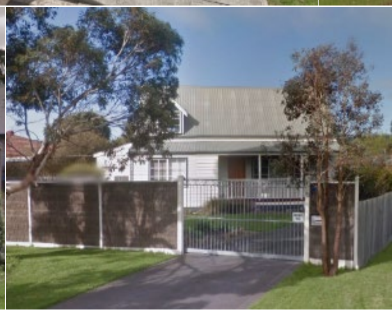
## Modern Weatherboard

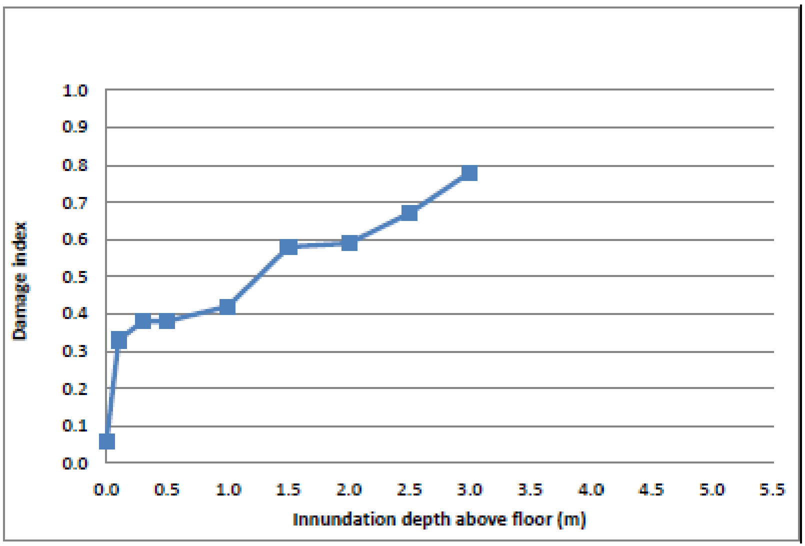
Similar to Mid-Century Weatherboard, but built in 1990 or later. Mass produced houses may be included, and synthetic materials with the appearance of weatherboard may be used, such as Hardiplank.

| | |
|---|---|
| **Year Built** | 1990 – present |
| **Materials** | Weatherboard; hardiplank |
| **Typical Foundation** | Stumps |
| **Floor Height Range** | 0.5 – 1 |







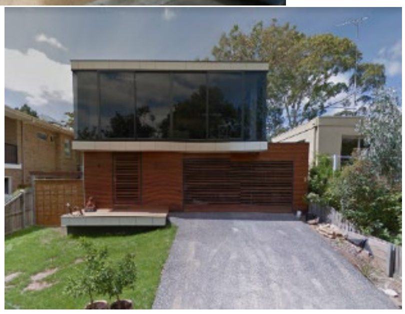


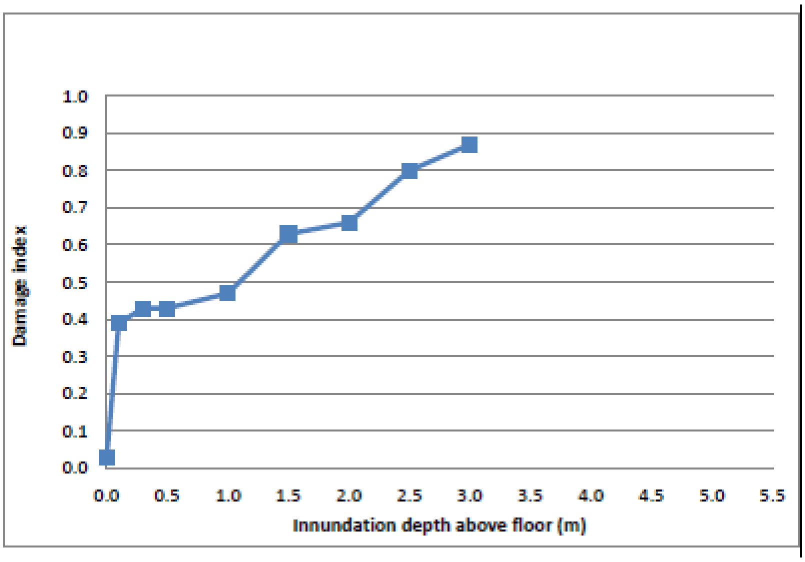
## Contemporary House

Modern house that has been architecturally designed, more individual/unique and probably more expensive materials than Modern Brick Veneer.

