Submission on Warragamba Dam Raising EIS

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Specialisations:

From 1967: Hydraulics

From 1976: Environmental engineering

From 1981: Economic and social impacts of flood-risk management strategies

From 1990: On-site wastewater management

From 1999: Archaeological studies of mediaeval water management systems

Professional Activities

1984-9 Environmental Engineering Panel, Sydney Division, Engineers Australia; Founding Chairman.

1995-2018: Standards Australia Committee WS-040 On-site Domestic Wastewater Management

Overseas experience: Oceania, Southeast Asia, Europe

1 Introduction

The draft Warragamba Dam Raising Environmental Impact Statement (WRDEIS) is considered to be an inadequate evaluation of the environmental and economic impacts of the Project to raise Warragamba Dam (the Project), were it to be implemented. This submission should be treated as an objection to the Project being approved on the basis of the draft EIS, or one with only minor or cosmetic amendments.

This submission identifies some serious deficiencies in the draft, and important instances of non-compliance with the Secretary's Environmental Assessment Requirements (SEARs). Even if these were addressed, I am doubtful that the benefits will be found to exceed the Project's costs.

Flood-risk management is concerned with social issues more than most fields of engineering. It is rare for infrastructure built for flood mitigation to produce monetary benefits that exceed their cost: usually the financial benefit-cost ratio is substantially less than one. The work can only be justified economically by assuming that the additional social benefits of avoiding floods are sufficiently great, so that the combined social and financial benefits exceed the costs. There is some evidence to support this assumption. In studies of the social and economic effects of the Sydney floods of 1986 and 1988, we found that the social losses—such as ill health, stress, continuing fear of the next flood, increased irritability and nervousness, breakdowns of family relationships and premature death—could be regarded as no less significant than the financial ones (Lustig and Haeusler, 1989).

It is laudable that the aim of the Project is "to provide flood mitigation to reduce the significant existing risk to life and property in the Hawkesbury-Nepean Valley downstream of the dam." (WRDEIS, 2021, p. 01-2). The EIS asserts that

> *"the Project would result in a range of flood mitigation benefits to the Hawkesbury-Nepean Valley including:*
>
> - *a reduction in flooding extents across all flood events especially in the Penrith, Windsor, Richmond and South Creek areas.* ***This would result in lower flood damages and social impacts from flooding.***
> - *there would be a more predictable rise in floodwaters and evacuation routes would remain open for longer.* ***This would reduce the risk of loss of human life during floods."*** (WRDEIS, 2021, p. 15-81).

Unfortunately however, it is not certain that either of the above assertions—underlined and in bold—follow inevitably from the sentences preceding them. As will be argued, the Project could even *increase* the risk to lives and property.

2 The levee paradox

What is often not accounted for in social and economic assessments of the value of installing a flood-mitigation structures is that their benefits usually decrease over time. What is worse, the levee or flood-storage dam that protects property from flooding can paradoxically make the losses even greater. No flood-mitigation structure can protect against all floods, but people unfamiliar with the local floods too often think that they are fully protected, and they willingly settle in the floodplain. As more and more properties are built, this adds to the value of property prone to flood losses. Ultimately, the worth of these assets can become so great that the damage from floods that exceed the capacity of the flood-mitigating structure can become more than what was suffered before the flood protection was installed. This is known by terms such as "the levee paradox", "the levee effect", "the escalator effect" or "the safe development paradox" (Parker, 1995, Tobin, 1995, Pielke, 1999, Burby, 2006, Keys, 2019). Tobin (1995, p. 365) is perhaps worth quoting in more detail:

> *Once [a levee] has been constructed, however, the structure may generate a false sense of security to the extent that floodplain inhabitants perceive that all flooding has been eliminated. With the incentive to take precautions removed, few residents will be prepared for remedial action in the event of future floods. Even more costly, however, this false sense of security can also lead to greater development in the so-called safe areas, thus adding to the property placed at risk . . . when the levee does fail, the increase in development can actually raise losses even higher than if no levee system had been constructed in the first place.*

This paradox has been documented in Australia too. Gissing et al. (2017) show how the flood-prone businesses in Lismore's CBD were almost universally prepared in 2002, but 12 years after a levee was built in 2005, only 80 per cent had a Flood Action Plan to prepare for the flood that overtopped the levee in 2017. This false sense of security can develop quickly. Vince and Atkins (2009) record how Launceston City Council voted to relax restrictions on flood-prone development behind the levee in order to promote development—contrary to measures agreed to just the year before. Keys (2016) has explained how the

increased development in Maitland had been enabled by the false sense of security provided by the local levees, even to the extent that its Council has sought government permission to allow developments with floors below the Flood Planning Level (FPL). Following the Brisbane Flood of 2011, the Queensland Floods Commission of Inquiry noted that there had been an apparent popular misconception that Wivenhoe Dam would contain all floods emanating in the upper Brisbane River (QFCI, 2011, p. 39), and indeed estate agents were making such assertions to new entrants to the Brisbane Floodplain (Cook, 2018).

The WRDEIS is silent on the issue of preventing such misinformation, even though it does concur that the Project could exacerbate the "complacency regarding flood risk" and that the community could *"(falsely) interpret that the Project would deliver complete flood immunity under all flood events"* (WRDEIS, 2021, p. 21-59). This is a deficiency in compliance with the Secretary's Environmental Assessment Requirements (SEARs) 2.1b, 2.1e, 2.1i, 2.1p, 3.1, 3.2c, 3.2e, 3.3, 8.2b, 8.2g, 8.4, 9.3e, 9.3f and 9.5 as listed below (Table 1).

The EIS implies (WRDEIS, 2021pp. 21-84 to 110) that, unlike with almost all structural projects to mitigate flooding around the world, there will no significant increase in complacency nor of a false sense of security. The reasoning appears to be that

- WaterNSW will support the relevant NSW Government agencies to support the Hawkesbury-Nepean Valley Flood Risk Management Strategy.
- WaterNSW will support the relevant NSW Government agencies and local government to build community awareness on flood risks and specifically the effect which the Project has upon flood risk.
- WaterNSW will publicly disclose the benefits of the Project to stakeholders via various appropriate communication channels as outlined in the Project's Community and Stakeholder Engagement Plan.

The NSW Government is to be commended for its award-winning Community Resilience Program (CRP) on the Hawkesbury-Nepean Floodplain. However, although the government claims that

> *The work under the Flood Strategy, including the Community Resilience Program, is periodically reviewed through a Monitoring, Evaluation, Reporting and Improvement (MERI) process. Outcomes from the MERI review inform the ongoing work.* (INSW, 2021b, p. 6)

this program seems to be very new, with the first Monitoring, Evaluation, Reporting and Improvement (MERI) report only to be available in early 2022 (Infrastructure NSW, pers. comm., 1/12/21). Further, the Program seems not to incorporate community flood drills yet, even though this is a vital strategy for enhancing awareness and preparedness (Bourque et al., 2012, Jamshidi et al., 2016, Karanci et al., 2005, Kazanidis et al., 2020, Novak et al., 2019, Saarinen, 1990, Whitney et al., 2004).

The sustainability of the CRP can hardly be assured, given that a key initiative of the 1997 Hawkesbury-Nepean Floodplain Management Strategy was "Implementation of regional public awareness campaign targeting communities and councils" (WRDEIS, 2021, Table 4-2), and yet a quarter of a century later, it is widely known that the Hawkesbury-Nepean flood-prone community remains largely unaware of the hazards (WRDEIS, 2021, Appendix

M, Table 5-1). The EIS does not even refer to the CRP, much less provide reports of success or discuss its sustainability.

