Frequently Asked Questions

Flood Evacuation Modelling

Why does the Hawkesbury-Nepean Valley have an elevated flood risk?

The Hawkesbury-Nepean Valley (the valley) covers around 500km^2 of floodplain in Western Sydney. This valley has the highest unmitigated flood risk exposure in Australia because of its unique landscape and large existing population. Floodwaters in the valley can be extensive, and much deeper than most other floodplains in Australia. This can have a significant impact on people's lives, livelihoods, homes and other critical infrastructure.

Why is evacuation important when it floods in the Hawkesbury-Nepean Valley?

The potential for extreme flood depths and extents in the valley, combined with the speed at which floods can rise compared to other major populated floodplains, mean that large numbers of people need to evacuate before roads are cut and often at short notice. This is the primary method for reducing flood risk to life in the valley, as shelter in place is not considered an option.

Some locations in the valley are more vulnerable than others because they are in areas which can become surrounded by floodwaters during a flood event. These flood islands form due to the undulating topography in the valley. As floodwaters rise, these areas can become isolated when low lying roads are cut. Some of these islands may then become fully submerged as the waters continue to rise, putting many lives at risk.

Why is evacuation challenging in the Hawkesbury-Nepean Valley?

The valley has a mix of urbanised areas - such as the Penrith City Centre, Windsor, Richmond and the newer suburbs in the North West Growth Area such as Marsden Park - interspersed with periurban and agricultural landscapes, all sharing an evacuation road network. This can lead to large numbers of vehicles all using roads and intersections that are not designed for such levels of traffic. In addition, evacuation routes can become flooded at low-lying points at short notice, meaning that alternative routes need to be used if available.

What is the Flood Evacuation Model (FEM)?

The FEM is an agent-based simulation model built on the Multi-Agent Transport Simulation (MATSim) software. MATSim simulates how agents (people or vehicles) travel across a transport network and how they can dynamically react to the travel of other agents. An agent in the FEM is defined as a vehicle as this is the dominant and preferred evacuation method for the Hawkesbury-Nepean Valley.

The FEM simulates the NSW SES evacuation arrangements under a range of assumptions. It provides the NSW Government with a repeatable process to quantify existing and ongoing risk to life associated with the cumulative impact of growth and climate change on road evacuation capacity in the valley.

Why was the FEM developed?

With growth and climate change, the nature and scale of evacuation continues to become more complex, warranting the development of sophisticated modelling to inform integrated regional land use, road evacuation and emergency planning. As part of development of the Hawkesbury-Nepean Valley Flood Risk Management Strategy (Flood Strategy), the NSW Government developed a purpose-built flood evacuation model to provide a more detailed understanding of the evacuation road capacity during a flood event.

Who was involved in developing the FEM?

Led by the NSW Government, a prototype FEM was developed and operated by National Information and Communication Technology Australia (NICTA, now the Data61 division of CSIRO). The prototype was further developed and refined through a collaboration between CSIRO Data 61, Urban Research and Planning (URaP), RMIT and international developers of the underpinning traffic modelling software (MATSim), for use by the NSW Government.

What does the FEM do?

The FEM simulates the NSW State Emergency Service (NSW SES) evacuation arrangements for a range of scenarios (including changes in population, differing infrastructure options and climate change). Findings from the model then allow the NSW Government to compare associated changes to risk to life on a regional scale to inform decision making.

What is in the FEM report?

The FEM report is technical in nature and provides an overview of why and how the model was developed, how it works, the input and output data, the key findings of the FEM and next steps. A significant finding is that the number of people who would be unable to evacuate increases significantly with development and climate change. Other key findings can be found in the Executive Summary.

Who will use the FEM's findings?

The model has been developed for use by NSW Government agencies as a strategic decision support tool. Key users of the model's findings include:

- Transport for NSW (TfNSW) – to inform potential upgrades to the flood evacuation network
- NSW SES – to inform the evacuation and emergency planning component of the Hawkesbury-Nepean Valley Flood Emergency Plan
- Department of Planning and Environment (DPE) – to inform land use planning
- Hawkesbury-Nepean Valley Flood Risk Management Directorate (now part of the NSW Reconstruction Authority) to inform regional flood risk management and monitor and evaluate changes to existing and future flood risk.

How is risk to life defined?

'Risk to life' is defined as people unable to evacuate by road due to either being trapped by floodwaters or being on the evacuation road network for more than 12 hours. Recognising these are exceptional circumstances and taking a conservative approach, 12 hours has been selected by the NSW Government as the limit of people's tolerance to access without food and water, as well as a time when cars would run out of fuel.

How were the assumptions in the FEM developed and validated?

As per all models, the FEM includes assumptions – all of which are outlined in the report with supporting rationale. The assumptions are based on the latest information including census data and other public data sources. Independent peer reviews were undertaken to validate the model and the assumptions, resulting in some modifications to subsequent modelling.

Why are there multiple scenarios?

The model is being used to assess the existing flood evacuation risk to life and how this may change over time. Modelling different scenarios allows for comparing how risk to life is impacted by committed and/or potential development, road infrastructure options, and other variables such as climate change. Modelling multiple scenarios allows for a comprehensive view of risk to life in the valley.

