SYDNEY: FLOODING AND THE CUMBERLAND PLAIN

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Abstract

Sydney sits at the centre of the Cumberland plain which is encircled by the Blue Mountains. The western edge of this plain is defined by the arc of the Nepean and Hawkesbury rivers. Into this system flow a number of rivers which rise in the rugged valleys of the Blue Mountains and contain dams which supply the growing population of Sydney. The largest of these is the Warragamba River and dam. Completed in in 1960 in response to the droughts which hit Sydney after World War II, it accounts for about 80 percent of the available water supply for the Sydney region. The catchment area is classified as UNESCO World Heritage and contains a rich cultural legacy of its first nations people, the Gundungurra people.

There are three pinch points between the dam and the sea, and these generate major floods in major rain events. The dangers of development in flood plain areas were pointed out by Governors Phillip and Macquarie in the earliest days of the colony, to be ignored with periodic and regular floods causing major loss of life and property ever since.

Extension of urban development as Sydney's population has grown has created westward pressure for urban development in flood prone areas creating major friction between planning regulators, land holders and developers. This conflict is exacerbated by continuing housing development on vulnerable land which insurance companies refuse to insure, leaving owners exposed to loss of home and livelihood and without recourse to compensation.

Raising the height of the Warragamba dam wall to alleviate flooding is a politically expedient proposal espoused by developers, ambitious landholders and politicians as an easy solution to flooding of urban and potential urban development areas. However, technical studies have shown a minimal benefit to flooding impacts in terms of time and extent. Raising the wall and the water level by fifteen meters impacts on the World Heritage Area by flooding the catchment area and inundating large areas of the wilderness area with loss of cultural and natural heritage. The public debate has been bitter and controversial, and extended to the NSW Parliament. The defeat of the Conservative coalition has resulted in the abandonment of the proposal, but development pressures remain, and the battle is far from over[1].

Key Words: Flooding, climate change, flood plain, urban development, affordability

[1] https://www.smh.com.au/environment/conservation/a-big-weight-off-the-shoulders-warragamba-dam-wall-raising-shelved-20230418-p5d1f4.html

1. Early History

In 1789, Governor Arthur Phillip was exploring at the confluence of the Hawkesbury, Nepean and Grose rivers at the foothills of the Blue Mountains in Sydney's north-west. He noticed weeds entangled in the tree canopy and learned from his Aboriginal guide it was remnants of a flood that had swirled through a few years previously. Phillip warned colonists about the dangers of living too close to the river. They ignored him. The first recorded flood in the area occurred in 1795, although it was a relatively small event. Subsequent floods occurred in 1799, 1806, and 1809. Ten years later colonists experienced their first major flood when the river peaked at 15.25 metres. Governor Lachlan Macquarie issued his first warning in 1810. He was largely ignored. Two floods later, his order to change their "wilful and wayward Habit" and move to higher ground was read from every church pulpit. Those who ignored him would be considered "wilfully and obstinately blind to their true Interests" and undeserving of government help or protection. Yet Catharine Eather, aged just 36, was mercilessly swept up with her sister-in-law Emma, 38, their five children apiece and eight others on June 21, 1867.[2][3]

On April 4, 1817, Governor Macquarie lamented "it is impossible not to feel extremely displeased and Indignant at [settlers] Infatuated Obstinacy in persisting to Continue to reside with their Families, Flocks, Herds, and Grain on those Spots Subject to the Floods, and from whence they have often had their prosperity swept away …"[4]

This highest flood since European settlement that spilled 19.26m above Windsor Bridge is spoken about with dreadful awe to this day. But a bigger monster swelling more than seven metres higher is not only possible but probable. Aboriginal stories remember it. We should have prepared – we were warned. There have been another five floods reaching fifteen meters and marginally lower recent measured at the Hawkesbury River at North Richmond. The largest flood in living memory was in November 1961, when the water reached 14.5 metres above normal river height at Windsor. Major flooding continues to occur here, and future events may exceed the levels reached during previous events in March 2021, March 2022, and April 20221.

2. First Nations Impact.

European settlement beginning at Sydney Cove extended westward following the river flats of the Hawkesbury and Nepean rivers, forcing removal westward as Europeans appropriated traditional lands through occupation, violence and land grants by the colonial administration, on the premise of *Terra Nullls* .[5] The search for rich soils capable of sustaining European patterns of agriculture was highly disruptive of traditional patterns of land and water use. This illegal extension met with vigorous resistance.[6] This native resistance was led by the notable warrior Pemulwuy culminating in the "Battle of Parramatta." However, occupation of the Cumberland Plain continued as migration and emancipation swelled European population numbers and westward pressure grew.[7]As One of the first places in the Gundungurra traditional homelands that most appealed to the Anglo-Celtic settlers were the river flats of the Burragorang Valley (now flooded under Lake Burragorang). Even

[2] https://www.smh.com.au/national/governors-phillip-and-macquarie-warned-about-building-in-the-path-of-floods-still-we-don-t-listen-20220303-p5a19i.html
[3] Hawkesbury Flood Levels 1799-1992
https://hawkesbury.nsw.gov.au/__data/assets/pdf_file/0020/45515/Hawkesbury-Flood-Levels-2018-May-SECURED.pdf
[4] Pittock
[5] Karskens, Grace 2023 People of the River
[6] Karskens, The Colony pp 474-481
[7] https://en.wikipedia.org/wiki/Warragamba_Dam

before the valley was officially surveyed in 1827-1828, many early settlers were already squatting on blocks that they planned to officially occupy following the issue of freehold title grants. From the Burragorang Valley and using Aboriginal pathways, other valleys to the west were occupied and developed by the settlers with construction of outstations and stock routes. These cattle entrepreneurs were then followed by cedar-wood extractors and miners.[3]

The story of occupation begins in the 1830s, when cattlemen from the Nepean districts gradually encroached upon the valley. The Gundungurra clans, with their distinct identities, inhabited the area. Over time, other surrounding groups also moved into and out of the valley.
The Gundungurra traditional owners resisted the taking of their lands and relying on various laws of the colony at the time, continually applied for official ownership. Although their individual claims failed, in some kind of recognition of the significance of the designated tracts of land claimed, six Aboriginal Reserves (under the control of the NSW Aborigines Protection Board) were formally declared in the Burragorang Valley. Even after these reserves were revoked, many of the traditional owners remained, quietly refusing to leave their traditional homelands.[3] In 1876, local Aboriginal people rallied to purchase a farm at the junction of the Cox's and Wollondilly Rivers.
However, in 1924, Aboriginal families, including those of Skerrit and Shepherd, were forced off the valley's farms. Some relocated to communities like La Perouse and Salt Pan Creek on the Georges River3. Aboriginal individuals and families played central roles in this unfolding narrative.
Their relationships with settlers, particularly the Catholic community, are documented, resonating with the work of eminent local historian Jim Barrett[8].

