The Colong Foundation for Wilderness submission to the Department of Planning, Industry and Environment regarding the Warragamba Dam Raising Project (SSI-8441)

We accept the Department of Planning, Industry and Environment (DPIE) submission disclaimer and declaration.

We consent to our submission being published in full, including the names and addresses of people and premises associated with our Foundation.

We have made no reportable political donations in the past two years.

Our Foundation is opposed to the Project, and believes that it cannot properly be approved by the Minister for Planning. We detail the reasons for our Foundation's opposition in this submission. We have divided our submission into 15 sections that deal with different aspects of the Warragamba Dam Raising Project and the Environmental Impacts Statement (EIS) that is currently on exhibition.

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1. The Colong Foundation for Wilderness

The Colong Foundation has worked for the conservation of the Greater Blue Mountains area for more than fifty years. In the 1960s, a proposal was advanced to mine limestone at the Colong Caves in the southern Blue Mountains for cement production. Artificial boundaries were drawn to exclude the Caves area from the new Kanangra-Boyd National Park. The Colong Committee was formed by the famous activist Milo Dunphy to fight the proposal and it achieved a historic conservation win when Mt Colong was added to the Park. Soon after, the Committee decided to extend the fight for wild areas and in 1973 changed its name to The Colong Foundation for Wilderness Ltd.

Our Foundation conducted successful campaigns for national parks and wilderness across the State in the many years that followed but always maintained a focus on the Blue Mountains region. It was instrumental in the establishment of the NSW Wilderness Act (1987) and the inscription of the Greater Blue Mountains on the list of World Heritage. The recent expansion of the Gardens of Stone protected area was achieved after decades of Colong advocacy.

It was inevitable, given the familiarity of our Foundation with the Greater Blue Mountains, that the proposal to raise the wall of Warragamba Dam would attract the attention of the Colong Foundation as soon as it was announced in 2017.

Our Foundation quickly discerned that the prospectus prepared for distribution to the public and entitled *Hawkesbury-Nepean Valley Flood Risk Management Strategy 'Resilient Valley Resilient Communities'* essentially presupposed the ultimate outcome of the Environmental Impact Statement (EIS) process.

Many professional submissions to the EIS exhibition process confirm our view that the planning and assessment of this Project has been manifestly preemptive and not carried out in good faith.

There was no acknowledgment in the original (2017) strategy document that new inundation caused by the Project would damage a World Heritage property. There was no acknowledgement that it would damage or destroy hundreds of Gundungurra cultural sites.

The Project was justified by the proponent on the grounds that the population vulnerable to flooding on the Hawkesbury Nepean Plain would inevitably increase by 134,000 people by 2050.There was however no acknowledgment that population growth could be halted by active government planning measures.

The assumptions that informed the decision to select raising of Warragamba Dam wall as the preferred flood management option were predicated on cursory cultural and environmental assessments undertaken before any SEARs were issued.

Planning and investigations informing the original strategy proposal were conducted in exceptional secrecy by a taskforce of government officials which dismissed all other possible flood mitigation methods -- for instance reduction of the level of the reservoir in high rainfall periods or construction of flood evacuation roads and levees -- out of hand and without peer review.

The underlying attitudes of the proponent have not changed since 2017 and the fundamental flaws in its proposal have never been corrected.

2. The Planning Minister cannot lawfully approve this proposal

An EIS for operating the dam has not been prepared

The EIS purports to have been prepared in support of an application for approval of both the physical raising of the Warragamba dam wall and the operation of the raised dam for flood mitigation purposes. In order to permit such an approval, EIS must describe both the design of the physical infrastructure *and* the proposed operation of that infrastructure in adequate detail to allow for at least the outer parameters of the project to be defined and assessed.[1] However, the EIS currently on exhibition does not describe, and therefore cannot assess the impacts of, the use of the raised dam wall for flood mitigation purposes.

The EIS itself properly acknowledges that both the design *and operation* of the raised dam will impact the extent of upstream flooding impacts, downstream flood mitigation, and impacts to the environment generally. In Chapter 4, the EIS states that (emphasis added):

> "*the peak levels and duration of inundation upstream of a raised Warragamba Dam are a function of:*
>
> - *the height of the spillway*
> - *the size of inflows to the dam*[2]
> - *the rate at which the captured floodwaters in the FMZ are discharged after a rainfall event.*"[3]

Despite this acknowledgement, the EIS admits that fundamental aspects of the project relating to the process for discharging floodwaters from the FMZ have not been decided. The rate at which captured floodwaters in the FMZ are discharged after a rainfall event will no doubt be determined by both the design of the dam's openings (namely, their size and location and whether they are gated or not) and how the dam's gates are operated (if the openings are gated). But the EIS admits that neither of these aspects of the proposal have been decided. Table 29-4 in Chapter 29 of the EIS lists "slots or conduits in the central spillway" as a "key uncertainty" of the project and states that:

> *"Two options to release water from the dam via the central spillway are currently being investigated. These are:*
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> - *gated conduits – the advantage of this alternative is that discharge rates from the dam would be able to be varied and controlled accurately. The disadvantages are that it would require complex operating procedures and maintenance requirements.*
> - *slots – the advantages of this alternative are there would be no operating procedures and maintenance requirements. The disadvantage is that discharge rates would be predetermined by flow and design, and not able to be varied.*

[1] *Community Action for Windsor Bridge Inc v NSW Roads and Maritime Services & anor* [2015] NSWLEC 167 at [63]-[68].