Be that as it may, to the best of my knowledge, there has not been any program in Australia that has succeeded—in the absence of a flood—in keeping a flood-prone community aware of and prepared for the risks of flooding for more than 5 years, much less for the decades and centuries that would be necessary following such a project. Programs like the CRP can be sustained if there are reasonably frequent floods, which serve to remind the community of the hazard. However, the Project would serve to *increase* the periods between floods, so that communal awareness would tend to decline (Lustig and Maher, 1997), rendering political support for the continuation of the CRP at peak effectiveness even more difficult. This impediment to the sustainability of the CRP is not addressed explicitly, even though the Project Team appears to be well aware of it, with the EIS simply acknowledging that

> *"history has shown that the longevity and effectiveness of such strategic and integrated planning initiatives are heavily reliant upon the allocation of resourcing in accordance with the priorities of the government of the day"* (WRDEIS, 2021, Appendix M, p. 207).

Given the almost invariable decline in other programs for sustaining the preparedness of communities subject to hazards that recur after long intervals (Lustig and Maher, 1997), the lack of assurance that this vital program will be adequately and sustainably funded beyond the EIS heightens the concern that the Project will increase the loss of life and property overall. It is telling that the EIS observes that

> *"Whilst Hawkesbury-Nepean Valley Flood Management Taskforce and Hawkesbury-Nepean Valley Flood Risk Management Strategy has (sic) done much to initiate the basis for a strategic and coordinated flood planning system, there remain many elements which need to come together."* (WRDEIS, 2021, Appendix M, p. 207).

The EIS does not set out how one might have confidence that the resources required for the continuing operation of a sustainable flood-preparedness strategy would be provided indefinitely, and the track record of the Government strongly implies that it cannot. The assertion

> *"The Warragamba Dam Raising proposal is only one workstream of the broader Hawkesbury-Nepean Valley flood recovery management strategy (HNVFRMS - Flood Strategy) that also includes a workstream for a comprehensive plan to improve emergency management response and recovery in the Hawkesbury- Nepean Valley (the valley). This workstream plan is to cover implementing changes to the state emergency plan and to respond to the changed operations with a flood mitigation dam in operation. Implementation of approved flood operation procedures would lower the likelihood for poorly managed dam discharges and increase community awareness about dam operations and flood characteristics."(WRDEIS, 2021, Table 15-33)*

might be seen as exemplifying a triumph of hope over experience. The deficiencies in addressing the feasibility of sustaining awareness and preparedness represent breaches of the SEARs 2.1b, 2.1e, 2.1i, 2.1p, 3.2e, 3.3, 8.2b, 8.4, 9.3e, 9.3f and 9.5 (Table 1).

3 Benefits less than costs

The standard method of evaluating the monetary benefits of a flood-mitigation structure entails estimating the Average Annual Damage (AAD) as set out in the Floodplain Development Manual (NSWG, 2005, Appendix M). However, because of the government policy of deliberately increasing the population in the Hawkesbury-Nepean Floodplain, expected to double in the next 30 years (INSW, 2017, p. 3), the AAD method has been modified to allow for an increase in population over time when comparing the benefits with the costs. This doubling is forecast without the Project, and is identified as being of concern (WRDEIS, 2021, Appendix M, pp. 206-7). Much less has there been any allowance for the even greater additions to population and their assets of this extra population, which would be induced onto the floodplain by the Project. Rather the EIS effectively side-steps the problem stating,

> *"Whether the Project would promote additional population growth in flood vulnerable areas is not able to be predicted with any confidence." (WRDEIS, 2021, Appendix M, p. 212)*

This cavalier approach would appear to run counter to Clauses 5.21and 5.22 of the Standard Instrument (Local Environmental Plans) Order 2021 under the Environmental Planning and Assessment Act 1979 (NSWG, 2021). Subclause 5.21(1) is worth quoting here as an example of where this Project is not conforming to government planning regulation.

> *5.21(1) The objectives of this clause are as follows—*
>
> > *(a) to minimise the flood risk to life and property associated with the use of land,*
> >
> > *(b) to allow development on land that is compatible with the flood function and behaviour on the land, taking into account projected changes as a result of climate change,*
> >
> > *(c) to avoid adverse or cumulative impacts on flood behaviour and the environment,*
> >
> > *(d) to enable the safe occupation and efficient evacuation of people in the event of a flood.*

The frequency of flooding is expected to increase because of climate change. This would also increase the AAD and thus decrease the benefits of the Project. The effect of climate change on flood frequency has only been evaluated for the 1% AEP flow (INSW, 2021a, p. 31), and other frequencies have been obtained by interpolation and extrapolation.

The omissions in the economic evaluation to account for the issue of the extra population induced on the floodplain, explicitly recognised in the EIS, appear to be breaches of the SEARs 2.1e, 2.1f, 2.1P, 3.1, 3.3 and 8.2b (Table 1).

4 Corruption of flood-risk management strategies

What is even more troubling is that one Minister of the NSW Government has already suggested that the flood planning level (FPL) might be lowered (Keys, 2021). To be sure, the EIS affirms that the FPL will be kept at its current elevation (WRDEIS, 2021, Appendix M, p. 207), but historical precedents provide no confidence that the resolve of the government is unlikely to wane, quite the contrary. For example, as late as last year, Infrastructure NSW advised Penrith Council that:

> *"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"* (Thompson, 2021).

While this low priority may have been rectified, it is illustrative of the steady tendency of the Government's resolve to sustain awareness and preparedness efforts to fade.

An additional case in point is the recent development of Marsden Park North (J. Wyndham Prince, 2018). Because much of the area is in the Hawkesbury-Nepean Floodplain, it was necessary that the residents could evacuate safely. This was taken to have been demonstrated in the report by Molino (2018). To estimate how long a resident would take to evacuate, one period that needed to be evaluated was what is known as the Warning Acceptance Factor (WAF). This is the estimated time for a resident to accept that a flood is coming after they have received an official warning. To understand how this should be done, Opper (2004) is here worth quoting in full:

> *Evacuation warning and particularly the human responses to such warnings involve inherent tendencies to under-react or delay in the hope that the situation will improve and a response may be avoided. This is an area of uncertainty but the SES's experience suggests that there will be a general reluctance to accept the validity of a warning until people can see some evidence of flooding. In the case of a severe flood in many NSW coastal valleys and other similar situations, waiting that long will be too late!*

In a subsequent paper by Opper et al. (2010), this point was made more specific:

> *If a warning has to be delivered at a time when the river may not have started to rise it could be expected that people will wait some time before deciding to respond. The WAF should be perhaps as much as a few hours. In other cases when warning will coincide with obvious environmental cues, the W AF could be considered to be zero. To provide a starting point for its own analysis the SES has adopted a minimum value of 1 hour.*

Unfortunately, a paper three years later (Molino et al., 2013) modified the WAF without obvious justification:

> ***"Warning Acceptance Factor (WAF)** … The NSW SES recommends a value of one hour."*

In the calculations for Marsden Park North, the WAF was accordingly taken as one hour rather than ten hours, as would have been recommended by the SES in 2004. The total time to evacuate should have been assessed as 25.9 hours, dangerously close to the time for the flood to reach its peak, 27.4 hours. Given that there will be some who cannot or will not leave their house without assistance or inducement, or some floods that will rise more rapidly than has been assumed, one can conclude that some occupants of residences in the newly developed precinct of Marsden Park North are at risk of drowning.