| | |
|---|---|
| **Year Built** | 1990 – present |
| **Materials** | Concrete; concrete render; timber; stone; steel; mixed materials etc. |
| **Typical Foundation** | Stumps or slab |
| **Floor Height Range** | 0.2 – 0.6 |



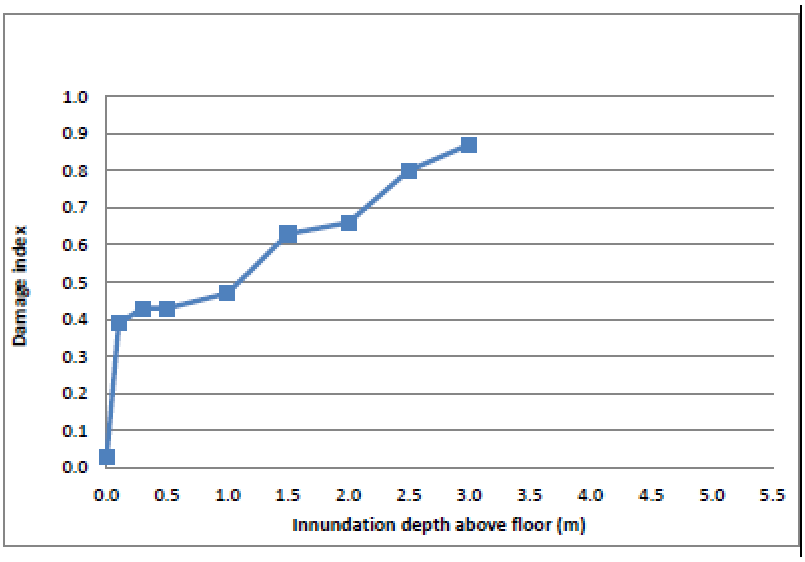





## Mid-Century Modern

Houses that utilized contemporary architectural styles of the era, such as internationalism, modernism

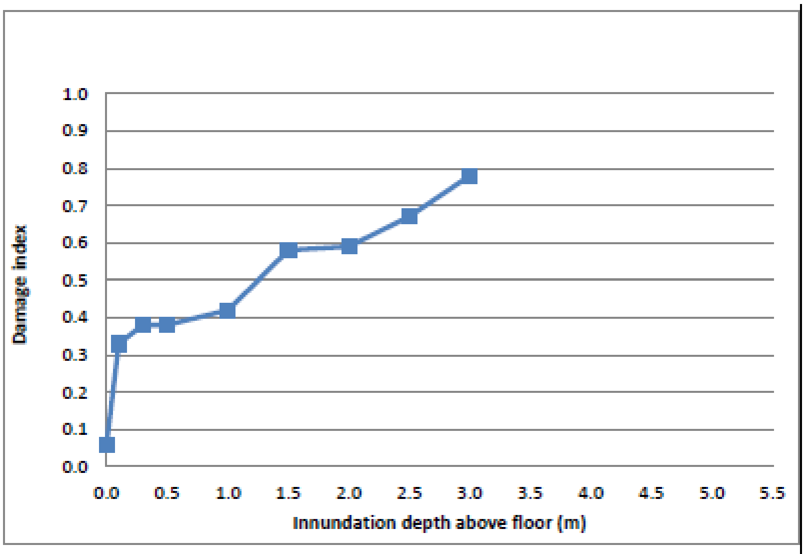
| | |
|---|---|
| **Year Built** | 1950 - 1989 |
| **Materials** | Mixed materials; brick render |
| **Typical Foundation** | |
| **Floor Height Range** | |



## Beach Shack

Prefabricated houses, or built from cheap materials such as fibre cement, sometimes weatherboard.

| | |
|---|---|
| **Year Built** | 1930 – 1990 |
| **Materials** | Fibre cement; aluminium clad; hardiplank; “cladding”; brick veneer & weatherboard |
| **Typical Foundation** | Usually slightly raised on stumps or piles, sometimes concrete slab |
| **Floor Height Range** | 0.2 - 1 |



Spatial Vision