[2] In addition to the size of the inflows, we would add their duration.

[3] EIS Chapter 4: Project development and alternatives, section 4.4.3.

A combination of slots and conduits is also being considered."

This admission calls into question the hydrological modelling, detailed in Chapter 15, that forms the basis of the predicted upstream impact area relied upon by several specialist chapters of the EIS, including upstream biodiversity and Aboriginal cultural heritage. While all hydrological modelling is speculative, the degree of uncertainty can be narrowed where the design and operating rules are known. In the present case, neither the design, aside from the height of the spillway, nor, consequently, the operating rules have been determined.

Chapter 15 the EIS contains several figures showing modelled flood impacts during the operation of the raised dam, both up and downstream (although noticeably less detailed upstream). These maps could not have been produced without relying on certain assumptions about how the dam's openings would be designed or operated during and after flood events, however, these assumptions have not been disclosed or described in the EIS.[4]

To resolve this uncertainty, the EIS proposes that:

> *"The provision of conduits, slots or a combination of both would be determined during detailed design. Should potential impacts arise that have not been considered in the EIS, then an amendment report would be prepared and submitted to DPIE."*

Such an approach is not supported by the *Environmental Planning and Assessment Act 1979* (EP&A Act). Decisions relating to fundamental aspects of a proposal cannot properly be made after a proposal has already been approved, because a proposal cannot be approved if fundamental aspects of it have not been articulated by the proponent. To the extent that the Planning Secretary or WaterNSW propose to address its lack of detail about the design and operation of the dam's openings in a Preferred Infrastructure Report ("PIR"), this too is not supported by the EP&A Act.

Subsection 5.17(6)(b) empowers the Planning Secretary to require the proponent to submit:

> "*a preferred infrastructure report that outlines any proposed **changes** to the State significant infrastructure to minimise its environmental impact or to deal with any other issue raised during the assessment of the application concerned."*

This provision operates to allow changes to a project that has already been defined and studied as the subject of a publicly exhibited EIS. In the current application, where neither the openings nor the operating rules have been defined, there is no object to "change". Further, to wait until the preparation of a PIR, which is not required to be publicly exhibited,[5] to define two out of the three key components of the project (namely, the design of the dam's openings and how those openings are operated during a flood event) is contrary to both the requirements of the Secretary's Environmental Assessment Requirements ("SEARs") and

[4] Section 3 of Colong Foundation for Wilderness submission by Slattery and Johnson; Submission of Dr Anthony Green, page 4.

[5] The Planning Secretary has the discretion not to make the PIR publicly available (section 5.17(6)(b) of the EP&A Act) and there is no statutory requirement that the PIR be publicly exhibited so as to allow public submissions to be made in response to it.

the fundamental community consultation objectives of the EP&A Act, including as set out in s.1.3(j).[6]

Table 29-4 in Chapter 29 also identifies the lack of operational protocols as a source of uncertainty and concludes that the final operational protocol "may" result in "minor" changes in the flooding impacts and benefits. However, the EIS fails to provide any evidence or justification to support its conclusion that the final operational protocols would only result in "minor" changes.

Elsewhere, the EIS states that further approvals will be obtained for the dam's operations, "as appropriate"[7]. The nature of these subsequent approvals, or their statutory basis, is not described in the EIS, despite the fact that the SEARs expressly require the proponent to identify "a list of any approvals that must be obtained under any other Act or law before the project may lawfully be carried out".[8]

The project purportedly on exhibition expressly includes not just the construction of the raised dam wall but "the operation of the dam for flood mitigation".[9] However, leaving aside the EIS's failure to define the dam's openings, as it does not address the dam's operation, any consequent approval would require the preparation of another EIS in order to be lawful. The EP&A Act provides that an EIS is required to be prepared for a Part 5 activity if the activity is likely to "significantly affect the environment".[10] It is undeniable that the operation of a raised Warragamba Dam for flood mitigation purposes will have a significant effect on both the downstream and upstream environments. Therefore, the *operation* of the raised dam itself carries with it a requirement for an EIS to be prepared, separate from any requirement to prepare an EIS for the construction of the raised dam.