When clarification was sought from the SES, the response was,

> *"It may be that residents themselves tend to wait until they see water before they agree to commence evacuation however the NSW SES position is to assume a default of 1 hour for the Warning Acceptance Factor, as opposed to waiting to see water. As noted previously however, each individual flood is different and hence the timing for the Warning Acceptance Factor may vary."*

Adhering to a default WAF of one hour in the Hawkesbury-Nepean Floodplain, where the Flood Planning Level is of the order of 10 m below the level of Probable Maximum Flood (PMF) has yet to be justified, particularly when it goes against most experience (e.g. Irish and Falconer, 1979). These equivocal and unsupported stances on ensuring effective flood warnings in the Hawkesbury-Nepean Valley, would render the Project deficient in satisfying SEAR 8.5 (Table 1). That the SES appears to have declined to discuss this with me further may be contributing to the transformation of an act of misfeasance to one of malfeasance.

5 The unfortunate use of the Project Under Impact Area (PUIA)

It is difficult to follow the logic underpinning the Project Under Impact Area (PUIA). This is the "average or likely inundation" area for floods that would rise above the upstream Full Storage Level (FSL). The reasoning appears to be presented in Section 13.3.2.1 and Appendix F6 of the EIS. Unfortunately, this PUIA is a groundless parameter for evaluating the losses of ecological and aboriginal heritage resources.

The EIS states that, "The approach taken has been to identify an 'impact area' that takes account of the variability of flood events and their extent over time." Next, it assumes that "there would be a complete loss of values in this area" in order to offset all the impacts of the Project.

This is illogical. The formula used might be expressed mathematically as follows.

Let X_i be the area inundated upstream in Flood Event i.

Let Y_i be the value of the losses to ecological or aboriginal resources upstream resulting from Flood Event i.

Let p_i be the probability of Flood Event i.

Let n be the number of Flood Events.

Let $\bar{Y}$ be the expected value of Y, and $\bar{X}$ and be the expected value of X.

Let the value of the losses Y be a function f of X, that is,

$$Y = f(X) \qquad (1)$$

Then the expected losses $\bar{Y}$ is given by

$$\bar{Y} = \sum_{i=1}^{n} p_i f(X_i) \qquad (2)$$

Equation (2), a standard statistical relationship, is the form of the formula for evaluating the AAD as set out in the Floodplain Development Manual (NSWG, 2005, p. M-9).

However, the formula used by the WDR Team to incorrectly estimate the expected value of the losses was

$$\bar{Y}_{WDR} = f(\bar{X}) \qquad (3)$$

Where $\bar{Y}_{WDR}$ is the expected value of *Y* according to the WDR Team

and $\bar{X}$, the expected value of *X*, given by

$$\bar{X} = \sum_{i=1}^{n} p_i X_i \qquad (4)$$

The Team's assumption that a total loss of all ecological and cultural assets, that is

$$\max(\bar{Y}_{WDR}) >> \bar{Y} \qquad (5)$$

without any rigorous evidence could be described as heroic, given the "survey limitations" acknowledged for the ecological assessment in Appendix F6 (WRDEIS, 2021, Appendix F6, p. 16), and the fundamental deficiencies in the archaeological assessment (WRDEIS, 2021, Appendix K, pp. iii-iv). The reasoning appears to be that "Areas/sites at lower elevations would have a greater risk of temporary inundation than areas/sites at higher elevations within the upstream study area." The idea that there may be higher sites that are much more sensitive and valuable than those lower down would seem not to have been considered as a matter of significant concern, even though "The Project is an incremental addition to a previous project (the dam construction) that has caused cultural trauma and significant loss of cultural heritage values." (WRDEIS, 2021, Appendix K, p. 79).

The Team developed its elaborate and illogical approach, being faced with evaluating four different types of hazard:

1. Reparable damage with constant hazard, such as with damage to flood-prone houses and their contents;
2. Reparable damage with increasing hazard, such as resulting from more frequent floods with climate change;
3. Irrecoverable damage with constant hazard, such as destruction of rock art; and
4. Irrecoverable damage with increasing hazard, such as the increasingly precarious survival of a threatened ecological association subject to progressively more frequent inundation because of climate change.

The formulae for evaluating the expected values and/or present worths of losses for these four types of hazards are available in Irish and Lustig (1993). It would have been quite feasible to use these formulae following the Treasury Guidelines for assessing non-monetised

impacts (NSW Treasury, 2007, pp. 44-6). Had the Team done so, it might have arrived at a defensible evaluation.

6 Benefit-Cost Analysis

The EIS has concluded that the Project has a benefit-cost ratio (BCR) of 1.05 (WRDEIS, 2021, Table 4-8). It asserts that this is the only option with a net benefit (WRDEIS, 2021, p. 4-45). Both statements are incorrect on several counts.

1. When the EIS writes that the BCR is 1.05, it implies that the ratio is accurate to ±2.5%, which is plainly wrong.
2. Hydrologists on the Team know or ought to know that hydrology is no less an Art than a Science, and that hydrological modelling is typically accurate to of the order of ± a factor of two, particularly when modelling volumes and inflow rates over an extended duration with limited rainfall and streamflow data.
3. Treasury Guidelines recommend that BCR evaluations undertake sensitivity analyses using discount rates of 4%, 7% and 10%, which would have given BCRs varying by much more than ±2.5%.
4. It is rare for government projects not to run over budget. Private enterprise typically allows for a minimum of 20% increase.
5. It is rare for government projects to attain their estimated benefits.
6. The EIS implicitly valued the losses to ecosystems and aboriginal cultural heritage at zero. This is plainly not so and could well be taken as offensive to a significant sector of the community. Table 4-8 provides Benefit-cost Ratios without including a monetary estimate of many intangible effects like social impacts (Section 4.7.7), even though the intangible cost of loss of life was monetised (Table 4-3). This is inconsistent with NSW Treasury Guidelines (NSW Treasury, 2007). Section 9.3.6 of tpp-07-5 states that one should use Cost-Benefit Analysis OR Cost-Effective Analysis. There seems to be no explanation of why the Guideline's Annex 4 was not used for valuing the ecological and aboriginal cultural losses.
7. Valuing ecosystems and aboriginal heritage at closer to their true value to society would mean that the net benefit of the Project was significantly negative.
8. There was no sensitivity testing of non-monetised impacts (NSW Treasury, 2007, p. 45)

7 Raising the Dam by 17 m

The Project includes the installation of abutments which would enable the Dam to be raised by another 3 m, or 17 m in total. The consequences of raising the Dam by this extra 3 m (the 17 m Project) have not been assessed in the EIS on the grounds that this would be a different project requiring separate approval (Warragamba Dam Raising Proposal Team pers. comm. 26/11/21). This contravenes SEAR 2 (Table 1). The Performance Outcome of SEAR 2 is that "the project has been developed through an iterative process of impact identification and assessment and project refinement to avoid, minimise or offset impacts so that the project, on balance, has the least adverse environmental, social and economic impact, including its

cumulative impacts." However, without having identified and assessed the impacts of raising by 17 m, it is not logically possible to: -

- go through an iterative process of project refinement to avoid, minimise or offset impacts;
- identify and assess the feasibilities of alternatives to the Project as required for SEAR 2.1e;
- identify, design and build into the 14 m Project the optimal features needed for the 17 m Project as mandated by SEAR 2.1i;
- provide the reasons justifying the 14 m Project in light of the cumulating impacts of the 17 m Project as required for SEAR 2.1p;
- identify and consider the multiple reasonable and feasible options to avoid or minimise impacts as required for SEAR 3.3;
- assess the riskiness of the 14 m Project to climate change leading to the 17 m Project as required for SEAR 7.1;
- produce maps showing the high-water mark resulting from the 17 m Project as required for SEAR 13.2.