In 1845, Paweł Strzelecki drew attention to the Warragamba River as a water supply catchment; in 1867, supporters proposed a dam.[4] Between 1867 and 1946, supporters of Strzelecki's proposal proposed various schemes before the site and design of the current dam received approval.[4] During the 1950s the entire population of Burragorang Valley was forcibly evacuated, houses were pulled down and the valley cleared on trees and vegetation in preparation for the completion of Warragamba Dam in 1960s.

Finally pushed into the "Gully", a fringe development in West Katoomba from about 1894, the Gully community stayed together for more than 60 years until dispossessed of the Gully by the then Blue Mountains Shire Council so a group of local businessmen could develop a speedway that became known as the Catalina Racetrack. The Gully people kept talking about areas of land they had walked in as children - the nearby Megalong and Kanimbla Valleys and the Burragorang Valley. They knew of the profound significance of these valleys for their parents and grandparents.[5][3] The poignant theme of loss reverberates throughout this history.

3. The Cumberland Plain, the Sydney Basin and its Hinterland.

The Cumberland Plain plays a crucial role in shaping the geography of Sydney.
Much of the Sydney metropolitan area is situated on this plain. The Cumberland Plain lies within the Permian-Triassic Sydney Basin. It spans approximately 2,750 square kilometres and is characterized by Triassic shales and sandstones. The plain extends from about 10 kilometres north of Windsor in the north to Picton in the south. Its eastern boundary includes parts of the Inner West and Northern Suburbs. Formed around 80 million years ago, the Cumberland Plain is not perfectly flat but rather a low-lying area. It predominantly consists of shale and labile sandstone. The plain's recognition is often based on comparison with the surrounding uplands of harder quartzose Sydney sandstone.

[8] Barrett, Jim 1995 Publisher: J. Barrett, 1995: *Life in the Burragorang* ISBN: 0646260545, 9780646260549

Central to the Cumberland Plain is the Sydney Basin with Sydney Harbour located on a layer of sandstone at the centre of its eastern edge. The Plain has nine rivers and just over a hundred creeks. The Nepean River rises to the south in the Woronora Plateau and wraps around the western edge of the city. Swamps and lagoons are existent on the floodplain of the Nepean River, one being Bents Basin, which is also a recreational area. Where the Nepean turns east it becomes the Hawkesbury River, which winds through the Hornsby Plateau before emptying into Broken Bay. Broken Bay and the lower Hawkesbury form the commonly accepted boundary between Sydney and the Central Coast to the north. The remaining section of Warragamba River flows 3.5 kilometres (2.2 mi) north-east from the Warragamba Dam spillway to its confluence with the Nepean River.[36]
According to modelling from the State Emergency Service (SES), there are three main "choke points" in this river system, which slow the water trying to escape to the ocean. They are at places where the rivers are particularly narrow around:

1. Windsor
2. Emu Plains
3. Wallacia[9]

All this water needs to get to the sea, but natural choke points, where the river narrows, slow the path in this valley. This is called the bathtub effect, where water backs up and starts filling the floodplain because there is only one plug hole letting water out. Five major tributaries act like taps pouring water into the valley during a flood, and while every flood is different the Warragamba River contributed up to 70 per cent of the water in major floods that happened in the past sixty years. The other tributaries typically make smaller contributions. The first chole point is at Wallacia. Because water is confined in a small valley at the Wallacia choke point the worst flood here reached depths around twenty meters above normal river level. Further downstream the flood plain at Penrith and Emu Plains is created by the next choke point. Because Penrith has naturally high riverbanks, which hold the river back, low lying areas around Emu Plains and Peach Tree Creek are affected first. However, extreme floods in the past have reached as far East as Woodriff St in Penrith.

[9] https://www.abc.net.au/news/2021-03-21/nsw-floods-explained-and-why-sydney-is-at-risk/100019728

