Submission No 74

INQUIRY INTO WATER NSW AMENDMENT (WARRAGAMBA DAM) BILL 2018

Organisation: NSW Government

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Inquiry into the Water NSW Amendment (Warragamba Dam) Bill 2018

Submission to the Legislative Council Standing Committee on State Development

Infrastructure NSW

WaterNSW

Office of Environment and Heritage

Department of Planning and Environment

NSW State Emergency Service

Office of Emergency Management

Transport for NSW - Roads and Maritime Services

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2 Introduction

This is a joint submission to the Legislative Council Standing Committee on State Development by:

- Infrastructure NSW
- WaterNSW – State Owned Corporation
- Office of Environment and Heritage
- Department of Planning and Environment
- NSW State Emergency Service
- Office of Emergency Management
- Transport for NSW - Roads and Maritime Services

Infrastructure NSW is responsible for overseeing the delivery of the *Resilient Valley, Resilient Communities* Hawkesbury-Nepean Valley Flood Risk Management Strategy[1] (Flood Strategy). Infrastructure NSW is also responsible for preparing the Final Business Case for the Warragamba Dam Raising proposal and the next phase of the Flood Strategy, due in 2020.

A number of agencies and organisations have responsibility for delivery of the nine key outcomes in the Flood Strategy.

WaterNSW is a State Owned Corporation established under the *Water NSW Act 2014*. As the owner and operator of Warragamba Dam, WaterNSW is preparing a comprehensive Environmental Impact Statement (EIS) and detailed concept designs for the Warragamba Dam Raising proposal for the Infrastructure NSW Final Business Case due in 2020.

The NSW Office of Environment and Heritage (OEH) has responsibility and functions under various environmental and heritage legislation. Most relevant to these matters are the *Biodiversity Conservation Act 2016* and the *National Parks and Wildlife Act 1974* (NPW Act). OEH is also responsible for the Floodplain Development Manual, the NSW Government's Flood Prone Land Policy and associated floodplain risk management guidelines and tools to help councils manage flood risk.

The NSW Department of Planning and Environment shares responsibility for strategic planning and development in NSW with the Greater Sydney Commission and councils under the provisions of the *Environmental Planning and Assessment Act 1979*. Within the Sydney basin the Department works within the strategic planning framework created by *Sydney Region Plan: A Metropolis of Three Cities* and the District Plans prepared by the Greater Sydney Commission. The Department has direct responsibilities to take and assess proposals for State Significant Development and State Significant Infrastructure, all other development types are typically taken and assessed by councils.

The NSW State Emergency Service is responsible for the emergency planning and response to floods.

The Office of Emergency Management is responsible for planning for the recovery from all hazards, including flood.

The Road and Maritime Services is responsible for state and regional road planning.

[1] *Resilient Valley, Resilient Communities* Hawkesbury-Nepean Valley Flood Risk Management Strategy 2017 https://www.hawkesbury.nsw.gov.au/__data/assets/pdf_file/0018/93051/Infrastructure-NSW-Resilient-Valley,-Resilient-Communities-2017-January.pdf

2.1 Terms of Reference

The Standing Committee on State Development will inquire into and report on the Water NSW Amendment (Warragamba Dam) Bill 2018.

The agencies provide this submission to support the inquiry. It includes background and context to the introduction of the Bill to the NSW Parliament in relation to the proposal to raise Warragamba Dam for flood mitigation. It also sets out relevant information about the assessment of options that informed the Flood Strategy. The submission details the range of complementary Flood Strategy initiatives that are under way to reduce flood risk in the Hawkesbury-Nepean Valley.

The investigations and analysis for the Warragamba Dam Raising proposal's environmental and cultural heritage assessment are in progress with the public exhibition planned for mid-2019. Responses are provided noting that the Environmental Impact Assessment is yet to be finalised, with field work ongoing. Importantly, the Bill does not constitute an approval for the Warragamba Dam raising.

3 Background

The Hawkesbury-Nepean Valley booked in Western Sydney has the highest flood risk in NSW, if not Australia. This high flood risk arises from the river being confined by narrow sandstone gorges, creating rapid, deep flooding over extensive floodplains. The floodplains are home to a large existing population that would be impacted by a major flood.

The Hawkesbury-Nepean floodplain was created by flooding over thousands of years. There have been 130 moderate to major floods in the valley since European settlement. The largest of these happened in 1867, when floodwaters reached around 19 metres above normal river height at Windsor. This caused massive and widespread damage, and resulted in the loss of 13 lives. While there hasn't been a significant flood in the valley since the early 1990s, more major floods are inevitable.

The high flood risk in the valley is exacerbated by the differences in the height and extent between the 1 in 100 chance per year flood (the 'standard' flood planning level) and the more extreme events such as the 1 in 500 chance per year flood (the flood of record), and the worst possible flood. In other valleys there is not a significant difference between these events. In this valley, there are differences of nine metres or more in height between the flood 'standard' flood planning level and more 'extreme' events.

The *State Infrastructure Strategy 2012–2032*[2] recommended that the NSW Government review all available major flood mitigation options, including raising Warragamba Dam wall, to significantly reduce the potential economic and social impact of flooding in the valley.

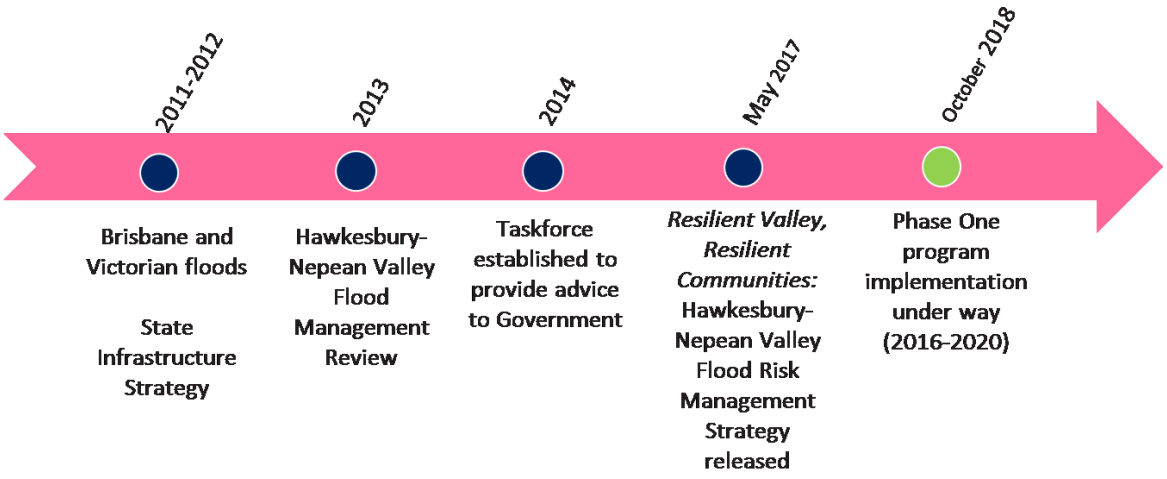
The *Hawkesbury-Nepean Valley Flood Management Review* [3] (the Review) began in early 2013, in response to the Government's adoption of the *State Infrastructure Strategy 2012- 2032*. The Government established the Hawkesbury-Nepean Valley Flood Management Taskforce (the Taskforce) in early 2014 to implement the recommendations of the 2013 Review and develop *Resilient Valley, Resilient Communities:* the Hawkesbury-Nepean Valley Flood Risk Management Strategy (Flood Strategy).[4]

Recognising the complexities of regional flooding in the Hawkesbury-Nepean Valley and the need for a coordinated approach, the NSW Government has invested significantly to better manage the flood risk to lives, homes, business and community assets.