8 Secretary's Environmental Assessment Requirements (SEARs)

Those of the Secretary's requirements for preparing the EIS (WRDEIS, 2021, Appendix A), which are considered to have been contravened, are listed below in Table 1.

Table 1 Secretary's Environmental Assessment Requirements

Desired Performance Outcome	Requirement	Where purported to be addressed in EIS	Not adequately addressed
2. Environmental Impact Statement The project is described in sufficient detail to enable clear understanding that the project has been developed through an iterative process of impact identification and assessment and project refinement to avoid, minimise or offset impacts	1. The EIS must include, but not necessarily be limited to, the following:		
	(b) a description of the project, including all components and activities (including ancillary components and activities) required to construct and operate it;	Chapter 5	*Not addressed*: how to sustain awareness and preparedness in the flood-prone community; the consequences of raising the Dam by 17 m.

Table 1 Secretary's Environmental Assessment Requirements

Desired Performance Outcome	Requirement	Where purported to be addressed in EIS	Not adequately addressed
so that the project, on balance, has the least adverse environmental, social and economic impact, including its cumulative impacts.	(e) an analysis of any feasible alternatives to the project.;	Chapter 4, Sections 4.3, 4.4, 4.5	*Not analysed at all:* the feasibility of sustaining awareness and preparedness; the consequences of raising the Dam by 17 m; substantially increased recycling for potable and non-potable uses (e.g. ~30% for Perth); meteorologically adjustable full-storage levels; cheaper desalination; flood bonds; potentially optimal combinations of these strategies and the strategies below. *Insubstantial analyses:* the Do Nothing Option; reducing the flood-prone population; buying up the houses lowest in the floodplain; self-revegetation of the episodically inundated foreshores of Lake Burragorang; combinations of strategies. *Incorrect analyses:* costs of losses to ecosystems and cultural heritage not included in benefit-cost studies; no sensitivity analyses with different discount rates.
	(f) a description of feasible options within the project.;	Chapter 4, Sections 4.3, 4.4	*Does not describe:* measures to slow the growth of population; raising the Flood Planning Level (FPL)

Table 1 Secretary's Environmental Assessment Requirements

Desired Performance Outcome	Requirement	Where purported to be addressed in EIS	Not adequately addressed
	g) a description of how alternatives to and options within the project were analysed to inform the selection of the preferred alternative / option. The description must contain sufficient detail to enable an understanding of why the preferred alternative to and options(s) within the project were selected;	Chapter 4, Section 4.2	Apart from options not analysed at all: Sections 4.6 to 4.8 were not listed in Appendix A; Sections 4.7 and 4.8 provide information that is not in Appendix M with no cross-referencing;
	(h) a concise description of the general biophysical and socio-economic environment that is likely to be impacted by the project (including offsite impacts);	Chapters 7 to 27	To describe twenty chapters as providing "a concise description" employs a meaning of the term that is not in common usage.
	(i) a demonstration of how the project design has been developed to avoid or minimise likely adverse impacts both upstream and downstream of the dam wall;	Chapter 4. Chapter 5	*Not addressed:* strategies for avoiding raising the Dam by 17 m; combatting the consequential reduction in awareness and preparedness *Incorrect analyses:* use of Project Under Impact Area for assessing upstream impacts is illogical and unfounded.

Table 1 Secretary's Environmental Assessment Requirements

Desired Performance Outcome	Requirement	Where purported to be addressed in EIS	Not adequately addressed
	(n) an assessment of the cumulative impacts of the project taking into account other projects that have been approved but where construction has not commenced, projects that have commenced construction, and projects that have recently been completed;	Chapter 28	*Not addressed or insubstantially addressed:* Outcome 1— coordinated flood risk management across the Hawkesbury-Nepean Valley now and in the future Outcome 5—Community Resilience Program (CRP); sustainability of funding of CRP; Outcome 7— best practice emergency response and recovery Outcome 9— ongoing monitoring and evaluation, reporting and improvement of the Flood Strategy.

Table 1 Secretary's Environmental Assessment Requirements

Desired Performance Outcome	Requirement	Where purported to be addressed in EIS	Not adequately addressed
	(p) a chapter that synthesises the environmental impact assessment and provides: - a description of any uncertainties that still exist around design, construction methodologies and/or - operational methodologies and how these will be resolved in the next stages of the project; - the reasons justifying carrying out the project as proposed, having regard to the biophysical, economic and social considerations, including ecologically sustainable development and cumulative impacts.	Section 29.4	*Not addressed:* reducing the flood-prone population; buying up the lowest houses; sustaining awareness and preparedness for the floods; *Insubstantially addressed:* self-revegetation of the episodically inundated foreshores of Lake Burragorang is simply accepted as a loss, and not a matter for mitigation. *Cumulative impact not addressed:* the levee paradox; raising the Dam by 17 m.
3. Assessment of Key Issues Key issue impacts are assessed objectively and thoroughly to provide confidence that the project will be constructed and operated within acceptable levels of impact.	1. The level of assessment of likely impacts must be proportionate to the significance of, or degree of impact on, the issue, within the context of the proposal location and the surrounding environment. The level of assessment must be commensurate to the degree of impact and sufficient to ensure that the Department and other government agencies are able to understand and assess impacts.	Chapters 7 to 29 and relevant Appendices	*Not addressed:* the relentless pressure to profit from land development, thereby inducing further population increases; the levee paradox *Insubstantially addressed:* the pressure to raise the Dam further from population increase; the extra population resulting from the false sense of security following the Dam Raising.
	2. For each key issue the Proponent must:		

Table 1 Secretary's Environmental Assessment Requirements

Desired Performance Outcome	Requirement	Where purported to be addressed in EIS	Not adequately addressed
	(b) describe the legislative and policy context, as far as it is relevant to the issue;		*Not addressed:* Historical precedents of Council incentives to keep the flood planning level (FPL) low; the appropriateness or otherwise of the current FPL being set at just above the 0.01 AEP level.
	(c) identify, describe and quantify (if possible) the impacts associated with the issue, including the likelihood and consequence (including worst case scenario) of the impact (comprehensive risk assessment), and the cumulative impacts;		*Not addressed:* The consequences of the levee paradox
	(d) demonstrate how potential impacts have been avoided (through design, or construction or operation methodologies);		Impacts on aboriginal culture and ecosystems not avoided through design or operation.
	(e) detail how likely impacts that have not been avoided through design will be minimised, and the predicted effectiveness of these measures (against performance criteria where relevant);		Impacts on aboriginal culture and ecosystems not avoided through design. Strategies for sustaining awareness and preparedness not detailed.
	(f) detail how any residual impacts will be managed or offset, and the approach and effectiveness of these measures.		No offset strategy for impacts on aboriginal culture.

Table 1 Secretary's Environmental Assessment Requirements

Desired Performance Outcome	Requirement	Where purported to be addressed in EIS	Not adequately addressed
	3. Where multiple reasonable and feasible options to avoid or minimise impacts are available, they must be identified and considered and the proposed measure justified taking into account the public interest.		*Not identified or considered at all:* the feasibility of sustaining awareness of and preparedness for the next large flood; the consequences of raising the Dam by 17 m; substantially increased recycling for potable and non-potable uses (e.g. ~30% for Perth); meteorologically adjustable full-storage levels; cheaper desalination; flood bonds; revegetation of the episodically inundated foreshores of Lake Burragorang with appropriate endemic or at least native rare and endangered ecosystems; potentially optimal combinations of these strategies and the strategies below. *Insubstantially considered:* reducing the flood-prone population; buying up the lowest houses; self-revegetation of the episodically inundated foreshores of Lake Burragorang; combinations of strategies.