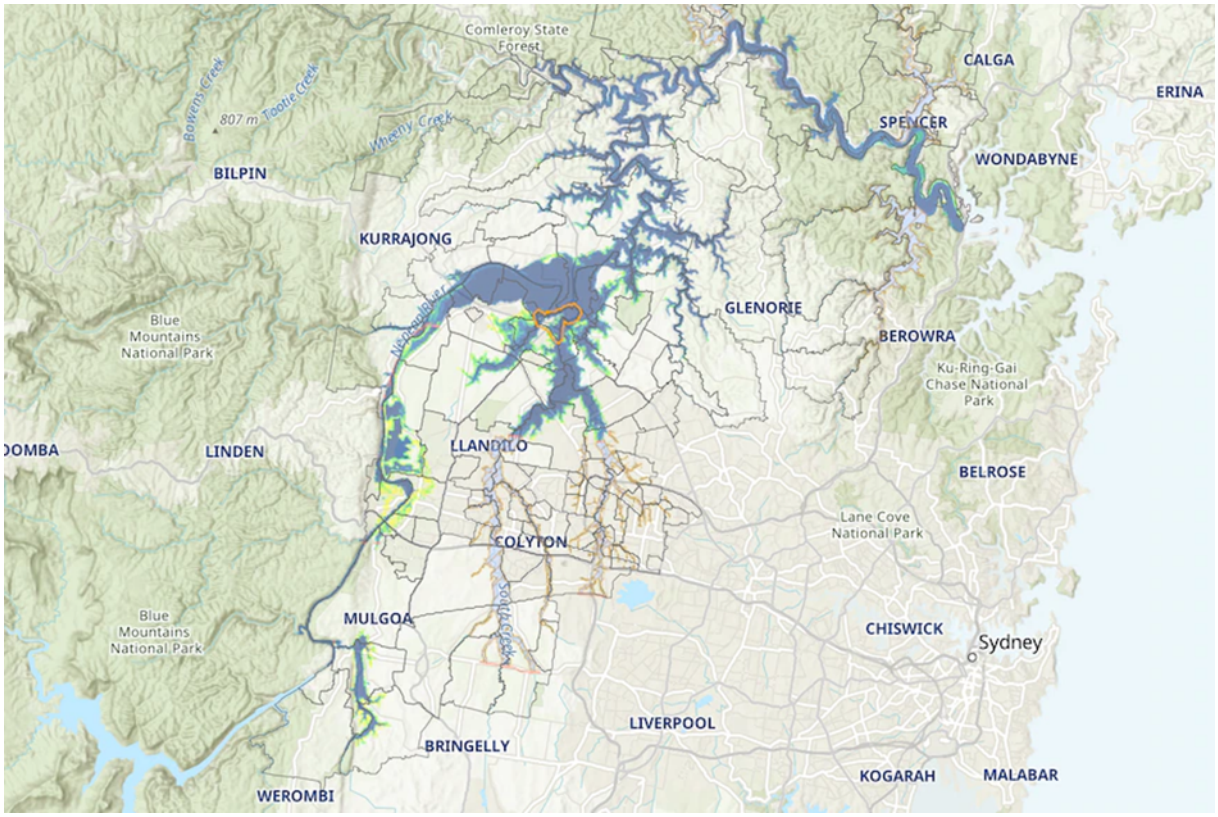

Figure 1. The Hawkesbury-Nepean floodplain (Infrastructure NSW Flood Factsheet, February 2018).

Further downstream the next choke point is caused by a series of gorges starting at Sackville. The Sackville Bathtub is located between Richmond and Sackville. As part of the Cumberland Plain area of Western Sydney it was formed very slowly over 100 million years due to plate tectonic processes. The bathtub's mudstone rock layers are folded into a broad, shallow, basin-shaped depression, which is surrounded by steep terrain. Because the Windsor/Richmond flood plane is relatively flat and wide flood waters spread quickly across a vast area. In the worst flood on record here the river reached nineteen meters above its normal level. Flood waters back up into creeks in the valley, and flood islands form as flood waters rise. It is this bathtub effect that makes floods in the Hawkesbury Nepean so devastating, putting tens of thousands of homes under threat of inundation.[10] Many of the 18,000 people who were evacuated in recent floods live in and around this region known as the "Sackville Bathtub". As the name suggests, this flat, low-lying section of the floodplain region was spectacularly affected. Downstream of Sackville, the Hawkesbury-Nepean River flows through sandstone gorges and narrows in width. This creates a major pinch-point that partially blocks the river channel. In these recent major floods, the Nepean River was forecast to exceed the levels it hit in April 1988, which was higher than both the 2020 and 2021 floods, and caused widespread devastating flooding, the Bureau of Meteorology has said. The river has reached 16.8 metres at Menangle Bridge, similar to the 1988 flood levels, when it peaked at 16.75 metres. However, the BoM warned it was expected to rise to about 17 metres overnight.[11]

4. Climate Change and Event Frequency[12]

[10] https://www.skynews.com.au/australia-news/explained-the-reason-floods-are-so-large-and-deep-in-the-hawkesbury-nepean-valley/news-story/3817cffbf64d7dd0a3113a2691bae5c3
[11] The Guardian 07-04 2022
[12] https://www.sydney.edu.au/news-opinion/news/2021/04/15/sydney-floods-not-if-but-when-sydney-can-expect-more-disasters-hawkesbury-nepean.html

Australia's climate change policies are set out in the document "Australia's climate change strategies". However, the policies relate to the future not the immediate and recurrent crises.

Based on long-term (1910–2013) observations, temperatures in the Metropolitan Sydney region have been increasing since about 1960, with higher temperatures experienced in recent decades. The region is projected to continue to warm during the near future (2020–2039) and far future (2060–2079), compared with recent years (1990–2009). The warming is projected to be on average about 0.7°C in the near future, increasing to about 1.9°C in the far future. Inland, away from the coast, the number of high temperature days is projected to increase. Fewer cold nights are projected in inland areas and the Blue Mountains. The warming trend projected for the region is large compared to natural variability in temperature and is similar to the rate of warming projected for other regions of NSW. The region is expected to experience an increase in all temperature variables (average, maximum and minimum) for the near future and the far future. The greatest increase in the number of hot days is projected for Western Sydney and the Hawkesbury with an additional 5–10 days in the near future, increasing to over 10–20 additional hot days per year by 2070. Rainfall is projected to increase in autumn, while the region is expected to experience an increase in average and severe fire weather in the near future and the far future. The increases are projected mainly in summer and spring in the far future.[13]
During March 2021, large regions of Eastern Australia experienced prolonged heavy rainfall and extensive flooding. This was associated with strong horizontal water vapor transport over this region that persisted for approximately 10 days. The amount of water vapor transported over Sydney during this event was extreme and within the top 0.3% of all days since 1980. In this study, we used climate models to project how much more often events such as these may occur by the end of the twenty-first century under two greenhouse gas emission scenarios. We found that the probability of long duration high water vapor transport over Sydney, as in March 2021, may increase by 80%. [14]

To quote Dr. King[15] on the impact of climate change on flooding, "We know that short-duration, extreme rain events — those dumps of rain we get in the space of half an hour or an hour — there is evidence to say that those are getting more intense. This was partly related to the amount of water the lower atmosphere could hold increasing by about 7 per cent for every degree Celsius of warming and the Australian climate has warmed by 1.4 degrees since 1910. In other words, more water in warmer air leads to more rain and more floods".