Figure 1 outlines the process informing the strategic approach to NSW Government's Flood Strategy, released in May 2017, and its ongoing implementation.

[2] http://www.infrastructure.nsw.gov.au/media/1127/sis_report_complete_interactive.pdf
[3] http://archive.water.nsw.gov.au/__data/assets/pdf_file/0005/548987/key_hawkesbury-nepean-valley-flood-management-review-stageone-report.pdf
[4] Flood Strategy fact sheets and frequently asked questions can be found at http://www.infrastructure.nsw.gov.au/expert-advice/hawkesbury-nepean-flood-risk-management-strategy/

Figure 1 Timeline for development of the Flood Strategy



The Flood Strategy is built on the recognition that there is no single or simple solution that can eliminate all flood risk. An integrated mix of measures is required to achieve a significant and sustainable reduction of flood risk in the valley. This is due to the risk of rapid and deep flooding over extensive floodplains in Western Sydney. Flood inflows come from the five main tributaries to the Hawkesbury-Nepean River, with the greatest contribution coming from the Warragamba catchment.

The Flood Strategy has adopted a best-practice approach that encompasses a range of measures for improved flood risk prevention, preparedness, response and recovery, **Figure 2**.

3.1 Risk to life

Around 134,000 people currently work and live on the Hawkesbury-Nepean Valley floodplain. The level of risk to life from a flood in the valley depends on:

- the size and rate of rise of the flood event
- prevailing weather conditions – floods are normally associated with cyclonic East Coast Low systems
- people's response to evacuation warnings and orders.

Currently, the Bureau of Meteorology is able to provide around eight to 15 hours warning ahead of a flood reaching a certain height, depending on the location in the floodplain. Modelling undertaken by the Taskforce demonstrates that the current road capacity is insufficient to evacuate all the residents impacted by large floods within this warning time. This would force the NSW State Emergency Service to order mass evacuation on uncertain flood forecasts.

Under the Flood Strategy, the NSW Government is investing over $2 million to upgrade the Bureau of Meteorology's flood forecasting capability for the valley with the aim of providing longer forecast timeframes and better quantifying the level of uncertainty of various forecasts.

Figure 2 Flood risk management approach to reduce the risk to life and impact on properties and community in the Hawkesbury-Nepean Valley

Evacuation needs to occur early in a flood in the valley because many key evacuation routes will be cut off by floods at low points, long before population centres are inundated. For example, in a 1 in 100 (1%) chance per year flood – similar to the 2011 Brisbane flood – Windsor Road, Richmond Road, and Hawkesbury Valley Way will be cut. Hawkesbury Valley Way is the last evacuation road for Windsor. See **Box 1** for an explanation on the likelihood of floods.

Many of the significant urban centres in the valley, including Windsor, Richmond, Bligh Park and McGraths Hill, become isolated on flood islands as these roads are cut. Some of these islands then become fully submerged as the waters rise during a catastrophic flood event. This could put many lives at risk, particularly if a significant number of people do not respond to evacuation orders.

Our analysis shows that many vital services such as electricity, water, sewerage and telecommunications are also vulnerable at these low points. Combined with the cyclonic East Coast Low conditions that lead to most flood events in the valley, and the fact that flooding could last for several days, staying in place will not be feasible even if the area is not inundated.

Roads, while vital for evacuation, do not reduce the number of people directly exposed to flood. As part of the development of the Flood Strategy, large scale upgrades to increase evacuation capacity

of roads leading away from the floodplain were investigated. Because of the many kilometres of the road evacuation network that would need to be upgraded, and the large number of low points in the roads, many billions of dollars would need to be spent on roads to make a material difference to evacuation rates. There are limits to how high roads and bridges can be raised.

No package of road upgrades was found to be as cost effective as the proposed Warragamba Dam raising for flood mitigation. This is because the Warragamba Catchment is the largest contributor to floods above the 'standard' flood planning level across the floodplain. Controlling flood flows from this single point is the most effective way of reducing the frequency with which roads are cut and properties are flooded – with a corresponding reduction to risk to life as well as property.

Box 1 Likelihood of floods

Floods are natural hazards and most often described in terms of the chance that floods of a certain size could occur. The terms '1 in 100 flood', or '100-year flood' refers to a flood that has a 1 in 100 (or 1%) chance of happening or being exceeded in any one year.

It does not mean that this flood will only occur once every hundred years.

For example, every year there is a 1 in 100 chance (or 1% chance) there would be a flood reaching around 17 metres or higher above the normal river level at Windsor.

Expressed another way, it means a person living to 70 years of age has a 50% chance of experiencing this type of flood during their lifetime.

The worst possible flood is often referred to as the 'Probable Maximum Flood' (PMF). Between the 1 in 100 chance per year flood and the worst possible flood, there are numerous other floods. It is possible to have multiple different floods in one year.

Recent research undertaken by Infrastructure NSW confirmed that 3% of the people who live in the floodplain would refuse to leave when told to evacuate, and 27% would use their own judgement.

If a flood similar to the 2011 Brisbane flood occurred today, around 64,000 people would need to evacuate from the valley. Even if only 3% failed to evacuate, around 2,000 people would be risking their lives. This number could be much higher in larger floods.

3.2 Risk to homes and businesses

Historic European settlement in the Hawkesbury-Nepean Valley over the last 200 years has resulted in a very significant existing flood risk. Based on the mapping, modelling and analysis that informed the 2017 Flood Strategy, 25,000 residential properties and two million square metres of commercial space are currently subject to flood risk. These figures are currently being updated with the latest census results and property data.

In developing the Flood Strategy, options for voluntary house purchase were examined and were found not to be feasible due to the economic and social cost of relocating whole suburbs. If the 12,000 dwellings that are currently below the level of the 1867 Flood, (the largest flood in European history) were purchased, this could cost over $10 billion. This estimate is based on an average house price of around $750,000 (2015) in the main affected Local Government Areas.

The Taskforce's modelling estimates that, if a flood similar to the 1867 flood happened today, over $5 billion in direct flood damages would be incurred, and thousands of homes and businesses would

be damaged or destroyed, **Figure 3**. This is a conservative estimate and does not account for the additional social and emotional toll on the community.

The road evacuation network is important for providing capacity for safe evacuation, but it does nothing to reduce damages to homes and other vital infrastructure. While the Flood Strategy does not include large scale regional road upgrades, it does include a package of smaller road upgrades targeted at improving access to major evacuation routes.

Flood risk in the valley is currently reflected in insurance premiums, with floodplain residents reporting significant increases in their insurance premiums. The Insurance Council of Australian has advised that, in assessing flood insurance, insurers take account of how often a property is expected to flood, how severe the flooding may be, and how deep the flood can get.

The Insurance Council of Australia has advised that, should the Warragamba Dam raising be approved and built, reductions in flood risk at each individual property will be considered by insurers and will typically result in reduced insurance premiums. They further stated that, where effective flood mitigation has been completed in other states, significant reductions in insurance premiums have been achieved.

Figure 3 Comparison of flood impacts[5]

[5] https://www.hawkesbury.nsw.gov.au/__data/assets/pdf_file/0018/93051/Infrastructure-NSW-Resilient-Valley,-Resilient-Communities-2017-January.pdf

4 The Bill

4.1 Purpose of the Bill

The proposal to raise Warragamba Dam by 14 metres is about creating 'airspace' above the current full supply level of the dam to allow floodwaters coming from the large Warragamba Catchment to be temporarily held back and then released in a controlled way following the flood peak. This would delay and reduce the flood peak for downstream communities, reducing risk to life and reducing damages by 75% on average.