<u>A staged infrastructure application has not been made</u>

The EIS also admits that "the design and construction approach presented in this EIS is based on a *concept design* and is indicative only."[11] For whatever reason, WaterNSW has decided not to make a staged infrastructure application, which was a course open to it under Division 5.2, Subdivision 3 of the EP&A Act, and which in the circumstances of its indicative "concept design" would have been the appropriate path. Sub-section 5.20(1) of the EP&A Act provides:

> *For the purposes of this Division, a **staged infrastructure application** is an application for approval of State significant infrastructure under this Division that sets out <u>concept proposals</u> for the proposed infrastructure, and for which detailed proposals for separate parts of the infrastructure are to be the subject of subsequent*

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[6] See also s.5.28(1)(c); s.5.29(h); cl 192(1)(a) EP&A Reg; State Significant Infrastructure Guidelines

[7] EIS Chapter 29: Summary, section 29.3.

[8] SEARs, requirement 2.1(o).

[9] EIS Chapter 5.1

[10] Section 5.7 of the *Environmental Planning and Assessment Act 1979* ("EP&A Act"). This section does not apply directly to State significant infrastructure projects. However, section 5.12 of the EP&A Act and clause 1(1) of Sch 3 of the *State Environmental Planning Policy (State and Regional Development) 2011* ("SEPP") provide that infrastructure that, but for Division 5.2 of the EP&A Act would, in the opinion of the proponent, require an environmental impact statement to be obtained under "Division 5.1" (in the case of section 5.12 of the Act) or "Part 5" (in the case of Sch 3 of the SEPP) is State significant infrastructure. Therefore, the test of "likely to significantly affect the environment" applies to determine whether a proposal will be State significant infrastructure, and therefore, require an EIS (as all SSI does under section 5.16(2) of the EP&A Act).

[11] EIS Chapter 29: Summary, section 29.1.

applications for approval. The application may set out detailed proposals for the first stage.

Relevantly to the current proposal, the EIS sets out *detailed proposals* for only one of the three elements of the project, being the raising of the wall/ height of the spillway. The other two critical elements, namely the openings in the wall by which the dam will be "operated", and rules for operating the dam in flood events, have yet to be determined. Moreover, the existence of Subdivision 3 implies as a matter of statutory construction that applications made on the basis of concept designs alone cannot be approved.

Sub-section 5.20(2) provides:

> *If approval is granted under this Division on the determination of a staged infrastructure application, the approval does not authorise the carrying out of any part of the State significant infrastructure unless –*
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> *(a) approval is subsequently granted to carry out that part following a further application for approval in respect of that part of the infrastructure, or*
> *(b) the staged infrastructure application also provided the requisite details of that part of the infrastructure and approval is granted for that first stage without the need for further approval.*

In relation to ss.5.20(2)(b), the openings and gates, or slots (as the case may be) by which outflows can be controlled are so integral to the overall project, and the physical infrastructure in particular, that approval of the raising of the wall cannot be approved until this aspect of the design is finalised and its impacts properly studied. The absence of details of the means by which outflows are controlled is patently an absence of "requisite details". Were the proposal to be one of inserting new openings, gates or slots in the existing Warragamba dam wall, there is no doubt that an EIS would be required for that aspect alone. Regardless of whether it was state Significant infrastructure, the construction of the openings and gates would, of itself, be an activity that is likely to significantly affect the environment. Accordingly, final approval of the physical works is not available under ss. 5.20(2) even if WaterNSW had made a staged infrastructure application.

Despite this, WaterNSW wishes to obtain full approval for the construction and operation of a raised Warragamba Dam, without having first done the work to design the proposal with sufficient detail to allow it to be assessed or approved.

<u>Inconsistent, vague, and inconclusive descriptions of the operation of the proposal</u>

Possibly as a consequence of the fact that the design and operation of the dam's openings have not been decided by WaterNSW, the various chapters of the EIS contain inconsistent, vague, and inconclusive descriptions of how the dam will operate once raised. The table in **Appendix A** extracts several examples of this. In summary, from these extracts it is apparent that:

1. the size and location of the dam's openings, and whether or not they will be gated, has not been determined;[12]

[12] EIS Chapter 29: Summary, section 29.1 and Table 29-4.

2. the operational protocols have not been devised for the project[13] (although admittedly, these cannot be developed until the design of the slots or gates has been settled because the EIS itself admits in Table 29-4 that if ungated slots are chosen, operational protocols will not be required);

3. the operational protocols will be subject to further consultation with relevant stakeholders and "approvals", but this approval process has not been described;[14]

4. floodwaters will be held within the FMZ "temporarily",[15] although no indication has been given as to what "temporarily" might mean. All water stored in any dam is stored temporarily. In the context of water stored in a dam, "temporarily" could mean anywhere from hours to years;

5. the EIS purportedly provides a "framework" for operational protocols,[16] however, to the extent that any framework can be gleaned from the EIS, it is extremely high level, inconsistent, and inconclusive. On any view, it does not constitute rules or protocols for the operation of the raised dam.[17]