5. Flood Patterns: Fukushima and Lismore Studies

In contrast to the detailed and thorough technical studies of the Hokuriku coastline following the Higashi Nihon Daishinsai detailed studies of the geomorphology and hydrology of the Sydney Basin are outstanding. The Japanese studies identified vulnerable areas and locations where urban facilities and housing could be developed with new escape and evacuation routes for those economic and administrative functions which required colocation with the port and the fishing industry. In Sydney this process remains incomplete and subject to political controversy.
The disastrous Lismore floods in 2022[16] with its huge loss of life, livelihood and property has generated a greater level of research in seeking future preventative measures. The regeneration of the town of Lismore[17]itself is requiring large amounts of government funding which may be a factor

[13] Climate change in Metropolitan Sydney | AdaptNSW
[14] State of the Environment: the findings - The University of Sydney

[15]

[16] https://www.smh.com.au/interactive/2022/lismore-flooding/
[17] https://www.smh.com.au/national/nsw/in-the-northern-rivers-planes-have-been-criss-crossing-the-sky-to-recreate-a-disaster-20240221-p5f6pn.html

in the process. Here too, based on historical data, geographical analysis, differentiation and location of economic and residential zonings has played a significant role in reconstruction with the long-term aim of the prevention of a reoccurrence. This includes property publicly funded buy-back and relocation programs and the development of improved access roads and escape routes.
In the Sydney basin studies by the NSW government have been carried out with a view to minimising loss of life, but the area is under fragmented local jurisdictions, administrations and zonings which militate against a holistic approach to the region and its planning. Attempts at Integrated approaches to planning include Cumberland Plan and Greater Sydney Commission. The Greater Sydney Commission was an independent agency funded by the New South Wales Government with its primary responsibility is metropolitan planning in partnership with state and local government. In December 2021, former NSW Premier Dominic Perrottet announced intentions for a new Cities ministry overseeing a region of Six Cities, including Greater Sydney, the Central Coast, Newcastle, and Wollongong. The Greater Cities Commission Act 2022 came into force, creating a new regional agency known as the Greater Cities Commission. It replaced the Greater Sydney Commission Act 2015. Current strategies and the environmental background can be viewed at the website nsw.gov.au ttps://majorprojects.planningportal.nsw.gov.au/prweb/PDF

[18] Report on the Great East Japan Earthquake Disaster
東日本大震災合同調査報告書編集委員会
Joint Editorial Committee for the Report on the Great East Japan Earthquake Disaster

6. Urban development and expansion

The Hawkesbury-Nepean Valley has a long history of dangerous and damaging floods. Since records began in the 1790s, there have been about 130 moderate to major floods in the valley, including five major and 20 other serious floods since Warragamba Dam was completed in 1960.[19]

Population Growth
Thousands more people could soon be living on an extensive flood plain on the fringes of Sydney if land already approved for development were to proceed, according to planning officials, councillors and the New South Wales government's own data. the region's population is expected to double over the next 30 years. Blacktown City Council alone has more than 10,000 homes already planned, with that region's population expected to swell by half to more than 600,000 over the next two decades.
About 425 square kilometres of land lie within the probable maximum flood in the Hawkesbury-Nepean valley, NSW estimates heard on Friday. While the NSW government is pausing new developments while it revises its flood strategy, pressure to open up more land for housing is not expected to ease.

Cultural Expectations
Since the conclusion of the Pacific War, Australians have shown a marked preference for a one family house and land with resistance to apartment living. This predilection has been encouraged by politicians who, in creating a lifetime housing finance system considered that home ownership would encourage political conservatism. The system was also based on the assumption that there would be an unlimited supply of land for housing on the Cumberland Plain However, due to Sydney's growing population and the housing affordability crisis, local governments in Western Sydney have been under pressure to build more and more homes, extending into vulnerable low lying areas,

[18]

[19] https://www.ses.nsw.gov.au/media/3172/it-will-flood-again-fact-sheet.pdf

despite the known flood risk. In 2018, more than 140,000 people lived or worked on the Hawkesbury-Nepean floodplain. Due to this large population and the region's geography, the area has the most significant and unmitigated community flood exposure in Australia. Further, the region's population is expected to double over the next 30 years. At the same time, climate change will change rainfall patterns and make severe flooding more likely.

Housing Affordability

There is limited land supply in the Sydney Basin so that Sydney is ranked as the second least affordable housing market in the world, the problem of housing affordability in Sydney has residents facing skyrocketing house prices, limited affordable rental options, and significant impacts on their lives. In 2021 Sydney's housing affordability was considered nearly the worst in a decade.[20] To address the issue of regular floods, strict new rules threaten construction of thousands of homes in south-west Sydney. Thousands of new homes earmarked for the Georges River basin are under threat from these new flood standards, with councils claiming the rules are hampering their ability to address Sydney's housing supply crunch[21]. The current government is in consequence wrestling with the dilemma of meeting ambitious housing targets and protecting communities from natural disasters supercharged by climate change

Infrastructure

Flooded roads around NSW Pitt Town, where residents have called for a safety evacuation plan. This and other NSW towns repeatedly cut off by floods demand safe evacuation route. Rob Stokes, NSW's infrastructure and a former planning minister, said the latest flooding reinforced the need to take a precautionary approach towards flood plain developments, including tackling the legacy of past decisions. "We had some real concerns," said Stokes, who intervened in late 2020 to halt development in part of the flood plains and gave regional councils more discretion to limit new projects in 2021.

Flood prone land and definition of a flood plain:

The standard hydrological definition of floodplain land is land that will be inundated in floods up to the estimated level of the Probable Maximum Flood (PMF) – the biggest flood believed to be possible at a given location. Invariably, this means land that will be inundated in floods that are much worse, and vastly more infrequent in occurrence, than any flood recorded at that place.
In the context of the Windsor area in 1867, a monstrous flood reached a level of 19.3 metres above mean sea level. Much of Windsor was submerged. Another two-to-three metres would have seen it all go under, with disastrous effects for its residents and those from the much lower lands of South Creek, Cornwallis and elsewhere who were sheltering on the town's relatively high ground.
In recent times the three biggest Hawkesbury River floods of 2021 and 2022 peaked between 12 and 14 metres on the Windsor gauge, vastly lower than the 1867 flood. Those floods, which were of scales that can be expected to occur there on average (note those words, on average) roughly every 20-30 years, got into scores of houses. They struck 30 years after the last similarly sized Hawkesbury flood, which occurred in 1990. The estimated 1 per cent (so-called one-in-100-years flood) would reach 17.3 metres on the Windsor gauge. IN normal weather condition, with no flood, the water is at about 1 metre on the gauge. The PMF is estimated to peak at 27 metres – more than 8 metres higher than the 1867 flood.
The word "floodplain" is tricky. Any definition not based on the PMF would be arbitrary and would exclude some land prone to inundation in rare, huge floods. If the highest parts of floodplains from development were to be excluded, we would completely sterilise them from all uses except recreation and agriculture. The PMF will not be part of the answer as regards floor levels for new

[20] https://www.afr.com/property/residential/sydney-s-housing-affordability-nearly-the-worst-in-a-decade-20211025-p592uh
[21] Michael McGowan November 1, 2023 — 5.00am

housing. The real question is: at what level on the floodplain is building an acceptable risk? Discussing this in the context of Sydney's tight real estate market and guaranteed growth will be extremely politically charged. Powerful development interests will be outraged by tightened building restrictions[22].