Under current legislation, the Minister for the Environment is prevented from granting any lease, licence, easement or right of way on National Park land to enable WaterNSW to operate the dam to mitigate floods.

The Bill amends the *Water NSW Act 2014* by stipulating that the lease, licence, easement or right of way which would otherwise be required under the *National Parks and Wildlife Act 1974* would not be required for temporary inundation of the land upstream of Warragamba Dam, when a raised Warragamba Dam wall was operated to mitigate a flood.

Temporary inundation of the areas upstream of the dam, including World Heritage Areas, occurs now in a flood with the existing dam (see area coloured blue in **Figure 4**).

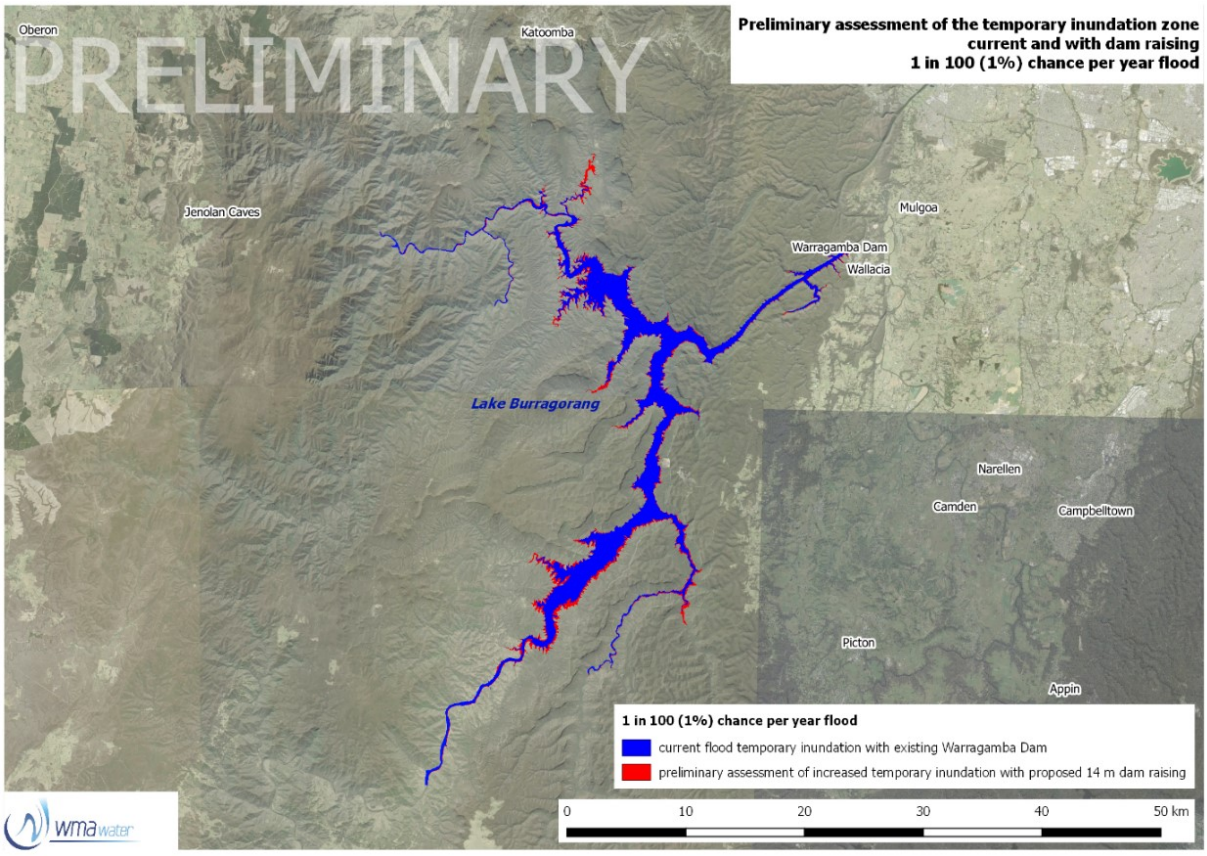
Based on preliminary assessment of the Warragamba Dam Raising proposal, in a 1 in 100 chance per year flood up to an additional six hundredth of one percent (0.06%) of the World Heritage Area would be temporarily inundated, above the area that would be flooded now (see area coloured red in **Figure 4**). The increase in the time of inundation, over and above what would happen now, would be from hours to a number of days - up to around two weeks. The extent of this incremental increase in temporary inundation would depend on the size of the inflows to the dam storage.

The EIS will assess the impacts of these increases in upstream temporary inundation consistent with the NSW Department of Planning and Environment Secretary's Environmental Assessment Requirements[6].

The Bill would permit this incremental increase in temporary inundation of land upstream of Warragamba Dam wall – only to provide flood mitigation and only if the raising of Warragamba Dam is approved.

[6] Secretary's Environmental Assessment Requirements: https://majorprojects.accelo.com/public/7636122903f88cbb759f65eac95f760f/SSI%208441%20-%20SEARs%20[As%20Revised%2013%20March%202018].pdf

Figure 4 Preliminary assessment of the temporary upstream inundation zone[7]



4.2 Bill is not an approval for the Warragamba Dam Raising proposal

Investigations and assessments on the proposal to raise Warragamba Dam for flood mitigation are currently under way. The Government is undertaking a proper and robust assessment process. A comprehensive Environmental Impact Statement (EIS) is being prepared for public exhibition and consultation next year.

Both State and Australian Government planning approvals will need to be obtained under the NSW *Environmental Planning and Assessment Act 1979* and under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. As the proposed dam raising is State Significant Infrastructure, the State approvals will be made by the Minister for Planning. The EIS will address the assessment requirements of both governments.

This Bill is not an approval for the dam raising proposal. The Bill will have no effect unless the proposal receives planning approval, and the NSW Government makes an investment decision to proceed with the raising based on a Final Business Case due to the Government in 2020.

[7] Preliminary Map by WMAWater 2018 – developed for informing the Warragamba Dam Raising Project Environment Impact Assessment.

4.3 Why the Bill amendment is proposed now

There are two key reasons why the Bill amendment is being proposed now.

Firstly, concerns have been raised by some stakeholders that the Warragamba Dam Raising proposal may not be able to be assessed under the current legislative arrangements. In this context, it is important to note that the amendment is project-specific and subject to approval before the Bill would have effect. Making the amendment now would mean that when the EIS is publicly exhibited, the focus can appropriately be on the substance and merits of the proposal rather than a legislative impediment.

Secondly, the amendment is needed to allow the Minister for Planning to be able to make a determination on the planning application for the proposal under the *Environmental Planning and Assessment Act 1979*.

4.4 Environmental safeguards

The Bill includes built-in environmental safeguards through the requirement for an Environmental Management Plan.

Under Part 4 of *Water NSW Act 2014*, the Minister administering that Act and WaterNSW are responsible for the management of Warragamba Special Areas for the protection of drinking water catchments upstream of Warragamba Dam.

WaterNSW jointly manages the Special Areas with the National Parks and Wildlife Service. The Environmental Management Plan proposed by the Bill would apply to the areas temporarily inundated, including the Warragamba Special Areas.

The Environmental Management Plan must also be consistent with any planning approval for the proposal under the *Environmental Planning and Assessment Act 1979*. Complying with the planning approval will be the responsibility of WaterNSW.

The Environmental Management Plan will need to balance the management of the upstream environmental impacts with the operation and management of a raised Warragamba Dam and its upstream Special Areas. This must be achieved in a way that is consistent with the proposal's planning approval.

To achieve this balance, the Bill specifies that the Environmental Management Plan will need to be approved or amended by both the Minister administering the *Water NSW Act 2014,* and the Minister administering *National Parks and Wildlife Act 1974*.