Table 1 Secretary's Environmental Assessment Requirements

Desired Performance Outcome	Requirement	Where purported to be addressed in EIS	Not adequately addressed
7. Climate Change Risk The project is designed, constructed and operated to be resilient to the future impacts of climate change.	1. The Proponent must assess the risk and vulnerability of the project to climate change in accordance with the current guidelines.	Chapter 14, Sections 14.4 and 14.5 Appendix G, Sections 3 to 6	The risk of raising the Dam another 3 m and the consequences have not been addressed.
	2. The Proponent must quantify specific climate change risks with reference to the NSW Government's climate projections at 10km resolution (or lesser resolution if 10km projections are not available) and incorporate specific adaptation actions in the design.	Chapter 14, Sections 14.2, 14.4,14.5,14.6 and 14.7 Appendix G, Sections 3 to 6	The impact of climate change on the extent of the Project Upstream Impact Area (PUIA) does not appear to have been addressed.
8. Flooding The project minimises adverse impacts on existing flooding characteristics. Construction and operation of the project avoids or minimises the risk of, and adverse impacts from, infrastructure flooding, flooding hazards, or dam failure.	2. The Proponent must assess and model the impacts on flood behaviour during construction and operation for a full range of flood events up to the probable maximum flood (accounting for sea level rise and storm intensity due to climate change) including:	Chapter 15, Sections 15.5, 15.6,15.7, 15.8, 15.9 and 15.10	

Table 1 Secretary's Environmental Assessment Requirements

Desired Performance Outcome	Requirement	Where purported to be addressed in EIS	Not adequately addressed
	(b) quantify the benefits of reducing flood affectation to developments, land, properties, assets and infrastructure;	Chapter 15, Section 15.7 Chapter 21, Section 21.7 Appendix M, Section 8	The effects of induced increase of population, induced increase of flood-prone assets, induced reduction in awareness and preparedness have not been addressed, ie. the effects of the levee paradox.
	(g) impacts the development may have upon existing community emergency management arrangements for flooding. These matters must be discussed with the State Emergency Services (SES) and relevant Councils;	Chapter 15, Sections 15.4 and 15.7 Appendix HI, Section 4.2.3	The impact of the levee paradox has not been addressed.

Table 1 Secretary's Environmental Assessment Requirements

Desired Performance Outcome	Requirement	Where purported to be addressed in EIS	Not adequately addressed
	(h) any impacts the development may have on the social and economic costs to the community as consequence of flooding. Specifically, events at a minimum must be assessed for the 1 in 5 year, 1 in 10 year, 1 in 20 year, 1 in 100 year and the probable maximum flood. Modelling should include flood characteristics such as extent, level, velocity, and rate of rise at a minimum. Discussion and an assessment of the flood management zone also needs to be included.	Chapter 15, Section 15.7 Chapter 21, Section 21.7 Appendix M, Section 8	The effects of these events were not assessed for the intangible effects—the morbidity visited on the flood-prone community, the impacts on upstream and downstream ecosystems, and the impacts on aboriginal and non-aboriginal heritage. Since the losses to property were also assessed for the 1 in 50 year, 1 in 200 year, 1 in 500 year, 1 in 1000 year, 1 in 2000 year and 1 in 5000 year events, the intangible effects should also have been assessed for these events too. The assessment of upstream impacts has largely concentrated on the PUIA and not fully on the flood management zone.
	4. The Proponent must identify and address any impacts the project may have upon existing emergency management arrangements for flooding. These matters are to be discussed with the SES and relevant councils downstream and upstream of the Dam.	Chapter 15, Sections 15.4 and 15.8. Appendix HI, Section 4.2.3	In Section 15.7 (not 15.8), we find only "The Project and other components of the Flood Strategy would require the existing Flood Plan to be revised to include … improved flood awareness and preparedness of the community (Flood Strategy)" In Appendix H1, the words "awareness" and "preparedness" have not been found.

Table 1 Secretary's Environmental Assessment Requirements

Desired Performance Outcome	Requirement	Where purported to be addressed in EIS	Not adequately addressed
	5. The assessment must discuss emergency management, evacuation and access, and contingency measures for the construction and operational stages of the project considering the full range or flood risk including the probable maximum flood. These matters are required to be discussed with the SES and relevant councils.	Chapter 15, Sections 15.4, 15.5,15.6,15.7, 15.8 and 15.9 Appendix HI, Sections 4.1 and 4.2.3	The information on warnings and evacuation appears to be flawed, since the SES nowadays uses a Warning Acceptance Factor (WAF) that is too small. The SES appears to have declined to discuss this with me.
	6. Discussion in the assessment of the consequences of flooding on social and economic costs to the community and in the broader catchment, including up to the probable maximum flood level.	Chapter 15, Section 15.7 Chapter 21, Section 21.7. Appendix M, Section 8.	The Survey Area for aboriginal heritage did not cover the full Upstream Study Area. The PUIA was even smaller. The justification for using the PUIA (Section 13.3.2.1) is not sound.
9. Health and Safety The project avoids or minimises any adverse health impacts arising from the project. The project avoids, to the greatest extent possible, risk to public safety.	3. The assessment must:		
	(e) assess the distribution of the health risks and benefits; and	Chapter 16, Sections 16.4 and 16.5.	The difficulties of sustaining a high level of awareness of and preparedness for the flood hazard are not addressed.

Table 1 Secretary's Environmental Assessment Requirements

Desired Performance Outcome	Requirement	Where purported to be addressed in EIS	Not adequately addressed
	(f) discuss how, in the broader social and economic context of the project, the project will minimise negative health impacts while maximising the health benefits.	Chapter 16, Sections 16.4 and 16.5	The difficulties of sustaining a high level of awareness of and preparedness for the flood hazard are not addressed.
	5. The Proponent needs to address whether the project incorporates specific measures to manage risk to life from flood, with these matters to be discussed with the SES and relevant Councils.	Chapter 16, Sections 16.4 and 16.5	The difficulties of sustaining a high level of awareness of and preparedness for the flood hazard are not addressed.

Table 1 Secretary's Environmental Assessment Requirements

Desired Performance Outcome	Requirement	Where purported to be addressed in EIS	Not adequately addressed
10. Heritage The design, construction and operation of the project facilitates, to the greatest extent possible, the long term protection, conservation and management of the heritage significance of items of environmental heritage and Aboriginal objects and places. The design, construction and operation of the project avoids or minimises impacts, to the greatest extent possible, on the heritage significance of environmental heritage and Aboriginal objects and places.			It is not possible to assess the impacts, nor the success or otherwise of the proposed mitigation measures without adequate information on the effects for each AEP:- • without climate change • with climate change • raising by 14 m • raising by 14 m with climate change • raising by 17 m • raising by 17 m with climate change

Table 1 Secretary's Environmental Assessment Requirements

Desired Performance Outcome	Requirement	Where purported to be addressed in EIS	Not adequately addressed
13. Protected and Sensitive Lands The project is designed, constructed and operated to avoid or minimise impacts on protected and sensitive lands.	2. Maps should be included that clearly indicate the proposed high water mark line and current high water mark line, as well as protected area boundaries.	Chapter 20	Maps do not show the effect of raising by 17 m.
16. Sustainability The project reduces the NSW Government's operating costs and ensures the effective and efficient use of resources. Conservation of natural resources is maximised.	2. The Proponent must assess the project against the current guidelines including targets and strategies to improve Government efficiency in use of water, energy and transport.	Chapter 23	No assessment of the benefits of a strategy to recycle, say 30% of urban water consumption.