Access and escape routes.

The NSW Government has released the Hawkesbury Nepean Valley Flood Evacuation Model (FEM) Report to help understand the impact of growth on the capacity of the evacuation network, how this risk changes over time and the potential risk to life. This modelling equips government to make informed decisions for the community and provides an integrated approach to emergency response, regional land use and road network plans for the valley. Development in one area of the valley can impact on the ability of other areas to safely evacuate during a major flood event. It is important further growth in the area is managed so it does not adversely impact evacuation capacity, which can put people's lives at risk.

Property Council NSW executive director Jane Fitzgerald said the Castlereagh Connection, a proposed freeway between the M7 and Castlereagh, and running through a road corridor set aside 70 years ago, was a "key piece of infrastructure that should be progressed".

In a May 2020 letter responding to Penrith City Council's pleas for the route to be prioritised, an Infrastructure NSW official wrote, "while a significant flood event has high impact, given its low probability it is difficult to justify the economic benefit when compared with the high cost of building the Castlereagh Connection. "I do not believe we can sustain any more development in the flood plain," Lyons-Buckett said. "We need to seriously consider the future of those already living there – we need flood proof evacuation routes, as we know the only true way of ensuring safety is to get people out of harm's way."

The Hawkesbury mayor, Patrick Conolly, said his council had halted new developments within the flood plain. His concern, though, was the plan for neighbouring councils such as Penrith and the Hills to increase their populations by many thousands, potentially jamming up evacuation routes. Conolly supported the dam wall raising, however, arguing it was needed to protect existing homes.

"We've got 12,000 houses under the one-in-100-year flood level because they've been here for decades," he said. "And we have to protect them.

"So, in the end, the answer can't just be stop developing, or buy them all back, because neither of those things is practical. "It doesn't solve the problem we've already got."

NSW Planning Minister Rob Stokes has put a stop to billions of dollars' worth of new residential development earmarked for Sydney's north-west until he can be satisfied there are adequate evacuation routes for people fleeing floods. The Herald can also reveal Infrastructure NSW previously told one of the councils flooded this week that a $1.8 billion evacuation route, deemed a priority by its federal counterpart, was not a state priority and not cost-effective, two years after saying there were insufficient evacuation routes for the Hawkesbury-Nepean Valley.

7 Planning legislation and zoning

Environmental Planning and Assessment Amendment (Flood Planning) Regulation 2021 under the Environmental Planning and Assessment Act 1979[23]

The Hawkesbury-Nepean Valley is particularly prone to flooding as it is naturally constricted in two places that, in conditions of severe rainfall, results in floodwaters backing up and inundating floodplains in north-west Sydney. During large flood events there is a risk of roads being inundated by floodwaters before residential areas are properly evacuated. Flood risk has been exacerbated by

[22] https://www.smh.com.au/national/nsw/we-can-t-buy-back-every-home-on-a-floodplain-but-we-can-stop-building-for-certain-disaster-20220704-p5az13.html

[23] https://legislation.nsw.gov.au/view/pdf/asmade/sl-2021-219

local councils and the NSW Government approving housing developments on low lying lands over several decades. Unfortunately, flood risk is likely to worsen given NSW Government plans to dramatically expand the number of people living on the floodplain in north-west Sydney, combined with increased frequency of severe storm events due to climate change[24].
NSW Planning Minister Rob Stokes has paused residential rezonings in Sydney's north-west.
Urban Development Institute of Australia CEO Steve Mann said the decision could cost thousands of jobs and cause house prices to rise: "Our concern is the government's ability to expeditiously find a solution to this issue."
A Department of Planning, Industry and Environment spokesperson said the draft plans prepared for the Marsden Park North area were prepared to ensure no residential development was below the 1 in 100-chance per year flood line, and that this week's floodwaters were "significantly" below the area to be developed. However, the spokesperson said that, given the risks of more severe flooding in the Hawkesbury Nepean Valley, the minister paused the approval of future residential rezonings in the north-west to allow for the completion of the business case and so "the minister has confidence new development can be safely evacuated".
On Sunday, NSW Planning Minister Paul Scully announced the cancellation of planned rezonings for about 10,000 new homes in Sydney's north-west at Marsden Park and Riverstone because of fears the developments would stop people evacuating the Hawkesbury-Nepean floodplain during a flood.

The report shows that a years-long rezoning process to add housing density to the town centres of Fairfield, Cabramatta and Carramar has stalled after advice from a Department of Planning flood advisory panel that the proposal had not adequately considered evacuation routes during a theoretical worst-case scenario flood. It is "unclear exactly how many properties" are affected by the advice, but the report estimates the total "potentially exceeds 1000 of the approximately 5000 properties" planned under the rezoning. In a statement, a spokesperson for the Department of Planning said that while the rezoning was yet to be finalised, a flood advisory panel recommended that "the flood risk should be considered which will result in a reduction in the amount of land that can be rezoned".

8. HOUSING AFFORDABILITY, INSURANCE AND DEVELOPER PRESSURE[25]

As its population approaches 27million, Australia is considered to be in the grip of a housing crisis. Due to natural growth and immigration, affordable accommodation is beyond the reach of many of the population. Despite increased construction and government policy, housing construction has not kept pace with demand[26]. Australia's migrant population is expected to have grown by more than 700,000 between the 2022 and 2024 financial years.[27] In addition to rising purchase cost, recurrent costs contribute to the problem of affordability. Of these required outlays, insurance costs continue to rise to levels where they are prohibitive for lower income house owners. Many of these owners have property in vulnerable or defined flood zones where premiums are higher, leading to owners taking the risk of going without in the hope that a "one-in-100-year flood" will not occur. . Insurers are also in financial difficulty.
The Financial Review[28]carried a recent article, Net loss to home insurers over the last calendar year amount to $635 million". However, what does it mean when a natural disaster is described as a "one-in-50-years" or "one-in-100-years" event? The precise meaning is:

[24] Pittock 2018
[25] Cinque, Peter 2017, *Challenges and mitigation - The inevitable Hawkesbury-Nepean flood* Australasian Fire and Emergency Authorities Council Conference 2017
[26] https://www.planning.nsw.gov.au/research-and-demography/sydney-housing-supply-forecast
[27] https://www.abc.net.au/news/2023-04-29/australian-migrant-population-growth-hits-all-time-record-high/102281798
[28] Read, Michael 2024 *Premiums Soar, Home Insurers Lose* AFR 06-04-2024

- A one-in-100-year flood has a 1 per cent chance of occurring any year
- Town planners use one-in-100-year floods to decide where housing can be built
- One-in-100-year floods are probably not becoming more common in NSW[29]

Thomas Mortlock[30], said "100-year floods" don't just happen once every 100 years. In fact, 100-year floods have happened twice in a fortnight in the same place. "The chance of a 100-year flood is not 100 per cent in 100 years". In that context how do insurers determine the flood risk to an individual property?

In partnership with state and territory governments, the general insurance industry has developed and licensed the National Flood Information Database (NFID) for use by insurers in determining the flood risk to individual properties. NFID is an address database containing 13.7 million property addresses, overlayed with the known flood risk according to government flood mapping. Commercial licensing arrangements between many governments and the specialist flood risk experts who prepare the flood maps means it is not a public database. Most insurers use NFID to determine the flood risk to individual properties, and calculate the premium based on this risk and other criteria including building type, location and claims history. However, it is up to individual insurers to decide what criteria they use to determine flood risk. They may examine information from many sources to identify properties that are prone to flooding. These may include local government flood mapping, historical flood information, terrain data and insurance claims information. Insurers assess how often a property is expected to flood, how severe the flooding may be, and how deep the flood can get. However, the ongoing affordability crisis continues to apply pressure on the real estate market and afford opportunities for ambitious developers.

Changes introduced by the previous Labor government in 2006 with its Resilient Valley Resilient Communities Flood Risk plan have opened the way for developments to proceed within the current one-in-100-year flood zone[31]. The key areas to be developed are Penrith Lakes, Riverstone North, Marsden Park and West Schofields. One obstacle has been the lack of insurance given the spate of recent floods as well as the historical record. However, the multibillion-dollar plan to lift the Warragamba Dam by as much as 14 metres, would serve as a green light for such developments.

One local government agreed thousands of homes that may be exposed to flood risks could be built. “There are over 40,000 hectares of flood-prone land just in the Hawkesbury-Nepean basin, much of it already slated for more housing, and if we let that happen, we are turbocharging future disasters,” Shoebridge[32] said. “Just like the flood waters, money will find its way.”
Hawkesbury city council’s area alone has 23,900 hectares of the flood-prone land, with 11,500ha in Penrith, 4,700ha in Blacktown and 4,500ha in the Hills shire. “The very first thing that the NSW government needs to do to protect homeowners from floods is stop allowing new homes to be developed on known flood plains. The planning minister could issue a state planning policy tomorrow and put a moratorium on new flood plain residential development, but developers hold so much power over state governments that they won’t even discuss it.”
The real question is: at what level on the floodplain is building an acceptable risk? Discussing this in the context of Sydney’s tight real estate market and guaranteed growth will be extremely politically

[29] https://www.abc.net.au/news/2021-03-28/one-in-100-years-flood-talk-misleading/100030144
[30] Adjunct Fellow, Climate Change Research Centre, UNSW Sydney
[31] Guardian Australia
[32] David Shoebridge Australian politician and former barrister. Senator, Federal Parliament

charged. Powerful development interests will be outraged by tightened building restrictions. There are guide documents available to determine individual flood risk[33].

9. Warragamba Dam: Its History and Function

The Warragamba River flows through a gorge that varies in width from 300 to 600 metres (980 to 1,970 ft) and is 100 metres (330 ft) in depth. This gorge opens at its upper end into a large valley, the Burragorang Valley. This river configuration allows for a relatively short but high dam wall, in the gorge, to impound a vast quantity of water.

In 1845, Paweł Strzelecki drew attention to the Warragamba River as a water supply catchment. Water that passes through the Warragamba Gorge drains from a catchment area of over 9000 square kilometres that stretches from south of Goulburn to north of Lithgow. Sustained droughts in the early post-war years impacted water supply to metropolitan Sydney. Presaging this situation, in 1943 the Metropolitan Water, Sewerage and Drainage Board invited the geologist William Browne to investigate a proposed site. Browne found a more suitable site and continued as geological adviser until completion. The site was reviewed and approved by Dr John Savage, considered the pre-eminent expert in this field, and formally accepted by the Metropolitan Water, Sewerage and Drainage Board on 2 October 1946. Dam construction began in 1948 and was completed in 1960. The resulting dam of the Warragamba River formed Lake Burragorang, which is one of the largest reservoirs for urban water supply in the world.

Warragamba Dam is Sydney's largest water supply dam. The dam is made of concrete and took 12 years to build. Lake Burragorang, which is formed behind the dam, holds about four times more water than Sydney Harbour and It accounts for about 80 percent of the available water supply for the Sydney region. When the lake reaches 100 percent capacity after heavy rain, water is released automatically down the central drum gate and radial gates. This water flows down the Warragamba River into the Hawkesbury-Nepean River and eventually enters the sea at Broken Bay.
The purpose of the dam was water supply for Sydney. It was not designed to function in a flood prevention measure, and it will automatically spill when it reaches capacity[34]. The dam itself does not overflow but reaches a trigger point for gates to automatically open and release small amounts to keep the level just below 100 per cent.