5 Options assessment to inform the Flood Strategy

5.1 Assessment methodology

The Flood Strategy is based on four years of assessments, including the work of the 2013 Hawkesbury-Nepean Valley Flood Risk Management Review and the Hawkesbury-Nepean Valley Flood Management Taskforce (2014-2016).

All potential infrastructure and non-infrastructure options to reduce flood risk in the valley were assessed. This work informed the integrated mix of infrastructure and non-infrastructure actions to better prevent, prepare for, respond to and recover from floods for a more flood resilient valley – now and in the future.

The Flood Strategy is based upon an adaptive management framework, recognising that our understanding of risk improves with new information, methods and technologies.

Best practice strategic risk assessment and planning requires an understanding of the key drivers that affect the risk profile over time. The Taskforce's evaluation methodology adopted an evidence-based approach to understand existing flood risk (2016 base case) and future flood risk (in 2041). The level of exposure to flood risk, and resilience of communities (both human and natural), changes over time. The key drivers of change are population growth, climate change and the future use of new technology.

The Flood Strategy noted that the population at risk was forecast to double in the next 30 years. This forecast was based on information provided by the Department of Planning and Environment and local councils on potential future development under current land use planning arrangements. This number is not a target, nor is it dependent on the proposed dam raising. Rather, it was a forecast used to understand the current and future risk environment without any risk treatment. It was both prudent and necessary to forecast possible growth to assess the efficacy of options to reduce the flood risk, now and in the future. Scenario testing and sensitivity analysis was also applied to test the efficacy of the flood risk mitigation options considered.

Flood risk was assessed by estimating the potential risk to life and adverse impacts on the economy and social amenity across the full range of flood events. This methodology included:

1. Flood modelling to quantify the likelihood and behaviour of floods – over 20,000 flood events were generated to characterise the full range of flood risk
2. Developing a floodplain assets database to define current and future exposure that records the location of all residential property and essential assets
3. Quantifying the potential consequences from floods for the current and future flood risks by estimating the:

- risk to life using a purpose built, 'agent-based' flood evacuation model. The model estimated the number of vehicles that were unable to evacuate for different floods under a combination of population, dam and road upgrade scenarios. More than 13,000 model runs were generated to simulate evacuations under a broad range of conditions
- potential impacts on the economy and social amenity using a flood damages assessment.

5.2 Options assessed and findings

There are different ways to manage flood risk across the flood risk management cycle, **Figure 1**. These fall into two broad categories:

Category 1: Infrastructure options can significantly reduce flood risk by lowering the chance of a flood event, reducing the exposure of homes and business to flood, and with some options, increasing the certainty of time for evacuation. Infrastructure options considered by the Taskforce include:

- controlling flows into the flood plains (new dams or changing existing Warragamba Dam either through operation, e.g. lowering the water supply level, or raising the wall)
- protecting areas within the floodplains (over 30 levees were assessed)
- reducing the constriction of the sandstone gorges (diversion channels, river dredging)
- increasing evacuation capacity (large scale regional and smaller road upgrades)
- upgrading drainage to prevent premature closure of local and state roads.

Category 2: Non-infrastructure options address different elements of the flood risk management cycle, **Figure 1**. They are essential to manage ongoing risk and to help ensure that the benefits of any infrastructure options are maintained over time. They include:

- helping to prevent exposure through integrated land use planning and appropriate flood planning controls by matching development potential to evacuation capacity
- reducing flood risk exposure through voluntary house purchase
- increasing community awareness, preparedness and response through community education
- increasing flood warning time through meteorological forecasting upgrades
- improving emergency and recovery planning and response
- strengthening the integration and coordination of organisations responsible for floodplain management.

Table 1 summarises the options considered and why they were either taken forward or not progressed. Flood infrastructure options were assessed on the basis of their ability to:

- significantly reduce the risk to life to downstream communities, and
- provide greatest net regional benefits (**Box 2**).

Flood infrastructure options such as dams, localised levees and drainage works were assessed in terms of their costs and benefits, including a preliminary analysis of socio-economic, environmental and cultural-heritage impacts. A thorough analysis of these aspects is being undertaken for the Warragamba Dam Raising proposal as part of the current EIS process.

Non-infrastructure options were assessed based on their contribution to the 'prevent, prepare, response and recovery' aspects of flood risk management - as well as the extent to which they contributed to the maintenance of flood mitigation benefits over time.

Box 2 Critical range for flood risk reduction – 1 in 50 to 1 in 1000 chance per year events

Flood islands are areas that are isolated by floodwaters during the flood event. These islands may become fully inundated in large floods, **Figure 5**. Many of the significant urban centres in the floodplain - such as McGraths Hill, Windsor, Richmond and Bligh Park - are located on these flood islands.

Due to the depth of flooding and the distance to safety, there is potential for significant fatalities if evacuation is not successful from the flood islands.

Effective flood infrastructure mitigation options are those that significantly reduce peak flood levels particularly in the range of 1 in 50 to 1 in 1,000 chance per year floods. This is because the 1 in 50 to 1 in 500 chance per year flood range contributes about two-thirds of the average annual flood damages. The 1 in 1,000 chance per year flood cuts the last evacuation road isolating Richmond, so it is the last flood level where mitigation has significant benefits in terms of saving lives. By this point major populations requiring evacuation should have left the floodplain.

Mitigating larger, rarer events is possible with very large dam raisings. As the major flood islands are below the 1 in 1,000 chance per year flood level, these would have limited additional reduction in risk to life. They would also have higher construction costs and greater upstream inundation impacts compared to the proposed 14 metre raising of Warragamba Dam for flood mitigation.

While some localised low points have been identified for upgrading to support evacuation, it is not feasible to significantly reduce the risk to life across the valley by raising or widening roads alone.

Figure 5 How a flood island can be isolated then fully submerged

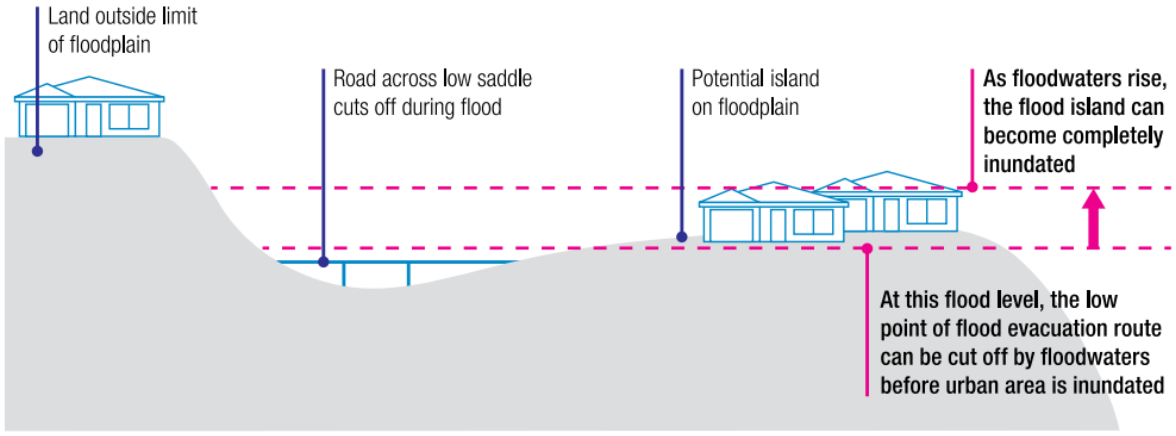


Table 1 Assessment of flood mitigation options across 'prevent, prepare, respond and recover'