<u>The EIS does not meet the SEARs</u>

The SEARs explicitly require a description of the project, including "all components and *activities* (including ancillary components and activities) required to construct *and operate* it" (see requirement 2.1(b)). Requirement 20.6 of the SEARs also states:

> *"The proponent must detail a framework for managing water releases from the dam that are capable of meeting the objectives of the project (in terms of flood mitigation),*

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[13] EIS Chapter 29: Summary, section 29-1; EIS Chapter 5: Project description, section 5.2.7.2.
[14] EIS Chapter 29: Summary, section 29-1; EIS Chapter 5: Project description, section 5.2.7.2.
[15] EIS Chapter 5: Project description, section 5.2.7.2; EIS Chapter 29: Summary, section 29-3; EIS Appendix H1: Flooding and hydrology, section 1.3.3.
[16] Chapter 29: Summary, Table 29-4.
[17] We also note the evidence given by the Minister responsible for the project, The Hon Stuart Ayres, to the Legislative Council on 27 October 2021. The Minister, in responding to questions about the lack of a legislative indemnity for the State's operation of the dam for flood mitigation, said:

> *"The legislation will need to be drafted to reflect the fact that you are now operating the dam in a dual fashion. A dam will need to do two things: It will need to store water and it will need to store water up to a height that is effectively consistent with where the level is now. When you raise the dam wall, you are raising the dam wall for the purposes of creating airspace. Right now the operation and function of the dam is designed entirely to protect Sydney's drinking water supply, so you have to change the legislation to allow the dam to have a dual purpose...*
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> *"If the Government decides to present this legislation to the Parliament, it would be doing so on the basis that we would want to be able to protect Sydney's drinking water assets as well as run flood mitigation capacity. If there were members of the Parliament that wanted to vote against that and allow the dam to fill and utilise all of the airspace that we have just built."*

The apparent implication of the Minister's extraordinary comments is that if the Parliament were to deny the government an indemnity for the use of the dam for flood mitigation, WaterNSW would use the FMZ for water storage. If this construction of the Minister's evidence is correct, the application for planning approval should be rejected on this basis alone as it makes the whole premise of the application and the EIS a lie. A failure by the Planning Minister to clarify this position would also constitute a fundamental error.

ensures impacts to upstream and downstream areas and ecosystems are minimised. The framework shall include consideration of the potential rates of rise and fall in the river, timing of water releases. These shall include consideration of antecedent, conditions within the river, flooding impacts, and transparent and translucent flows."

As demonstrated by the extracts in **Appendix A**, the EIS has failed entirely to meet these requirements because fundamental aspects of the dam's design and operation have not been decided.

The SEARs also provide that the EIS must include "a description of feasible options within the project" (requirement 2.1(f)). This is distinct from the requirement to include "a description of any feasible alternatives to the project" (requirement 2.1(e)). The SEARs provide the following guidance on the difference between the two concepts:

> *"Alternatives to a project are different projects which would achieve the same project objective(s) including the consequences of not carrying out the project. For example, alternatives to a road project may be a rail project in the same area and alternate routes for the road."*[18]

> *"Options within the project are variations of the same project. For example, options within a road project could be design of an intersection; the location or design of a bridge; locations for a vent stack."*[19]

In other words, once a particular infrastructure solution has been decided, such as a raised dam wall, options "within" the project means the various ways that infrastructure could be constructed or operated. In the context of the Warragamba Dam wall raising proposal, options within the project should properly include different design options and operating procedures for the raised dam wall.

The EIS claims to address requirement 2.1(f) in sections 4.3 and 4.4 of Chapter 4.[20] However, these sections do not consider options *within* the Warragamba Dam raising project. Rather, they provide an account of the alternatives to the project considered by the Taskforce when preparing the Taskforce Options Assessment Report in 2019, such as lowering the FSL of the existing dam or changing the gate operations of the existing dam. Presumably, the reason that the EIS has not provided this information is because the development and consideration of options within the project is still ongoing.

<u>The operation of the raised dam cannot be validly approved</u>

The fact that fundamental aspects of the proposal have not been determined, and that the EIS at best contains vague, inconsistent, and inconclusive statements as to how the dam will actually operate to mitigate flood impacts, preclude the Minister's ability to validly approve the proposal.

Without the re-submission and re-exhibition of a substantially reworked EIS, in which the proposed design and operation of the dam has been described with sufficient detail to allow the outer parameters of the proposal to be identified and studied, any decision by the

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[18] SEARs Footnote 2, page 2.
[19] SEARs Footnote 3, page 2.
[20] EIS Chapter 4: Project development and alternatives, Table 4-1.