What impact does climate change have on risk to life?

Climate change is predicted to increase the rainfall intensity resulting in increased flood peaks and rates of rise. Findings from the FEM have shown that risk to life will significantly increase due to climate change by mid-century.

Why were 2018, 2026 and 2041 selected?

To understand changes in the risk to life over time, three time points were modelled – 2018 (to represent the existing situation), 2026 and 2041. These time points are indicative of current, short and longer-term changes and are intended to represent general trends. In recognition of the dynamic nature of the valley, future development scenarios will be periodically updated to reflect new information, such as results of the 2021 census.

Have all flood events been assessed?

A suite of representative flood events was used, from a 1 in 50 chance per year flood up to a 1 in 5000 chance per year flood. The analysis focused on 2 major flood events - 1 in 500 chance per year (worst flood on record), and 1 in 1000 chance per year (more probable with climate change and the flood event which cuts off the last major evacuation route for the flood islands).

The report presents the risk to life using two key metrics - the average annual people unable to evacuate within 12 hours, and the geographical distribution of the average annual people unable to evacuate across the valley, for a specific flood event. The metric 'average annual people unable to evacuate' is a measure used to assess relative change in risk to life over time and the relative performance of flood mitigation options.

How were the roads in the 2026 and 2041 model scenarios determined?

The road evacuation network scenarios for 2026 and 2041 that are included in the FEM are based on Transport for NSW's Strategic Traffic Forecast Model. The 2026 and 2041 scenarios include the 2022 road network as well as potential network upgrades by those dates. This includes upgrades identified in the Future Transport Strategy, in addition to upgrades that would specifically enhance flood evacuation. Some of the future road infrastructure projects included in the model currently do not have Government commitment or funding but are projected based on strategic plans for construction in the medium and long-term future.

When and where is it considered that people are safe?

Research and experience have shown around 80% of people usually evacuate to family, friends and accommodation providers, and 20% usually go to evacuation centres. In the model, evacuation destinations are modelled as safe points where the road network has sufficient capacity so people can travel to their destination of choice. Major evacuation centres are located beyond the evacuation road network.

Can members of the public or stakeholders access the model?

The FEM is a complex, highly technical tool to support government decision making and given this, it is not possible for non-expert users to operate the model. There are currently only a few NSW Government experts trained to operate the model and running scenarios can take multiple days.

Why has it been assumed that there will be 100% compliance with evacuation orders?

We know that in a flood emergency people display a range of responses and there are a range of reasons why people may not evacuate. This would vary with every flood. The model assumes 100% of people would evacuate because it is essential to test whether there is sufficient road capacity to evacuate the large numbers of people at risk before roads are cut.

Why is evacuation by vehicle considered the primary method?

The NSW SES Flood Plan identifies self-evacuation by vehicle as the most likely mode of evacuation in the Hawkesbury-Nepean Valley. Evacuation by rail is not included due to the impacts of early inundation on railway lines. Evacuation on foot is not included due to the inclement weather and large distances, and therefore seen as a last resort.

Will it be possible for the FEM to look at smaller individual developments?

The model is designed to a regional scale, due to the interconnected nature of the road evacuation network. It is not possible to model individual developments in isolation of the rest of the valley.

What does FEM mean for land use planning in the Hawkesbury-Nepean Valley?

The FEM provides the NSW Government with a tool to assist in land use planning decisions. The FEM will also be an input into the development of the regional Disaster Adaptation Plan for the Hawkesbury-Nepean Valley as well as the Regional Land Use Planning Framework which will establish a settlement pattern for the valley based on the flood risk and the evacuation capacity constraints.

How have the findings of the 2022 NSW Flood Inquiry impacted development in the Valley?

In response to the February-March 2022 flooding events, the NSW Government established an independent review, led by Professor Mary O'Kane AC and Michael Fuller APM, to examine and report on the preparation for, causes of, response to and recovery from the floods.

The 2022 NSW Flood Inquiry made 28 recommendations in response to the 2022 floods. Ten of these recommendations relate to land use planning. The inquiry noted opportunities to improve and strengthen proactive flood planning, including resetting flood planning levels using a catchment-specific, risk-based approach. The inquiry identified high risk catchments, which included the Hawkesbury-Nepean Valley.

The inquiry recommended adopting a new risk-based approach to calculating flood planning levels. This work is to be undertaken by the NSW Government and it is estimated this work will take several years to complete.

The inquiry recommended modelling for high-risk catchments, such as the Hawkesbury-Nepean Valley, be completed in several years. Implementing this recommendation could result in different flood planning levels across catchments.

What are the next steps for the flood evacuation modelling?

This work is ongoing due to the dynamic nature of flood risk in the valley. Future modelling will periodically test new scenarios and new information as it becomes available. This includes improved flood modelling, updated census data, climate change predictions, and consideration of different behavioural responses.

What other steps are the NSW Government taking to mitigate flood risk in the Hawkesbury-Nepean Valley?

To address the significant and ongoing flood risk in the Valley, the NSW Government is building on the work of the former Flood Strategy to develop a high-priority regional Disaster Adaptation Plan (DAP) focused on reducing flood risk. Integrated measures to be considered include infrastructure, policy and other initiatives.