Flood management options	Prevent*	Prepare	Respond	Recover	Outcome	Key reason(s)
Infrastructure measures						
Surcharge existing dam gates during floods	✓				Not supported	Does not provide significant, regional reduction of flood risk
Pre-release water before forecast flood events	✓				Not supported	Does not provide significant, regional reduction of flood risk; risk of loss of water supply
Permanently lower full water supply level by 5m	✓				Not supported	Does not provide significant, regional reduction of flood risk; loss of water supply
Permanently lower full water supply level by 12m	✓				Not supported	Provides moderate regional benefits in critical flood range but has high net cost due to high costs of addressing water supply and water quality
New flood mitigation dams upstream of Warragamba	✓				Not supported	High social, environmental & cultural heritage impacts; no sites as well suited as Warragamba
New flood mitigation dams downstream of Warragamba	✓				Not supported	Does not mitigate predominant Warragamba catchment floods
Raise Warragamba Dam wall by about 14m	✓				**Supported**	Provides significant, regional reduction of flood risk; highest net benefit of all options considered
Raise Warragamba Dam wall by 20m	✓				Not supported	Provides greatest flood mitigation but has lower net benefit than +14m; higher impacts from temporary upstream inundation and downstream post flood releases.
Currency Creek diversion channel	✓				Not supported	Does not provide significant, regional reduction of flood risk; high net cost; high-extreme environmental impact
Sackville cut-off (short diversion)	✓				Not supported	Does not provide significant, regional reduction of flood risk
Sackville large diversion	✓				Not supported	Does not provide significant, regional reduction of flood risk. Extreme cost; likely extreme environmental impact
Dredging between Windsor and Wisemans Ferry	✓				Not supported	Does not provide significant, regional reduction of flood risk. High net cost; high-extreme environmental impact; must be maintained for ongoing flood mitigation
Levees (Peachtree Creek, McGraths Hill, Pitt Town)	✓				Not supported	Provides local benefit only and not for severe or catastrophic floods
Regional evacuation road upgrades (>10 major packages assessed)			✓		Not supported	Even with multiple major road upgrades, still less effective at reducing risk to life than dam raising; high net cost since does not reduce property damages – provides capacity for evacuation only.
Local evacuation road upgrades			✓		**Supported**	Improves local evacuation, complementing existing regional evacuation routes
Non-infrastructure measures						
Voluntary house purchase (VP)	✓				Not supported	Extreme cost (billions) to significantly reduce flood risk; extreme social disruption requiring mass relocation
Voluntary house raising (VHR)	✓				Not supported	Impractical due to building styles and extreme flood depths in this valley
Flood risk-based regional land use planning	✓				**Supported**	Essential and complementary to dam raising; limits increase in future exposure; manages impact of growth on evacuation capacity
Flood risk-based regional road planning			✓		**Supported**	Road Evacuation Master Plan will consider flood evacuation risk when regional roads are upgraded for growth in the valley
Improved flood forecasting and warning system			✓		**Supported**	Complementary to infrastructure measures; provides increased certainty of time for evacuation
Community flood awareness, preparedness and responsiveness		✓	✓		**Supported**	Complementary to infrastructure measures; critical component for successful evacuation and resilient communities
Best practice emergency response and recovery		✓	✓	✓	**Supported**	Complementary to infrastructure measures; critical for optimum decision making, rescue capacity, efficient recovery etc
Improved governance to support integrated flood risk management	✓	✓	✓	✓	**Supported**	Coordination of flood risk management in valley
Collection of post-event flood data/intelligence	✓	✓	✓	✓	**Supported**	Continuous improvement of flood models, emergency response and recovery plans

* In the strict sense, flood mitigation measures and measures that target exposure such as land use planning can reduce or manage the risk but not prevent it

5.3 Options to lower full water supply of Warragamba Dam

Raising Warragamba Dam for flood mitigation is the most effective option because it provides a single point of control for the catchment with the largest contribution to regional floods above the flood planning level (see 5.4.1).

An alternative option is to create airspace for flood mitigation by permanently lowering the full water supply level of Warragamba Dam. Warragamba Dam is a water supply dam and currently holds approximately 80% of Sydney's stored water capacity. Options to change the way the existing Warragamba Dam is operated are either not cost effective, or do not sufficiently mitigate the floods that pose the greatest risk to life or property.

In arriving at this conclusion, two options to permanently lower the dam's full water supply to create airspace to capture floods were investigated - five metres, and 12 metres (12 metres is the maximum possible to the depth of the dam spillway gates).

These investigations were undertaken as part of the development of the 2017 Metropolitan Water Plan for greater Sydney.

A five metre lowering was found to have relatively limited benefits for the larger floods that pose the most risk to lives and property - reducing flood damages by only 27 percent and the dam's capacity by around 18 percent or 360 billion litres of water.

A 12 metre lowering provides moderate flood mitigation capacity, reducing flood damages by around 60 percent on average. However, due to the deep 'V' shape of the reservoir, it would reduce the dam's capacity by around 40 percent or 795 billion litres of water. To make up for the forgone water, new sources of water would need to be built and the existing desalination plant would need to be operated at its maximum effective capacity, at a cost of well over $1 billion.

Reducing water storage would have a significant impact on water security for greater Sydney and on water bills for Sydneysiders. In addition, lowering the dam storage by 12 metres would have its own environmental and water quality costs, and would have serious implications for the release of environmental flows from Warragamba Dam.

The option to pre-release or discharge water from Warragamba Dam's water supply storage to create a temporary air space to capture inflows before a forecast flood was also examined. Pre-releasing has limited effectiveness – it has some benefits for small floods, but minimal benefits for the larger floods that pose the greatest risk to life and people's homes. This is because it is not possible to safely release enough water based on flood forecasts to create sufficient airspace to mitigate significant floods in the critical range where lives and properties are at risk.

5.4 Why raising Warragamba Dam wall by 14 metres is the preferred option

The proposal to raise Warragamba Dam for flood mitigation is effective because it delays and lowers downstream flood levels to:

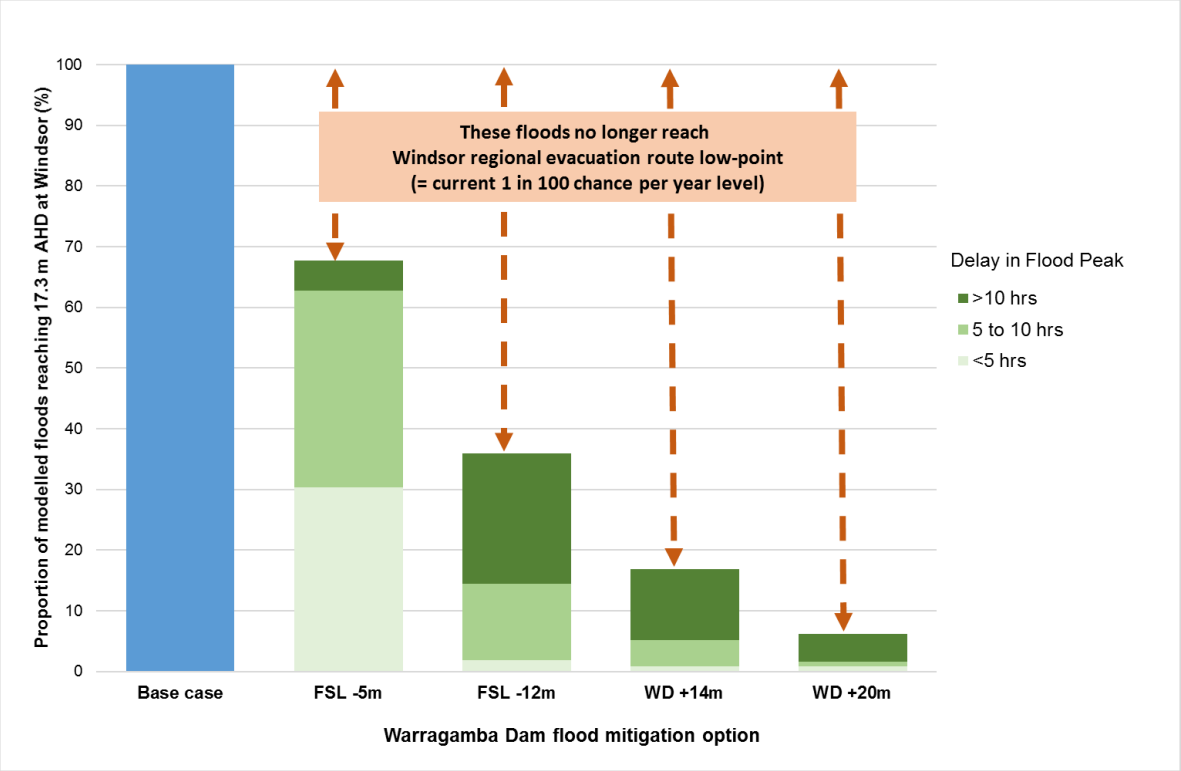
- reduce risk to life by reducing the number of floods that trigger evacuations, **Figure 6**
- increase the certainty of time for evacuation for the floods that still require evacuations, **Figure 6**
- significantly reduce flood damage to homes and businesses by 75% on average.