Planning Minister to approve the operation of the raised dam would be invalid. Specifically, the Planning Minister's approval would be invalid because:

- a fundamental statutory prerequisite to the exercise of his power, being the preparation of an EIS, would not have been met;
- the decision would be uncertain or lack finality if key aspects of the proposal are not articulated in the approval; and
- his decision would have been made without considering a mandatory relevant consideration, being the full environmental impact of the proposal during operation.

The sole purpose of the proposal is to raise and operate Warragamba dam for flood mitigation. Therefore, the design and operation of the dam's openings, which dictate how and to what extent floodwaters can be controlled, are the single most important aspect of the proposal. This is particularly pertinent given that project's operating objective of "minimising environmental impact" would require completely different operational procedures to the remaining operational objectives relating to minimising risk to life and property downstream. The development of operational protocols early on in the planning process is essential for the public and the Planning Minister to understand how this conflict would be managed during a flood event. Currently, the only insight we have into how these conflicting objectives will be managed is that minimising downstream flooding impacts will take priority over minimising environmental impact.[21] Determining discharges during flood events on a "case by case basis"[22] is not only irresponsible, having regard to the seriousness of the impacts from operating the discharges, it is completely at odds with the EIS's claims that a detailed operational protocol will be developed.

The proposal cannot possibly be assessed or approved until these aspects of the project have been decided. This proposal has the potential to cause immense environmental damage to areas of world heritage listed national park; further decimate populations of critically endangered species that cannot be offset;[23] and result in the destruction of numerous significant Aboriginal cultural sites.[24] The EIS is also claiming huge benefits in terms of mitigation of risks to life and property downstream. The information contained in the current EIS is not sufficient or transparent enough for the public, or the Planning Minister, to determine whether the author's determinations of likely environmental impacts are reasonable or whether the touted benefits will likely be realised.

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[21] EIS Chapter 29: Summary, section 29.1.

[22] EIS Chapter 15: section 15.8.4.

[23] Refer to the submissions of Dr Stephen Douglas and Debbie Andrew in response to this EIS.

[24] Refer to submission by the submission made by Traditional Owner, Kazan Brown and the associated expert reports attached to her submission by Paul Irish and Val Attenbrow.

Appendix A Extracts from EIS describing operational protocols

Ref	Extract (emphases added)	Comment
Chapter 5: Project Description **5.2.7.2**	**Flood operations** During large rainfall events when the storage level rises above FSL, flood operations mode would commence. In this mode, inflows to Lake Burragorang would be captured and *temporarily* stored (increasing water levels in Lake Burragorang and upstream tributaries). The raised dam would provide capacity (i.e. the FMZ) to capture temporarily around 1,000 gigalitres of water during a flood event. *Water would be discharged in a controlled manner via the gated conduits or slots until the dam level returns to FSL.* *FMZ operating protocols would guide this process and be developed for approval by the relevant regulatory authorities.* The raised dam would not be able to fully capture inflows from all floods. For floods that exceed the capacity of the FMZ, water would spill firstly over the central spillway and then, depending on the size of the flood, the auxiliary spillway.	• This section uses the word "temporarily" but gives no indication of what temporary might mean in this context. All water stored in any dam is stored temporarily. In the context of water stored in a dam, "temporarily" could mean anywhere from hours to years. • The phrase "discharged in a controlled manner" is vague. Subsequent chapter of the EIS (particularly Chapter 15) provide more detail on what "a controlled manner" might mean, however, these chapters are not conclusive and only slightly more detailed. This statement is also inconsistent with the description in Appendix H1 (extracted below) which states that "for larger floods the FMZ would be filled and *uncontrolled* discharge would occur over the central spillway, and potentially, auxiliary spillway of the dam." • The process for approving the FMZ operating protocols is not described in the EIS. The use and operation of the raised dam for flood mitigation is an activity which, in itself, requires an EIS. The FMZ operating protocols would require a separate EIS for approval, and yet, despite no operating protocols having been developed, the "project" for which approval is sought includes the 'operation' of the dam. • 29.1 lists operational objectives of flood operations in order of priority. As with the Wivenhoe disaster, the complexity and conflict between the objectives highlight the need for clear and detailed operating rules/protocols on how the dam would be operated in the crisis of a major flood. The fact that the EIS says nothing about how these conflicts would be resolved in