The NSW government wants to raise the wall of the Warragamba Dam to help alleviate this problem. But as others have argued, this controversial proposal might not work. That's because raising the wall will control only about half the floodwater and won't prevent major floods delivered by other rivers feeding the region. The second factor making the current floods so bad is the exposure of infrastructure and housing. In the Hawkesbury-Nepean region, lots of stuff people care about – such as homes, businesses and schools – is in the path of floodwaters. In an ideal world, nothing would be built on a floodplain. But due to Sydney's growing population and the housing affordability crisis, local governments in Western Sydney have been under pressure to build more and more homes, despite the known flood risk. In 2018, more than 140,000 people lived or worked on the Hawkesbury-Nepean floodplain. Due to this large population and the region's geography, the area has the most significant and unmitigated community flood exposure in Australia. Further, the

[33] Flood Impact and Risk Assessment Flood Risk Management Guideline LU01 A fit for purpose flood impact and risk assessment can examine flood constraints and how to manage the flood risks posed to and by new development.
[34] https://www.abc.net.au/news/2024-04-06/nsw-warragamba-dam-spills-afer-massive-rainfall-explainer/103677270

region's population is expected to double over the next 30 years. At the same time, climate change will change rainfall patterns and make severe flooding more likely[35].

10. Proposal to raise the wall: perceived benefits and negative impacts[36]

There has been continuing debate and polemics over the proposal to raise the wall of the Warragamba Dam by fourteen meters[37]. This debate continues in the press and parliament as the dam overflows again following a major storm event[38].
Proponents considered that the project, which has been under way for several years, would have resulted in the dam wall being raised by 14 metres, allowing for a flood mitigation zone above the dam's current capacity. It would have been able to hold an extra trillion litres and possibly reduce flood damage by 75 per cent. This would have allowed floodwaters coming through the catchment to be released in a controlled way, delaying and reducing the flood peak for thousands of residents in the Hawkesbury-Nepean region.
The NSW Government commissioned a technical report in September 2017 as the NSW Government response to the growing flood crises. This was the Hawkesbury – Nepean Valley Flood Risk Management Strategy (Infrastructure NSW 2017). This report was met with trenchant criticism from a number of sources including the Colong Foundation for Wilderness 2018, stating:
This strategy does not appear to have benefitted from any independent expertise, nor is there any evidence of scientific peer review. The strategy focuses on infrastructure options that were evaluated by means of a narrowly framed cost-benefit analysis. The strategy discards a number of response options before focusing on a proposal to spend $690 million to raise Warragamba Dam wall by 14 metres to provide 995 gigalitres of air space to store flood waters originating upstream of Warragamba Dam (Infrastructure NSW 2017). This proposal would result in flooding of up to 4,700 hectares of the Blue Mountains National Parks and World Heritage Area, including 65 km of wilderness watercourses, populations of 48 threatened species, as well as numerous sites of cultural significance to the Gundungurra people. Jamie Pittock (2018)[39] has eloquently argued the case against the increased height of the wall and alternative preventative measures. In his view, conservative politicians with the support of the development industry use floods to push the pointless dam project: As we should today, colonials should have known better as they experienced the Hawkesbury-Nepean River ebb and swell with frightening regularity – March 1800, three times in 1806, May and August 1809, June 1816, February 1817, February and June 1819, July 1857, thrice in 1860, June and July 1864, and so on.

However, Water NSW claims Warragamba dam wall project stacks up despite not knowing cost of offsets. Agency dismisses criticisms of the project, insisting it will deliver an overall economic benefit. The New South Wales government agency charged with delivering the controversial raising of the Warragamba dam wall insists the project will have an overall economic benefit, despite not knowing how much it will have to pay in environmental offsets. Dismissing criticisms of the project, Water NSW on Monday released a series of long-awaited reports responding to almost 2,500 submissions objecting to the plan to raise the wall by 14m in a controversial bid to reduce flood risk in the Hawkesbury-Nepean Valley.

[35] https://www.msn.com/en-au/news/australia/warragamba-dam-reaches-capacity-amid-severe-storm-warning/06-04-2024
[36] file:///C:/Users/Peter%20Armstrong/Downloads/HawkesburyvalleyfloodriskmanagementSep18.pdf
[37] https://www.wildernessaustralia.org.au/stuart_ayres_gives_train_wreck_interview_on_warragamba_dam
[38] As at 089-04-2024
[39] Jamie Pittock (2018) Managing flood risk in the Hawkesbury -Nepean Valley A report on the alternative flood management measures to raising Warragamba Dam wall ANU
https://www.smh.com.au/national/stop-putting-people-in-the-way-of-floods-20210321-p57cn6.html

The proposal has been the subject of significant pushback, including from a series of government departments, local councils and environment groups, who have raised concerns about its impact on the World Heritage-listed Blue Mountains area, as well as Aboriginal cultural heritage and threatened species. But the agency has dismissed the vast majority of those concerns, insisting that the project would mean 5,180 homes would be spared from a worst-case scenario flood event – a 68% reduction. It found that a one-in-100-year flood in the Hawkesbury Nepean Valley would affect about 7,600 residential properties, require the evacuation of about 55,000 people and cause about $3bn in damage.
Opponents of the project have insisted it would not alleviate flood risk in the valley, and some have instead called for funding for property buybacks. But the reports by WaterNSW dismiss those calls, saying a land buyback would be prohibitively expensive. Based on June 2021 housing price figures, it found that a wide-scale property buyback would cost about $5.2bn. While the agency said the project had returned a cost-benefit ratio of 1.05 – anything greater than 1 is expected to deliver a net benefit when compared with the cost of the project – WaterNSW said it did not know how much it needed to pay in environmental offsets for the project.
The responsible NSW minister took just five days to agree to fast-track project to raise Warragamba Dam. “As suitable, publicly or privately owned [land] has not yet been identified, and the offset requirements are not confirmed, it is difficult to cost the offset program,” it stated. “The Warragamba Offset Program will consider and respond to non-biodiversity values as well as the biodiversity values of the World Heritage and national park areas.” The release of both the preferred infrastructure and response to submissions reports mean the project will now be again opened for submissions, before further review by the state’s planning authority.
The debate continues as rain events precipitate flooding and controversy[40].