Table 1 Secretary's Environmental Assessment Requirements

Desired Performance Outcome	Requirement	Where purported to be addressed in EIS	Not adequately addressed
20. Water - Hydrology Long term impacts on surface water and groundwater hydrology (including drawdown, flow rates and volumes) are minimised. The environmental values of nearby, connected and affected water sources, groundwater and dependent ecological systems including estuarine and marine water (if applicable) are maintained (where values are achieved) or improved and maintained (where values are not achieved). Sustainable use of water resources.	1. The Proponent must consider potential alternatives for managing flood waters and justify the selection having regard to the relative environmental impacts.	Chapters 3 Chapter 4	No consideration of options to lower the FSL during periods of La Niña, when the flood risk is high and the risk of inadequate water storage is low.

9 A suggested combination of alternative strategies

The EIS assessed combinations of strategies, focussing on what were considered the better performing options— Castlereagh Connection as the best regional road option, lowering the permanent water supply by five or 12 metres, and buying back all homes below the current 1% AEP flood planning level. However,

> *"None of the combination packages were able to achieve similar benefits to raising Warragamba Dam wall. All were cost prohibitive, and none mitigate climate change impacts beyond mid-century. Therefore, these alternative packages were not considered suitable for further consideration."* (WRDEIS, 2021, p. 4-46) P. 4-46

This evaluation was largely informed by the work of Infrastructure NSW (INSW, 2019).

Since none of the alternatives evaluated in the EIS have been shown to have benefits greater than costs, it is necessary to explore other options that alone or in combination could produce positive results. The options presented below include ones that have become better available lately through technological developments, or that build on recent research. Of course, other strategies again could have even more improved outcomes. The strategies which are suggested here are: -

- lowering the full storage level during periods of La Niña;
- recycling of the order of 30% of the water supplied to Sydney Water;
- not just flood education but also flood training of the community, such as through drills;
- amending Standard Instrument (Local Environmental Plans) Order 2006 to encourage new developments with a net reduction in flood affectation on the floodplain;
- involving insurance companies in flood-risk management.

9.1 Lowering the full storage level during periods of La Niña;

With improved weather forecasting, it is now possible to predict long-term weather patterns to a much greater accuracy than even a decade ago, when much of the investigations for this EIS were begun. A major enhancement has been the ability to predict the behaviours of the El Niño Southern Oscillation (ENSO) (e.g. Solow et al., 1998). The most severe floods in the Hawkesbury-Nepean Valley will tend to be during periods of La Niña, when the weather will be wet and the demand for water will be lower than the average. Conversely, it is more desirable for Warragamba Dam to be full during times of El Niño when the weather will be dry and the demand for water will be higher than the average.

During times of La Niña therefore, it should be feasible to reduce the volume of water stored in the Dam, since the risk of Lake Burragorang running low will be small while the likelihood of floods will be high. By contrast during periods of El Niño, the risk of floods should be low.

How low the Full Storage Level (FSL) could be kept with reasonable water security could be evaluated with hydrological modelling and sensitivity testing of parameters such as water demand, to help the community reach consensus on a suitable balance between security of water supply and flood hazard. This consensus could be reviewed periodically—say every

five years or sooner if needed—to take account of progress with complementary strategies such as those put forward here.

9.2 Substantially increased recycling

The Water Corporation of Western Australia aims to recycle 30% of its water by 2030 and 60% of its water by 2060 (Water Corporation, 2009, pp. 7-8). Were the same goal adopted for the Sydney Water network, this could allow the FSL to be lowered even further and for longer periods than with the La Niña strategy alone.

9.3 Not just flood education but also flood training of the community

A near universal finding of surveys of the awareness of a flood hazard in a flood-prone community is that the awareness of the flood hazard is low, and that the flood preparedness is even lower, as has also been reported in this EIS and discussed above. The same results are also found for awareness of and preparedness for other inevitable disasters around the world.

I may be told of a hazard, but for one of several reasons, I may delay preparing for it (Langer, 1983, pp. 175-84). I may deny; I may resist taking steps to prepare for it for fear of admitting to myself that the hazard exists; I may rationalise it as being unlikely or a long way off. Even people who have been flooded unexpectedly will often be telling themselves that it won't happen again, "Another hundred-year flood? I won't be around in another hundred years!" (Lustig and Maher, 1997).

To appreciate the reasons for this, it is important to understand the psychological impediments, which all of us are subject to. The underlying cause of these different impediments is that the hazard presents as a threat to people's sense of control, which is vital for our well-being (Langer, 1983, pp. 227-39). If something threatens to make us feel disempowered, we will do anything to get around this, including denying that the problem exists. It follows that one way to get around this is to provide people with a sense of empowerment, and for people living on the floodplain, their sense of control can be restored through community hazard-preparation drills (e.g. Jamshidi et al., 2016) or sessions where the participants must act to protect themselves against the threat (Novak et al., 2019, Kazanidis et al., 2020)—and not just be told that they need to do this.

This helps overcome denial and disempowerment, so that people become more responsive to flood awareness and preparedness campaigns. It may also help mitigate the levee paradox. As Bourque et al. (2012) write,

> *Increasing the public's perception about the probability and severity of a future event does not, by itself, lead to preparedness in the absence of providing people with the knowledge, resources, information, and ability to develop and sustain preparedness for a future, low probability, high consequence event such as 9/11 and Hurricane Katrina.*

They show from a very large study that for people to prepare effectively for a hazard, they must have three things: -

1. an understanding of the threat,
2. knowledge and ability to respond to the threat, and
3. information about the threat from several sources.

Until now, the Community Resilience Program in the Hawkesbury-Nepean Valley (CRP) seems to have concentrated on enhancing awareness in the community (Item 1) and improving the capabilities of the flood-warning systems (Bureau of Meteorology (BOM) and State Emergency Services (SES)) which addresses Item 3. Flood drills are confined to public agencies like the SES (SES, 2020), but which, if applied to the community, would address Item 2. We can see that Item 2 is well understood when addressing the fire hazard in buildings: it is a requirement under Australian Standard AS3745-2010 that occupants of office blocks practice full evacuation of the building as part of a fire drill at least annually. It is recommended that the scope of the work of the CRP be expanded to put greater emphasis on encouraging flood drills and similar exercises.

The SES' current default assumption of the Warning Acceptance Factor being only one hour, whereas 17 years ago it held that people move only when they see the water, would appear to be dangerously imprudent, particularly in the Hawkesbury-Nepean Valley. It is suggested that a better sense of the length of this delay could be based on what is learned from flood drills.

9.4 Amending Standard Instrument (Local Environmental Plans) Order 2006 to encourage new developments with a net reduction in flood affectation on floodplains;

Clause 5.21 incorporates an objective of minimising "the flood risk to life and property associated with the use of land" (Subclause 1(a)). This is consistent with the primary objective of the Flood Prone Land Policy as stated in the Floodplain Development Manual, namely,

> *"to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods,"* (NSWG, 2005, p. 1)

This objective, if interpreted literally, could be taken to mean that all development on the floodplain should be such that it results in no reduction in public and private losses. If applied strictly in practice, and to allow for deficiencies in execution, this would mean that the authorities should aim for a *progressive reduction* in losses.