		practice illustrates why the Planning Minister is not in a position to approve the "project".
Chapter 7: Air Quality **7.1**	**Flood operation** Flood operations would apply when the water level is higher than the FSL. The FMZ would have sufficient storage to accommodate up to a 1 in 40 chance in a year flood. For larger floods the FMZ would be filled and uncontrolled discharge would occur over the central spillway and, potentially, the auxiliary spillway of the dam. Operational objectives are to: • maintain the structural integrity of the dam • minimise risk to life • maintain Sydney's water supply • minimise downstream impact of flooding to properties • minimise environmental impact • minimise social impact.	• Table 29-3 in Chapter 29 states that "one of the key operational objectives of the discharge protocol for the flood mitigation zone would be to minimise the duration and extent of upstream temporary inundation", however, this does not appear to be reflected in the operational objectives described in section 7.1.
Chapter 15: Hydrology **15.8.1**	Raising the dam wall and creation of the FMZ would require modification of the operational rules of dam releases. An initial assessment and development of preliminary operating protocols was done by WaterNSW (2017)... Final operational protocols will be further developed in conjunction with detailed design of the dam and in consultation with stakeholders responsible for flood management and emergency response in the downstream floodplain.	• This statement highlights the conceptual nature of the current proposal and yet final approval, as opposed to Subdivision 3 (Staged Infrastructure Applications), is being sought. This is not a course that is validly open to WaterNSW where 2 of the three key components to the project remain undetermined and, consequently, unstudied.
Chapter 15: **15.8.3**	**FMZ maintenance** Minor rainfall events and associated inflows may result in small increases in the dam water level, which in turn may exceed the FSL. Once the water level in the dam reaches a nominated level above the FSL (and no significant rainfall is predicted), the FMZ maintenance protocols would be implemented. These include discharging approximately 48 gigalitres of water via the conduits until the dam water level drops to the FSL. While this could be	• This section is inconsistent with Table 29-4 in that it assumes that the timing and rate of discharge will be able to be controlled, when Table 29-4 indicates that it has not been decided whether the dam's openings will be gated or always open.

	undertaken in a single day with minimal downstream impacts, the discharge rate would be determined by several factors including downstream water levels and the predicted short-term rainfall forecast. The need for maintenance discharges may be minimal depending on the environment flow release regime adopted.	
Chapter 15: Hydrology **15.8.4**	**Discharge during flood events** The timing and rate of discharge during flood events would be determined on *a case-by-case basis*. Generally, the discharge of water from the FMZ during a flood event would only occur: • when there was a reliable prediction of significant future rainfall • when the discharge would not cause unacceptable downstream flooding impacts.	• Leaving discharges to be determined on a "case-by-case" basis without developing operating protocols means there can be no certainty of impacts downstream or upstream during flood events. For a project with the potential to have devastating environmental impacts, including social and economic impacts, the Minister and the public are entitled to know what the operating rules are in advance of any construction, let alone a flood event, and the EP&A Act requires it. • This section is also inconsistent with Table 29-4 in that it assumes that the timing and rate of discharge will be able to be controlled, when Table 29-4 indicates that it has not been decided whether the dam's openings will be gated or always open.
Chapter 15: Hydrology **15.8.5**	**Discharge after a flood event** This section is too long to be extracted, however, it describes two potential methods for discharging water after a flood event: 1. piggy back discharges, whereby water is released from the FMZ after the peak flood level has been reached at a rate that does not exceed the previous flood level peak; 2. constant discharge, whereby water is released from the FMZ at a constant rate of "around 100 gigalitres per day"	• This section of the EIS states that a constant discharge rate of around 100 gigalitres / day was assessed against a number of factors, however, the maximum discharge rate for the new outlet conduits are said to be 230 gigalitres/day. • It is not explained in the EIS how the authors decided on the discharge rate of 100 gigalitres/day for the purposes of assessment, as opposed to some higher or lower rate. It is not even stated that 100 gigalitres/day is going to be the likely discharge rate for a constant discharge scenario. • The EIS describes two potential methods for discharge after a flood event, but does not state which is the preferred method, or if both are to be used, nor how this decision would be made. Appendix H1 appears to provide that piggy backing will be used for major flood releases (flood events above 2.5%

		AEP), and constant discharge would be used for minor flood releases (flood events between 5% and 2.5% AEP). However, this is contained in a sub-consultant's report and is not confirmed anywhere in the body of the EIS. • This section is inconsistent with Table 29-4 in that it assumes that the timing and rate of discharge will be able to be controlled, when Table 29-4 indicates that it has not been decided whether the dam's openings will be gated or always open.
Chapter 29: Summary **29.1**	The Project does not include a detailed operational protocol for the operation of the FMZ or the environmental flow release regime. These activities would be subject to separate approvals, as appropriate.	• The process for approving the FMZ operating protocols is not described in the EIS. The use of the raised dam for flood mitigation is an activity which, in itself, requires an EIS. The FMZ operating protocols would require a separate EIS for approval. [See comments in response to Chapter 5 above.]
Chapter 29: Summary **29.4**	The design and proposed operational protocols presented in this EIS are indicative and subject to further detailed design and development, which may further minimise impacts. The design serves to: • confirm that the proposed performance and technical requirements can be achieved • validate the feasibility and potential operational protocols for flood mitigation • identify key risks, constraints and potential environmental impacts. There are some uncertainties relating to technical requirements and Project operations, which would be resolved during detailed design. A summary of the uncertainties that have the potential to impact on the environment, and how these would be resolved, is provided in Table 29-4. The identified uncertainties are not expected to result in significant or unacceptable impacts to the	• The design does not serve to confirm that the proposed performance and technical requirements can be achieved because key technical information and assumptions are not disclosed or are as yet undetermined. • The EIS provides no evidence or justification for the assertion that the identified uncertainties in Table 29-4 will not have unacceptable impacts to the environment that would not be capable of mitigation or management. • On the contrary, the modelling in the EIS around loss of vegetation and habitat, are built on assumptions that depend, amongst other matters, on knowing the methods and rates for discharge of anticipated flood waters and the operating rules for the dam, neither of which have yet been determined.