11. **UNESCO WORLD HERITAGE**

The Blue Mountains National Park lies on the eastern side of the Great Dividing Range. The plateau slopes gently down from west to east from a height of around 1,100 metres (3,600 ft) above sea level near Mount Victoria to less than 200 metres (660 ft) above sea level around Glenbrook. There are four major rivers that have most of their catchment inside the park: the Wollangambe River in the north, the Grose River in the centre, and the Coxs and Wollondilly rivers in … The Greater Blue Mountains Area consists of 10,300 square kilometres (4,000 sq mi) of mostly forested landscape on a sandstone plateau, 60 to 180 kilometres (37 to 112 mi) inland from the Sydney central business district.[3] The area includes vast expanses of wilderness and is equivalent in area to Lebanon.
The property, which includes eight protected areas in two blocks separated by a transportation and urban development corridor, is made up of seven national parks as well as the famous Jenolan Caves Karst Conservation Reserve. These are the Blue Mountains National Park, Wollemi National Park, Yengo National Park, Nattai National Park, Kanangra-Boyd National Park, Gardens of Stone National Park, and Thirlmere Lakes National Park.
The area does not contain mountains in the conventional sense but is described as a deeply incised sandstone plateau, rising from less than 100 metres (330 ft) above sea level to 1,300 metres (4,300 ft) at the highest point. There are basalt outcrops on the higher ridges. According to the Australian Department of Climate Change, Energy, the Environment and Water (DCCEEW),[4] this plateau is thought to have enabled the survival of a rich diversity of plant and animal life by providing a refuge from climatic changes during recent geological history. It is particularly noted for its wide and balanced representation of eucalypt habitats from wet and dry sclerophyll, mallee heathlands, as well as localized swamps, wetlands, and grassland. Ninety-one species of eucalypts (13 percent of

[40] https://www.abc.net.au/news/2021-03-22/nsw-weather-ministers-warragamba-dam-stoush-amid-flooding/100020672

the global total) occur in the Greater Blue Mountains Area. Twelve of these are believed to occur only in the Sydney sandstone region

12. Political Debate and Consequences[41]

The controversial plan to raise Warragamba Dam's wall is dead in the water after the NSW government decided not to proceed with the project due to huge costs and environmental and heritage concerns. The news has been welcomed by campaigners including Indigenous communities and environmental groups who have opposed the project for almost a decade and whose position was bolstered by an objection from the United Nations Educational, Scientific and Cultural Organisation (UNESCO).[42]

The NSW government has confirmed it will shelve the controversial raising of the Warragamba Dam wall. NSW Water Minister Rose Jackson said Labor's position had been clear: it had always opposed the raising of the dam's wall. "The project will not guarantee communities in Western Sydney will be safe from flood events," she said. "We know raising the wall would flood the Blue Mountains World Heritage Area; inundating 1200 Aboriginal sites and artefacts, destroying habitat for critically endangered species and [risking] Blue Mountain's World Heritage listing." She added the government would build levies and improve evacuation routes and emergency communications in the Hawkesbury-Nepean. "I have also requested urgent briefings, in the coming days, from the Department and Water NSW regarding Warragamba Dam," she added.

NSW Environment Minister Penny Sharpe said the project would have cost more than $1 billion and affected a portion of the Blue Mountains World Heritage Area that sits around the dam's huge Lake Burragorang reservoir. "We don't think it solves the problem that it says it [will]," she said of raising the wall. "With my environment minister hat on, as a World Heritage Area it should be given the highest level of protection. I am pleased that will be saved. I am happy in relation to habitat for endangered species." She added the area also held significant cultural importance to Indigenous people. "We've been clear about what our position is on that," she said.

Sharpe's announcement follows a commitment NSW Premier Chris Minns made before the election that a Labor government would instead lower the maximum water level, creating a flood mitigation zone without needing to raise the dam wall. Long-term campaigner Harry Burkitt, who has led the campaign against raising the dam, said it had been an eight-year fight to see the project stopped. "Lots of blood, sweat and tears have been poured into this win, and it's a great credit to all the people out there who have supported the campaign – chief among them Chris Minns," he said. "We look forward to seeing [Water] Minister [Rose] Jackson officially withdrawing the development application for the dam raising in the coming weeks and embark on new flood mitigation measures in the Hawkesbury-Nepean Valley.

13. Legislative Proposals

The current relevant legislation is the 2018 Water NSW Amendment (Warragamba Dam) Bill 2018
https://www.parliament.nsw.gov.au/lcdocs/inquiries/2513/Final%20report%20-%20Water%20NSW%20Amendment%20(Warragamba%20Dam)%20Bill.pdf
A proposal to raise the Warragamba Dam wall by 14 metres has been declared Critical State Significant Infrastructure (CSSI), as it is deemed essential to NSW for economic and social reasons.

[41] https://www.planning.nsw.gov.au/news/warragamba-dam-proposal-declared-critical-state-significant-infrastructurehttps://www.parliament.nsw.gov.au/lcdocs/inquiries/2513/Final%20report%20-%20Water%20NSW%20Amendment%20(Warragamba%20Dam)%20Bill.pdf

[42] 'Big weight off the shoulders': Warragamba Dam wall-raising shelved SMH April 19, 2023

This document remains the relevant legislation. However, a recent legislative proposal,[43] "The Six Cities Region"[44] is proposed to transform metropolitan Sydney into a global mega region, the state government says after clearing the way to incorporate Newcastle, the Central Coast and Wollongong into a new Sydney mega planning region. The role of the Greater Cities Commission has been expanded from its original remit of developing a metropolis of three Sydney cities, to creating a six cities vision for the region following the passage of the Greater Cities Commission Bill The region includes Eastern Harbour City, Central River City, Western Parklands City, Central Coast City, Lower Hunter and Greater Newcastle City and the Illawarra-Shoalhaven City. Commissioners to oversee planning for the three new cities will be appointed in close consultation with relevant councils. However, the proposal does not address the long terms issues of climate change, flooding in the major river catchments and the fragmented structure of local administration across the region.

Controversy over the issue continues including the popular press, local government and state parliament characterised by an earlier exchange in a bitter dispute between NSW ministers over Warragamba Dam spilling when former NSW Emergency Services Minister David Elliott blamed his cabinet colleague, Water Minister Melinda Pavey, for failing to mitigate Warragamba Dam spilling as western Sydney faced flooding and evacuations. He said there would need to be "a full and frank discussion" about managing dam levels once the severe weather event was over. Ms Pavey said the significant rainfall caused the spill.
As housing prices and availability continue to cause hardship in the community, this discussion will continue.

Acknowledgements

This paper deals with current and continuing issues and events which are recorded in the daily press as well as other media sources. There is little scholarly recording of research and much of the material in this paper uses these sources which are referenced as accurate as practicable. The authors acknowledge with thanks sources from Commonwealth and State Government web sites, the ABC, Guardian, the Sydney Morning Herald and related newspapers and web sites.

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