The Taskforce's detailed modelling work and assessment of options over four years has shown that mitigating floods between the 1 in 50 to 1 in 1,000 chance per year are the most effective to reduce risk to life and property, **Box 2**. Raising Warragamba Dam by 14 metres would provide significant and cost-effective risk reduction in this critical flood range, whilst balancing upstream impacts. It also reduce flood levels by up to five metres in the critical range (**Box 1**) for the high risk flood islands, depending on the location and size of the event.

The 14 metre raising would also provide benefits for the worst possible flood, which is an extremely rare event. It would reduce flood the levels by up to two metres depending on the location on the size of the event. Focusing on the worst possible extreme events rather than the critical range would require a much higher dam wall raising. Higher dam raising such as a 20 metre dam raising would result in larger and longer temporary upstream impacts, and, based on the Taskforce's cost benefit analysis, would not be as cost effective, **Figure 7**.

Figure 6 shows the relative flood mitigation benefits of airspace for flood mitigation created either by raising the dam wall (by 14 metres or 20 metres) or permanently lowering the water supply (by 5 metres or 12 metres) compared to the existing dam. For example, with a 14m dam raising, 83% of the modelled events that currently reach the 1 in 100 chance per year flood planning level would no longer reach that level. The option would also provide additional time for evacuation for the remaining events that would reach or exceed that level, with most delayed by 10 or more hours. The 20 metres dam raising provides greater benefits but is not as cost effective because the incremental benefits over the 14 metre raising are outweighed by the additional costs.

Figure 6 Relative benefits of Warragamba Dam flood mitigation options



5.4.1 Relative contributions from other catchments

The proposal to raise Warragamba Dam for flood mitigation is also effective because the Warragamba Catchment represents around 80% of the catchment at Penrith, and 70% of the catchment at Windsor. Flows from the Warragamba Dam catchment contribute to all of the floods that pose a significant risk to life, homes and businesses.

The current flood planning level, which is based on the 1 in 100 chance per year flood, is 17.3 metres Australian Height Datum (AHD) at Windsor. This is the level above which residential development is currently permitted. Without flows from the Warragamba Dam catchment, flooding downstream is extremely unlikely to reach the flood planning level.

In other words, floods resulting from flows only generated by the Nepean and Grose rivers and all other tributaries do not pose as significant risk to risk to life, homes and businesses compared to floods that involve the large Warragamba Dam catchment.

5.4.2 Impact on insurance

The Insurance Council of Australia has indicated that any reduction in flood risk at individual properties will be considered by insurers, and will typically result in reduced premiums.

The Council also notes that, where effective flood mitigation has been implemented in other states, there have been significant reductions in insurance premiums.

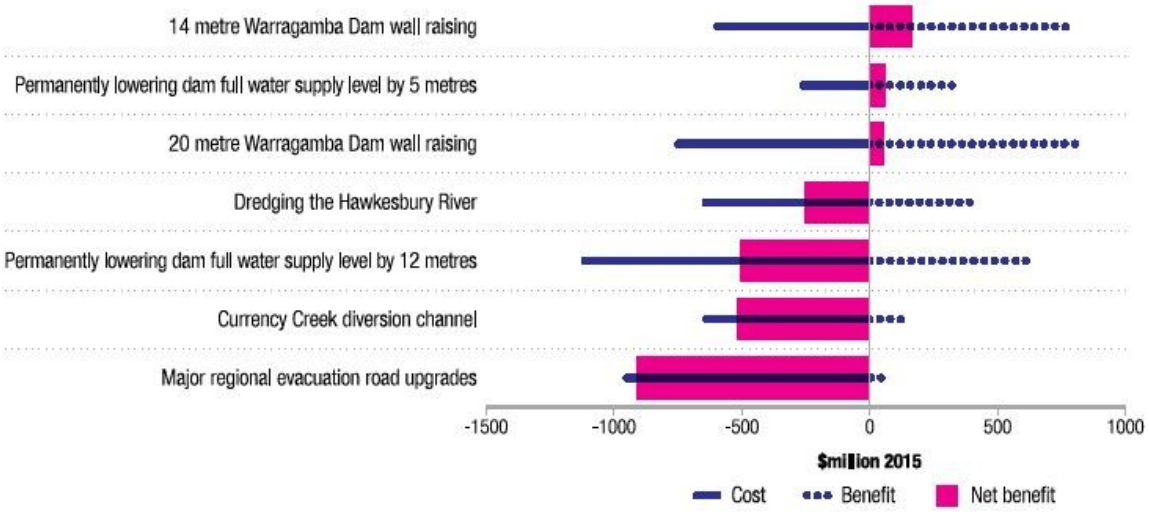
Reductions in flood insurance premiums will make this insurance more affordable. This may lead to an increase in the take up rates for flood insurance resulting in more households and businesses being better able to financially recover from the devastating impacts of future flood events.

5.4.3 Cost effectiveness

Raising Warragamba Dam by 14 metres for flood mitigation was recommended in the Flood Strategy as it the most cost-effective infrastructure option, with net benefits of around $200 million (2015), **Figure 7**.

The raising was estimated to cost in the order of $690 million in 2015 based on a detailed feasibility study. Under the Flood Strategy implementation, the detailed concept design is currently being completed by WaterNSW. This final design will provide the final cost estimate for the raising. A final cost estimate will inform a NSW Government investment decision on the Final Business Case in 2020 (subject to planning approvals).

Figure 7 Comparison of 14 metre Warragamba Dam raising with other infrastructure options[8]



5.4.4 Raising Warragamba Dam is not about increasing water supply

Raising Warragamba Dam proposal does not involve increased water storage. The flood mitigation zone created by the raised dam would only be used to temporarily store floodwaters during floods.

Increased water storage at Warragamba Dam was considered as part of the development of the 2017 Metropolitan Water Plan for greater Sydney, but not taken forward. The main reasons for not progressing this option were that it would further increase the reliance on Warragamba Dam, which already holds 80% of Sydney's stored water capacity, and the larger and more permanent upstream impacts associated with permanently increasing the level of stored water behind the dam wall.