	environment that would not be capable of mitigation or management.	
Chapter 29: **Table 29-3**	Table 29-3 lists environmental aspects and details how impacts are to be avoided or minimised. Against “upstream impact” it states: • “Provision of a 14 metre flood mitigation zone rather than a 20 metre FMZ. While a 20 metre FMZ would provide a greater reduction in flooding downstream compared to a 14 metre FMZ, the greater environmental costs from the longer period and extent of upstream temporary inundation were a major factor in discounting this alternative.” • “Emptying the FMZ as soon as practicable. One of the key objectives of the discharge protocol for the flood mitigation zone would be to minimise the duration and extent of upstream temporary inundation.”	• This section is inconsistent with the description of operational objectives contained in section 29.1, which does not list “minimising the duration and extent of upstream temporary inundation” as a key objective, and places “minimising environmental impact” as the second last of six objectives.
Chapter 29: Summary **Table 29-4**	Identifies “slots or conduits in the central spillway” as a “key uncertainty” for “hydrology” and states that “two options to release water from the dam via the central spillway are currently being investigated. These are: • gated conduits – the advantage of this alternative is that discharge rates from the dam would be able to be varied and controlled accurately. The disadvantages are that it would require complex operating procedures and maintenance requirements. • slots – the advantages of this alternative are there would be no operating procedures and maintenance requirements. The disadvantage is that discharge rates would be predetermined by flow and design, and not able to be varied.	• Whether the openings in the dam are gated or not, and therefore, whether they can be controlled or not, is a key aspect of how the dam will operate and will have inescapable implications for the extent of flood mitigation downstream and flood impact upstream. This level of detail would be required even at a concept phase. • This section is also inconsistent with other aspects of the EIS, such as the description of proposed operations in Chapter 5, Chapter 15, and Appendix H1, all of which state that floodwaters would be discharged in a controlled manner, at least for flood events up to the 2.5% AEP.

	A combination of slots and conduits is also being considered. The provision of conduits, slots or a combination of both would be determined during detailed design. Should potential impacts arise that have not been considered in the EIS, then an amendment report would be prepared and submitted to DPIE.	
Chapter 29: Summary **Table 29-4**	Identifies the operational protocols for the dam as a “key uncertainty” for “hydrology” and states that “a framework operational protocol for the flood mitigation operations has been developed and is presented in the EIS. A detailed operational protocol would need to be developed during the detailed design of the Project and in consultation with relevant stakeholders up and downstream of the dam. The final operational protocol may result in some minor changes in the flooding impacts and benefits. The final operational protocol would be developed during the detailed design and in further consultation with relevant stakeholders.	• The lack of detailed operating protocols is an uncertainty for all aspects of the EIS, and in particular impacts to upstream biodiversity and the effectiveness of downstream flood mitigation. This is because without knowing how the gates will operate, it is impossible to predict, with any certainty, the extent of upstream flood impact or downstream flood mitigation. • The process for approving the detailed operational protocol is not described in the EIS. The use of the raised dam for flood mitigation is an activity which, in itself, requires an EIS. The operational protocol would require a separate EIS for approval. • The EIS provides no justification or evidence to support the assertion that the final operational protocol may result in only minor changes to flooding impact and benefits.
Appendix H1: Flood and Hydrology **1.3.3**	Flood operations would apply when the water level is higher than the full supply level. The FMZ would provide capacity to capture temporarily around 1,000 gigalitres of water during a flood. For larger floods the FMZ would be filled and uncontrolled discharge would occur over the central spillway, and potentially, auxiliary spillway of the dam. When inflows are falling, the FMZ will be emptied to ensure capacity for any subsequent events. The rate of discharge from the FMZ would be determined based on several factors:	• The description of the emptying protocols in this section is inconsistent with the description in Chapter 15 of the EIS. • This section is inconsistent with Table 29-4 in that it assumes that the timing and rate of discharge will be able to be controlled, when Table 29-4 indicates that it has not been decided whether the dam’s openings will be gated or always open.