Indeed, Subclause 2(c) mandates that development consent should be withheld for land below the flood planning level (FPL) unless it will not affect safe occupation. As has been argued above, and as the EIS acknowledges (WRDEIS, 2021, Appendix H1, p. 60), occupation of these lowlands is hazardous. However, evacuating all such housing at once would be cost prohibitive (WRDEIS, 2021, p. 4-33).

One approach, which may contribute to a lessening of the hazard, may be to use a combination of strategies as part of a plan to manage retreat from the flood threat over several decades (Siders, 2019). Some strategies, which might be considered, could be: -

- amortising, where homes could be purchased by the government and rented back to the former owners for the rest of their lives or for up to two or three decades;
- helping communities to plan to move as a group or in stages, in order to preserve the social bonds;

- planning the new community with communal participation to represent a new beginning;
- returning appropriate lowlands or sacred lands to custodianship of the Registered Aboriginal Parties (RAPs);
- returning vacated land to parklands or heritage areas;
- moving houses to higher ground;
- allowing only replacement houses that can be moved;
- using art and heritage management to enhance cultural value in the vacated land.

Clause 5.22 deals with land above the FPL but below the PMF, and Subclause 5.22(3) mandates that there can be no development on these lands unless it does not affect efficient evacuation. Since any development will tend to add to congestion, this could be interpreted to require that development can proceed only as long as evacuation routes are regularly improved to cope with the increase in population.

It is suggested that this concept could be developed further. Could Clause 5.22 be amended to encourage a progressive reduction in flood losses on the floodplain? In this way, Councils, which till now have been structured to encourage development, could have built-in incentives to formulate innovative approaches to ensure the floodplain is not sterilised.

None of this would be easy, but there are examples in Australia and elsewhere where towns have been moved out of the floodplain successfully (Coates, 2012, Siders, 2019). There are also many examples of many major centres both today and in the past located squarely on floodplains. Indeed, the city of Sawankalok (also known as Sisatchanalai) a city of the Ayyuthian Kingdom in present-day Thailand, was on the floodplain of the Yom River which flooded annually to such an extent that the silt aggraded by between 1.5 and 3.5 metres, so much so that many doorways were filled in. Yet it flourished for perhaps half a millennium (Bishop et al., 1996).

Hanoi, the capital of Vietnam, has a two-millenium history on the floodplain of the Red River Basin (MWR et al., 1994).

9.5 involving insurance companies in flood-risk management.

The formulation of the NSW Floodplain Development Policy in the 1980s was a major advance in avoiding the sterilisation of valuable land. It used a carrot-and-stick approach, the carrot being that Councils were indemnified when permitting the development of land that was prone to flooding, the stick being that this development needed to be done safely, in accordance with the Floodplain Development Manual.

An original deficiency of the Manual however, was that it concentrated on only typically half of the average annual damage (AAD), those losses below the FPL—invariably the 0.01 AEP level plus half a metre freeboard. This has been largely addressed for most NSW floodplains with the promulgation of the Instrument Clauses 5.21 and 5.22.

There remains however a residual risk on floodplains, particularly where the difference in height from the FPL and the level of the PMF is large, as it is for NSW coastal rivers in excess of two metres in many places. Two notable cases are Lismore and the Hawkesbury-Nepean Valley. For Lismore, with a height difference of 3.5 m, a partial solution has been to move many of the residences most at risk to high ground, such as to nearby Bonnegilla, and

to build a levee to provide protection against nuisance flooding to the CBD. High ground is readily available for evacuation on routes largely under the control of Council, and the community is well aware of the flood risk because of the very frequent floods (SES, 2018).

For the Hawkesbury-Nepean Valley with a height difference of nine to ten metres however, there are places where the floodplain is very wide. Evacuation becomes more problematic than for Lismore, both because awareness of the flooding problem diminishes within the flood-prone population over time since the last flood, and it also entails coordination between agencies, which almost invariably also degrades over time since the last flood. (See Lustig (2012, Appendices A and B) for simplistic models of these processes.) Since neither the flood-prone community nor the Government can be relied on to sustain an adequate level of preparedness, including ensuring evacuation systems have a capacity that is kept adequate for when the next rare flood comes, one approach might be to facilitate the involvement of a body that would have a perpetual interest in ensuring

- flood losses reduce continually;
- both the preparedness of the community and of the relevant government agencies are sustained;
- the flood-prone land is not being sterilised.

One type of entity that might fit these requirements could perhaps be adapted from the example of the UK's Flood Re (https://www.floodre.co.uk). One modification to the Flood Re model that might be suggested could be that the entity paid a levy, along the lines of the ambulance levy, to help fund appropriate operations of the flood-preparedness agencies, and that it was empowered to ensure it got value for money.

This insurer could employ three strategies to help reduce flood losses continually: -

- becoming a member of the flood committee of every NSW council with a flooding problem;
- designing a flood insurance scheme, which included innovative options such as flood bonds (Irish, 1987) that would be a continuing requirement of home loans and home insurance, and which provided price signals to deter inappropriate and hazardous development on the floodplain;
- working with the agencies to ensure that flood insurance remained available and affordable, even to the extent of threatening—publicly if necessary—to withdraw cover from developments that increased the flood losses in the floodplain.

Conclusions

1. It is almost certain that the benefits of the Project to raise Warragamba Dam would be less than the costs. If history is any guide, the benefits could even be negative. Even a key objective, the reduction in loss of life is not likely to be attained: instead, it could increase. The Treasury Guidelines for Economic Appraisal have not been followed properly.
2. The ecological and cultural impacts of the Project have been implicitly valued at zero in the benefit-cost analysis, an assessment that can only be taken as offensive.
3. The Secretary's Environmental Assessment Requirements have not been fulfilled in many instances.

4. The use of the Project Under Impact Area for evaluation is illogical.
5. There are deficiencies in addressing the difficulties in sustaining a continuing level of preparedness, awareness and measures to counter the levee paradox.
6. Some strategies that, in combination, might contribute to a sustainable management of development on the Hawkesbury-Nepean Floodplain have been put forward briefly for consideration. These are: -
    - lowering the full storage level during periods of La Niña;
    - recycling of the order of 30% of the water supplied to Sydney Water;
    - not just flood education but also flood training of the community, such as through drills;
    - amending Standard Instrument (Local Environmental Plans) Order 2006 to encourage new developments with a net reduction in flood affectation on the floodplain;
    - involving insurance companies in flood-risk management.

References

BISHOP, P., HEIN, D. & GODLEY, D. 1996. Was medieval Sawankhalok like modern Bangkok, flooded every few years but an economic powerhouse nonetheless? *Asian Perspectives,* 35**,** 119-153.

BOURQUE, L. B., REGAN, R., KELLEY, M. M., WOOD, M. M., KANO, M. & MILETI, D. S. 2012. An Examination of the Effect of Perceived Risk on Preparedness Behavior. *Environment and Behavior,* 45**,** 615-649.

BURBY, R. J. 2006. Hurricane Katrina and the paradoxes of government disaster policy: bringing about wise governmental decisions for hazardous areas. *The Annals of the American Academy of Political and Social Science,* 604**,** 171-191.

COATES, L. 2012. Moving Grantham? Relocating flood-prone towns is nothing new. *The Conversation*, January 10, 2012.

COOK, M. 2018. "It will never happen again": The myth of flood immunity in Brisbane. *Journal of Australian Studies,* 42**,** 328-342.

GISSING, A., VAN LEEUWEN, J., TOFA, M. & HAYNES, K. 2017. Flood levee influences on community preparedness: a paradox? *Australian Institute for Disaster Resilience,* 33**,** 38-43.