5.4.5 Warragamba Dam environmental flows

Environmental flows are releases from dams for supporting downstream river health. The NSW Government approved the release of a variable environmental flow from Warragamba Dam as part of the 2017 Metropolitan Water Plan. Variable environmental flow releases from dams are designed to maintain and improve river health by more closely mimicking the natural inflows to the storage.

The infrastructure required to release the variable environmental flow from Warragamba Dam is included in the designs of the dam raising for flood mitigation, and will be constructed as part of the

[8] https://www.hawkesbury.nsw.gov.au/__data/assets/pdf_file/0018/93051/Infrastructure-NSW-Resilient-Valley,-Resilient-Communities-2017-January.pdf

raising if approved. However, regardless of whether the Warragamba Dam Raising proposal is approved, a variable environmental flow regime from Warragamba Dam will be implemented.

A raised Warragamba Dam would only operate as a flood mitigation dam during a flood event. Most of the time the dam would continue to operate as water supply dam with environmental flow releases.

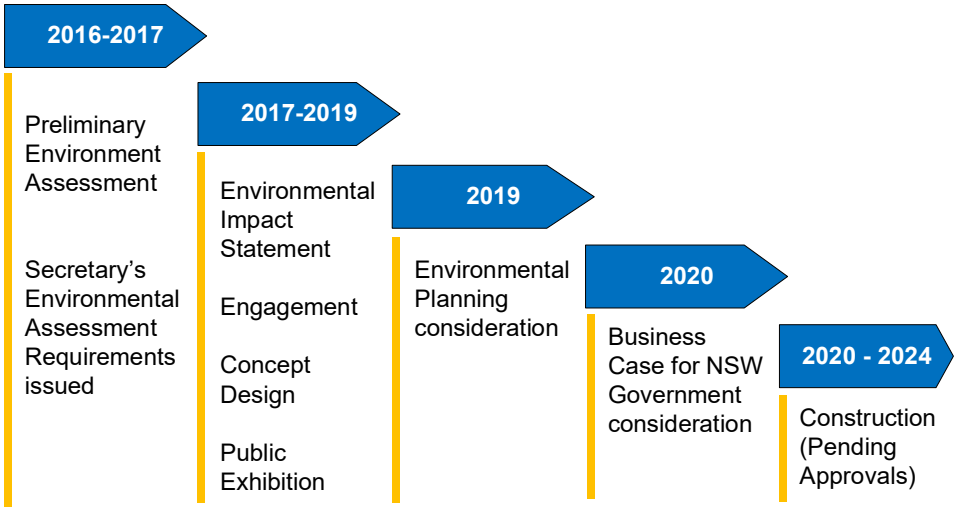
5.5 Warragamba Dam Raising proposal assessment process

The Warragamba Dam Raising proposal is considered state significant infrastructure and will be assessed under NSW and Australian Government legislation, **Figure 8**.

The NSW Secretary of the Department of Planning and Environment has issued a detailed set of assessment requirements.[9] An Environmental Impact Statement (EIS) is currently being prepared for public exhibition.

The proposal is also considered a 'controlled action' under the *Environment Protection and Biodiversity Conservation Act 1999*, and will be assessed in relation to matters of World Heritage, National Heritage and threatened species and communities.

Figure 8 Timeline for the proposal to raise Warragamba Dam for flood mitigation



Modelling, technical studies and analysis are under way to inform the EIS which is scheduled to be exhibited for public comment in 2019. The assessments are being prepared to quantify the benefits and impacts of raising the dam for flood mitigation, including in relation to:

- flooding and hydrology
- biodiversity
- aquatic ecology
- Aboriginal Cultural Heritage
- water quality
- socio-economic impact
- soils, geology and geomorphology
- construction impacts.

[9] Secretary's Environmental Assessment Requirements: https://majorprojects.accelo.com/public/7636122903f88cbb759f65eac95f760f/SSI%208441%20-%20SEARs%20[As%20Revised%2013%20March%202018].pdf

Community and stakeholder consultation is an important part of this process. The environmental impact assessment process will be robustly executed and consider all known possible impacts. The assessments and surveys are not being fast-tracked, and are ongoing. While the dam raising proposal will have very significant community benefits, the Government recognises that decision-makers must fully understand the potential environmental and social impacts, and how they may be managed, mitigated or offset as part of the project design and operation.

5.5.1 Aboriginal Cultural Heritage assessment

Aboriginal Cultural Heritage assessments are ongoing and are being undertaken in accordance with the detailed set of assessment requirements issued by the Secretary of the Department of Planning and Environment[10]. The processes are designed and delivered to meet the requirements for assessment under the *Environment Protection and Biodiversity Conservation Act 1999*.

There is ongoing consultation with Aboriginal communities that have a connection to the land upstream of the Warragamba Dam that would be affected by the proposal. The study area is covered by an indigenous land use agreement (ILUA) with the Gundungurra people.

The design of the Aboriginal Cultural Heritage Assessment Methodology was informed by the requirements and released to the Registered Aboriginal Parties for the proposal - who include Aboriginal representatives of the Gundungurra ILUA Consultative Committee - for review, comment and agreement.

All Registered Aboriginal Parties were also provided with an opportunity to express interest in taking part in site surveys, and given extra time and assistance to respond to the requirements. WaterNSW is in the field this September and October, continuing the surveys that are integral to informing the Aboriginal Cultural Heritage Assessment.

To date, the work has been respectfully recognising and accurately recording Dreamtime Creation Stories which will be an important part of the EIS. The sites which have been identified to date will also be submitted to the Office of Environment and Heritage for inclusion the Aboriginal Heritage Information Management System.

In line with the methodology agreed with the Registered Aboriginal Parties, once the survey effort is complete a report will be drafted that assesses the results of the field surveys in relation to possible increased temporary upstream inundation. The draft report will be provided to the Registered Aboriginal Parties for review and comment. The parties will have 28 days to provide feedback on the draft report. During that period, WaterNSW will schedule meetings with the parties to provide opportunities for clarification and feedback.

The final results of the assessment will be analysed and presented as part of the EIS for the proposal when published for public comment in 2019.

[10] Secretary's Environmental Assessment Requirements: https://majorprojects.accelo.com/public/7636122903f88cbb759f65eac95f760f/SSI%208441%20-%20SEARs%20[As%20Revised%2013%20March%202018].pdf

5.5.2 Biodiversity assessment

Surveys for all species are being undertaken in accordance with the required framework for biodiversity assessment and other relevant guidelines. All relevant threatened and listed species, including the endangered Regent Honeyeater, have been included in the scope of the surveys and the biodiversity assessment. This work is being undertaken in consultation with the NSW Office of Environment and Heritage.

The results of the assessment will be analysed and presented as part of the EIS for the proposal when published for public comment in 2019. Where impacts cannot be avoided or mitigated, biodiversity offsets will be developed. These will also be detailed in the published EIS.

6 Implementing the Flood Strategy

The Flood Strategy is currently in its first implementation phase (2016-2020).

While there has been much focus on the Warragamba Dam Raising proposal, implementation of other important elements of the Flood Strategy is well under way. This implementation is focused on shorter-term actions to improve resilience to floods. These actions include improving land use planning arrangements to account for flood risk, improving capacity to respond to flood emergencies, improving flood mapping, forecasting and warning, and improving flood awareness and resilience of the community.

6.1 Land use planning and development

Development in the Hawkesbury-Nepean Valley is the result of both past and present planning practices and Government approvals that date back to the early days of European settlement. The valley includes historic settlements at Windsor, Richmond, Pitt Town, Warragamba and Penrith, as well as newer development areas such as those associated with the North West Growth Centre.

The Flood Strategy noted that the population at risk was forecast to double in the next 30 years. This forecast was based on development that can occur under current land use planning arrangements. This number is not a target, nor is it dependent on the proposed dam raising. Rather, it was a forecast used to understand the current and future risk environment without any risk treatment.