INSW 2017. Resilient valley, resilient communities: Hawkesbury-Nepean Valley flood risk management strategy. Sydney: Infrastructure NSW.

INSW 2019. Hawkesbury-Nepean Valley flood risk management strategy taskforce options assessment report. Sydney: Infrastructure NSW.

INSW 2021a. Climate Change and flooding effects on the Hawkesbury-Nepean: Final Report. Sydney: WMA Water.

INSW 2021b. Hawkesbury-Nepean Flood Strategy: Community Resilience Program: Building flood resilient communities in a high-risk valley: Program update: July 2021. Sydney: Infrastructure NSW.

IRISH, J. L. 1987. Flood insurance. *Australia/new Zealand Forum on Floodplain Management.* Sydney.

IRISH, J. L. & FALCONER, B. 1979. Reaction to flood warning. *In:* HEATHCOTE, R. L. & THOM, B. G. (eds.) *Natural hazards in Australia.* Canberra: Australian Academy of Science, Canberra.

IRISH, J. L. & LUSTIG, T. L. 1993. Economic evaluation of coastal protection strategies. *11th Australasian Conference on Coastal and Ocean Engineering.* Townsville: Institution of Engineers Australia.

J. WYNDHAM PRINCE 2018. Marsden Park North Precinct: Watercycle & Flood Management Strategy Report. Penrith.

JAMSHIDI, E., MAJDZADEH, R., SABERI, M., ARDALAN, A., MAJDZADEH, B. & SEYDALI, E. 2016. Effectiveness of Community Participation in Earthquake Preparedness: A Community-Based Participatory Intervention Study of Tehran. *Disaster Medicine and Public Health Preparedness,* 1**,** 1-8.

KARANCI, A. N., AKSIT, B. & GULAY, D. 2005. Impact of a community disater awareness training programin Turkey: does it influence hazard-related cognitionsand preparedness behaviours IMP. *Social Behavior and Personality,* 33**,** 243-258.

KAZANIDIS, I., VASILIOS, G., FOTARIS, P. & TSINAKOS, A. 2020. Educational escape room for disaster preparedness and response training.

KEYS, C. 2016. A community, a council and a flood risk: The case of Maitland, New South Wales, and some ramifications. *Journal of the Royal Australian Historical Society,* 102**,** 152-172.

KEYS, C. Submission to the New South Wales Legislative Council Select Committee on the Proposal to Raise the Warragamba Dam Wall. Inquiry into proposal to raise the Warragamba Dam Wall., 2019 NSW Legislative Council. NSW Parliament.

KEYS, C. 2021. Alarming inconsistency: NSW Government Ministers on development in flood-prone areas. *Pearls and irritations: John Menadue's Public Policy Journal*, 20/04/21.

LANGER, E. J. 1983. *The psychology of control,* Beverly Hills, Sage.

LUSTIG, T. L. 2012. Could the insurance industry help make floodplain management sustainable? *Floodplain Management Association Conference.* Batemans Bay: Floodplain Management Australia.

LUSTIG, T. L. & HAEUSLER, T. M. 1989. Social and economic effects of floods. *29th annual conference of flood mitigation authorities.* Batemans Bay: Flooplain Management Authorities of NSW.

LUSTIG, T. L. & MAHER, M. M. 1997. Sustainable floodplain management plans. *Australian Journal of Emergency Management,* 12**,** 10-17.

MOLINO, S. 2018. Marsden Park North Evacuation Strategy: 2018 ILP Preliminary Analysis, Appendix D Flood Evacuation Strategy, in J. Wyndham Price, Marsden Park North Precinct Watercycle & Flood Management Strategy Report. Penrith: J. Wyndham Price.

MOLINO, S., MORRISON, T., HOWARD, M. & OPPER, S. 2013. A technical guidleine for the usde of the SES Timeline Evacuation Model in flood evacuation planning. *Proceedings of the 53rd Annual Floodplain Management Authorities Conference,.* Tweed Heads: Floodplain Management Australia.

MWR, UNDP & UNDHA 1994. Strategy and Action Plan for Mitigating Water Disaters in Viet Nam. New York and Geneva: Ministry of Water Resources,

United Nations Development Program,

United Nations Department of Humanitarian Affairs.

NOVAK, J., LOZOS, J. C. & SPEAR, S. E. 2019. Development of an Interactive Escape Room Intervention to Educate College Students about Earthquake Preparedness. *Natural Hazards Review,* 20.

NSW TREASURY 2007. NSW Government guidelines for economic appraisal. Sydney: NSW Treasury.
NSWG 2005. Floodplain development manual: the development of flood liable land. Sydney: Department of Infrastructure, Planning and Natural Resources.
NSWG 2021. Standard Instrument (Local Environmental Plans) Amendment (Flood Planning) Order 2021 under the Environmental Planning and Assessment Act 1979. *In:* GOVERNMENT, N. S. W. (ed.) *Standard Instrument (Local Environmental Plans) Amendment (Flood Planning) Order 2021 [NSW].* Sydney: New South Wales Government.
OPPER, S. 2004. The application of timelines to evacuation planning. *Proceedings of the 44th Annual Floodplain Management Authorities Conference,.* Copffs Harbour: Floodplain Management Australia.
OPPER, S., CINQUE, P. & DAVIES, B. 2010. Timeline modelling of flood evacuation operations. *First International Conference on Evacuation Modelling and Management.* Den haag, The Netherlands: ScienceDirect.
PARKER, D. J. 1995. Floodplain development policy in England and Wales. *Applied Geography,* 15**,** 341-363.
PIELKE, R. A. 1999. Nine fallacies of floods. *Climatic Change,* 42**,** 413-438.
QFCI 2011. Queensland Floods Commission of Inquiry: Interim Report. Brisbane: Queensland Floods Commission of Inquiry.
SAARINEN, T. 1990. Improving public response to hazards through enhanced perception of risks and remedies. *In:* HANDMER, J. & PENNING-ROWSELL, E. (eds.) *Hazards and the communication of risk.* Farnham: Gower [Accessed Date Accessed].
SES 2018. Lismore City Flood Emergency Sub Plan. Lismore: Lismore City.
SES 2020. Hawkesbury-Nepean Valley Flood Emergency Plan. Wollongong: State Emergency Services.
SIDERS, A. R. 2019. Managed retreat in the United States. *One Earth 1***,** 216-25.
SOLOW, A. R., ADAMS, R. F., BRYANT, K. J., LEGLER, D. M., O'BRIEN, J. J., MCCARL, B. A., NAYDA, W. & WEIHER, R. 1998. The value of improved ENSO prediction to U.S. Agriculture. *Climate Change,* 39**,** 47-60.
THOMPSON, A. 2021. 'I could see it coming': Thousands of new homes halted over flood evacuation fears. *Sydney Morning Herald*, 26/3/21.
TOBIN, G. A. 1995. The Levee Love Affair: A Stormy Relationship? *Journal of the American Water Resources Association,* 31**,** 359-367.
VINCE, J. & ATKINS, B. 2009. The Launceston flood policies: levees and beyond. *Australian Journal of Emergency Management,* 24**,** 32-37.
WATER CORPORATION 2009. Water forever — towards climate resilience. Perth: Water Corporation.
WHITNEY, D. J., LINDELL, M. K. & NGUYEN, H. H. 2004. Earthquake beliefs and adoption of seismic hazard adjustments. *Risk Anal,* 24**,** 87-102.
WRDEIS 2021. Environmental Impact Statement Warragamba Dam Raising. Sydney: Water NSW.