This is why the Flood Strategy includes actions to integrate land use and road planning to adapt to and manage the ongoing flood risk in the valley.[11] Much of the flood risk relates to homes and businesses between the 1 in 100 chance per year flood level, the current 'standard' flood planning level, and the worst possible flood. While this level may be appropriate for other floodplains, it does not adequately take into account regional flood risk in the valley. This is because flood levels can be up to nine metres above the 'standard' flood planning level at Windsor.

The flood planning level is intended to reflect the combination of likelihood and consequences (e.g. damages), that creates the greatest risk to be considered in land use planning decisions. However, in the valley, the extent of possible damages from more extreme events means the 'standard' level will be reconsidered as part of the work under the Flood Strategy.

Since a Ministerial Direction made in 2007, local councils have been restricted in their consideration of flood risk above the 1 in 100 chance per year flood level, including applying flood development controls above that level. The Direction was issued in response to concerns that flood controls and notations on planning certificates would increase the insurance costs for landowners in the valley. The insurance industry data reviewed in the development of the Flood Strategy show premiums have increased due to the risks in any case.

An action under the Flood Strategy is to review the current planning policy arrangements to account for the high flood risk above the 1 in 100 chance per year flood level in the valley. This review will be consistent with the principles of the Western City District Plan, which includes consideration of the full range of flood risk. The result will be a new Regional Land Use Planning Framework, that will take account of the cumulative impacts of growth and an Evacuation Roads Masterplan being developed by Roads and Maritime Services.

[11] See frequently asked questions on 'Land use planning' at http://www.infrastructure.nsw.gov.au/expert-advice/hawkesbury-nepean-flood-risk-management-strategy/

The areas subject to flood-related development controls - based on the current 1 in 100 chance per year flood level - will continue to be subject to current controls should the Warragamba Dam Raising proposal be approved. In other words, even though the flood risk at the current 1 in 100 chance per year flood level will be reduced to less than 1 in 400 years with the proposed dam raising, development will still be restricted to the current 1 in 100 chance per year flood level to preserve the flood mitigation benefits of the dam raising.

In the case of new developments, land use planning decisions are being taken on the basis of the cumulative impact of growth on evacuation capacity. In past five years, the NSW Department of Planning and Environment has refused multiple proposals for rezonings to allow new developments on flood grounds because evacuation capacity did not match the likely development potential. This included not rezoning the proposed 5,000 dwelling residential development in Penrith Lakes, a planning proposal for increased residential development in Windsor, and the Emu Plains Corrections facility which NSW Corrections decided not to proceed with once the flood risks were modelled and understood.

The approach to development in the North West Growth Centre has also been changed. Recently exhibited land releases (Marsden Park North and West Schofields) include flood provisions to cap development between the 1 in 100 chance per year flood level and the worst possible flood (Probable Maximum Flood or PMF). Higher density development is only allowed above the PMF for safe regional evacuation out of the floodplain in these areas. The draft masterplans ensure that new houses will not be located in high risk flood areas and that evacuation routes allow residents to leave the area safely in the event of severe to extreme flooding.

The Regional Land Use Planning Framework will provide the basis for decisions to be taken on the vulnerability of certain locations in the Hawkesbury-Nepean to further development. It may be necessary to consider whether the development allowable under current planning controls needs to be restricted to ensure evacuation capacities can match the development potentials. This would involve changing existing zonings and land use planning policies.

6.2 Monitoring, forecasting and warning actions

To safely evacuate people in a flood emergency, the NSW State Emergency Service relies on forecasting and flood predictions from the Bureau of Meteorology.

Under the Flood Strategy, over $2 million has been allocated to the Bureau of Meteorology to enhance their flood forecasting capability for the Hawkesbury-Nepean Valley.

Improved rainfall and flood forecasts, new modelling, flood guidance, and decision-making tools for the NSW State Emergency Service will provide greater clarity about the timing, behaviour and heights of floods. This will support improved emergency response. The project is underway and on track to start trialling the new forecasting tools in 2019.

6.3 Resilience road upgrades

While the Flood Strategy does not include large-scale regional road upgrades as they are not cost effective (see page 7 above), it identified that a package of smaller scale road upgrades should be further investigated.

Surveys and investigations are currently under way to identify the flood evacuation benefits of these 40 smaller scale road upgrades. These priority upgrades would improve access to major evacuation routes during a flood event. They include intersection upgrades and improved drainage to prevent premature closure of local and state roads.

Once investigations are complete, business cases will be submitted to obtain funding for these upgrades.

6.4 Emergency response and recovery planning

NSW government agencies, including Roads and Maritime Services, Infrastructure NSW and the NSW State Emergency Service are working together to improve evacuation planning and response.

The evacuation plan for the Hawkesbury-Nepean Valley is included in the Hawkesbury-Nepean Flood Plan[12], a state-level emergency plan in recognition of the significant flood risk in this valley. It has been revised and updated to reflect the ongoing emergency planning work over the last five years.

A specific Hawkesbury-Nepean Valley Flood Recovery Plan has been developed in recognition of the long term social and economic consequences of recovery associated with the significant flood risk in this valley.

A key element of the Flood Strategy is a $1.8 million signage project to help guide people along evacuation routes and out of the floodplain. The signage system has been developed for use along the current Hawkesbury-Nepean Valley flood evacuation routes. The new signage will help people safely navigate out of the floodplain during an evacuation. The design of the system was informed by extensive user testing through driver simulations, technical field surveys and surveys of floodplain residents. The rollout of the new signage across the valley is scheduled to start later this year.

6.5 Better flood risk information

A new Regional Flood Study has been prepared for the Hawkesbury-Nepean Valley. The Regional Flood Study covers riverine flooding, it does not cover overland flow or tributary flood risk which are usually covered in local flood studies (done by councils). The flood study updates the modelled flood risk from the Hawkesbury-Nepean River across the region, and helps plan for and manage flood risk.

The last regional flood studies for the valley were completed more than 20 years ago. Since then, there have been significant advances in the science of flood modelling, increased understanding about the impacts of climate change, infrastructure changes, and significant population growth and development within the valley.

The Regional Flood Study will provide guidance for significant planning and development considerations at regional level. It will inform the Warragamba Dam Raising project, emergency management including evacuation planning, and strategic land use planning for the valley. It will provide regional flood information for local councils, residents and businesses, and be available to be used by insurance companies to help inform insurance premiums. The Regional Flood Study is currently being reviewed by all floodplain councils

[12] https://www.ses.nsw.gov.au/media/1627/plan-hawkesbury-nepean-flood-plan-sept-2015-endorsed.pdf

As a companion piece to the Regional Flood Study, an asset database has been developed and updated with the latest information to map and assess all development in the floodplain, both now and in the future.

6.6 Increasing community flood risk awareness and preparedness

The Flood Strategy includes a broad range of actions across government and the community to build resilience to floods.

A recent survey of floodplain residents found that only 18% were aware that they lived in a high-risk area for flooding. Around 80% had done nothing to prepare for floods.

As part of raising flood risk awareness, contemporary flood risk information is essential. The Regional Flood Study with updated flood maps is scheduled for release later this year. This new mapping, along with information on how to prepare for floods, will be made available to the community as part of a flood risk awareness campaign planned for early 2019.

Other initiatives under way include:

- a new syllabus support tool being developed for year 9 Geography teachers and students using flooding in the Hawkesbury-Nepean Valley as a case study
- increasing flood preparedness for vulnerable communities, such as the aged, people with a disability, and families with young children
- updated information on flooding for local communities using contemporary information and platforms under the Government's new 'Get Ready' for disasters program.