	• ensuring the FMZ is emptied in sufficient time to capture a subsequent flood event • minimising the duration of upstream catchment inundation • not causing any increase in the extent of flooding downstream of the dam • the need to keep downstream bridge river crossings open. There will be two different emptying protocols: 1. Minor flood releases – releases of inflows captured from a 5% to 2.5% AEP event or at the tail end of larger floods. The rate of discharge of these releases will be identified based on potential flooding risks downstream, noting that as the dam raising will reduce the immediate exposure of downstream areas to these flood events, the subsequent release from the dam will need to be restricted to avoid increases in these reduced downstream flooding extents. Typically, discharges would be at 1,150 m3 /s (around 100 GL/day) but would not occur until after the peak of the flooding downstream has passed. 2. Major flood releases – releases for significant flood events. As the FMZ is designed to contain a 5% to 2.5% AEP event above FSL, any event above this will cause spilling to downstream areas, albeit at a lower level. During this scenario there is an opportunity to increase the rate of discharge from the FMZ at a higher rate than for minor flood releases without increasing the extent of downstream flooding (that is, piggyback releases). This can typically occur for the first two days before the FMZ discharge rate would then be reduced to the same rate as for minor flood releases (that is, 1,150 m3 /s).	

	For all events, the dam raising will cause a substantial reduction in the flow rate of spills over the dam. This will reduce flood levels and delay the downstream peak. The extent and duration of inundation is important to defining potential impacts on environmental values…The Warragamba Dam Raising is expected to temporarily increase the existing impoundment area within the upstream reservoir from approximately 75 km^2 to up to 94 km^2.	

3. Project design and operation

This section of The Colong Foundation for Wilderness submission has been written by water engineering consulting firm Slattery and Johnson. It is attached below.

Warragamba Dam Raising

Environmental Impact Statement review

Slattery & Johnson
Research · Communication · Policy

Project questions

The Colong Foundation has requested that Slattery & Johnson provide responses to three questions related to the proposed raising of Warragamba Dam, below:

1. *We understand that there are three main elements to a dam that will determine the extent of upstream flooding and downstream flood mitigation:*
    a. *the height of the dam / size of the flood mitigation zone (FMZ);*
    b. *the size and location of the openings, including whether or not they have operable gates; and*
    c. *how the openings are operated.*

    Is this correct?
2. *Do you think that the EIS provides sufficient detail about the operating procedures to enable an accurate prediction of the likely extent/duration of upstream flooding and downstream flood mitigation?*
3. *If the second and third elements in the above list have not been described in detail, what impact does this have on the ability to accurately predict the likely extent/duration of upstream flooding and downstream flood mitigation?*

Introduction

WaterNSW proposes to raise Warragamba Dam to provide additional flood security for western Sydney. Warragamba Dam is Sydney's primary water reservoir and does not currently have a designated flood storage volume. The proposal would create a Flood Mitigation Zone to store water temporarily to avoid or mitigate flooding downstream. WaterNSW does not propose to increase the volume held for water supply.

An Environmental Impact Statement is on public exhibition. The purpose of the Environmental Impact Statement is to provide:

> *a detailed assessment of the project impacts and the mitigation measures and offset strategies proposed to address the impacts.*[1]

The Environmental Impact Statement must identify and assess all impacts of the project.

One of the primary impacts of raising Warragamba Dam will be to increase the size of the upstream lake. The upstream catchment has heritage and ecological values, including parts of the Greater Blue Mountains Area, a UNESCO World Heritage site. Parts of the World Heritage site will be flooded if the project proceeds.

[1] SMEC. (2021). *Environmental Impact Statement – Executive Summary, 10 September 2021.* https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSI-8441%2120210928T030926.168%20GMT

Existing structure

Warragamba Dam's current storage capacity is 2,027 gigalitres.[2] The dam includes one central drum gate and four radial gates that are used to pass large flows. The full supply level of 116.72m AHD[3] is set by the top of the central drum gate and floods an upstream area of about 7,700 hectares. It is not possible to store water above the full supply level. However, when the dam spills the water level is temporarily above the full supply level.

The project

The proposed project will raise the spillway crest level by approximately 12 metres, to 128.5m AHD (see Figure 1). This will be achieved by raising and thickening the main concrete structure of the dam. The additional 12 metres of height creates about 1,000 gigalitres of airspace in the dam that would be used to store floodwaters. The maximum area of the upstream lake will increase by 5,600 hectares to 13,300 hectares. The project includes construction of new Flood Mitigation Zone outlets which will be used to discharge floodwaters. The maximum discharge from the outlets will be 230 gigalitres per day.[4] Figure 1 shows a cross section of the proposed dam raise through the central spillway.

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[2] SMEC. (2021). *Environmental Impact Statement – Chapter 4: Project development and alternatives, 10 September 2021.* https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSI-8441%2120210917T063809.783%20GMT

[3] Australian Height Datum. This is the elevation above sea level.

[4] SMEC. (2021). *Environmental Impact Statement – Chapter 5: Project description, 10 September 2021.* https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSI-8441%2120210917T063810.118%20GMT

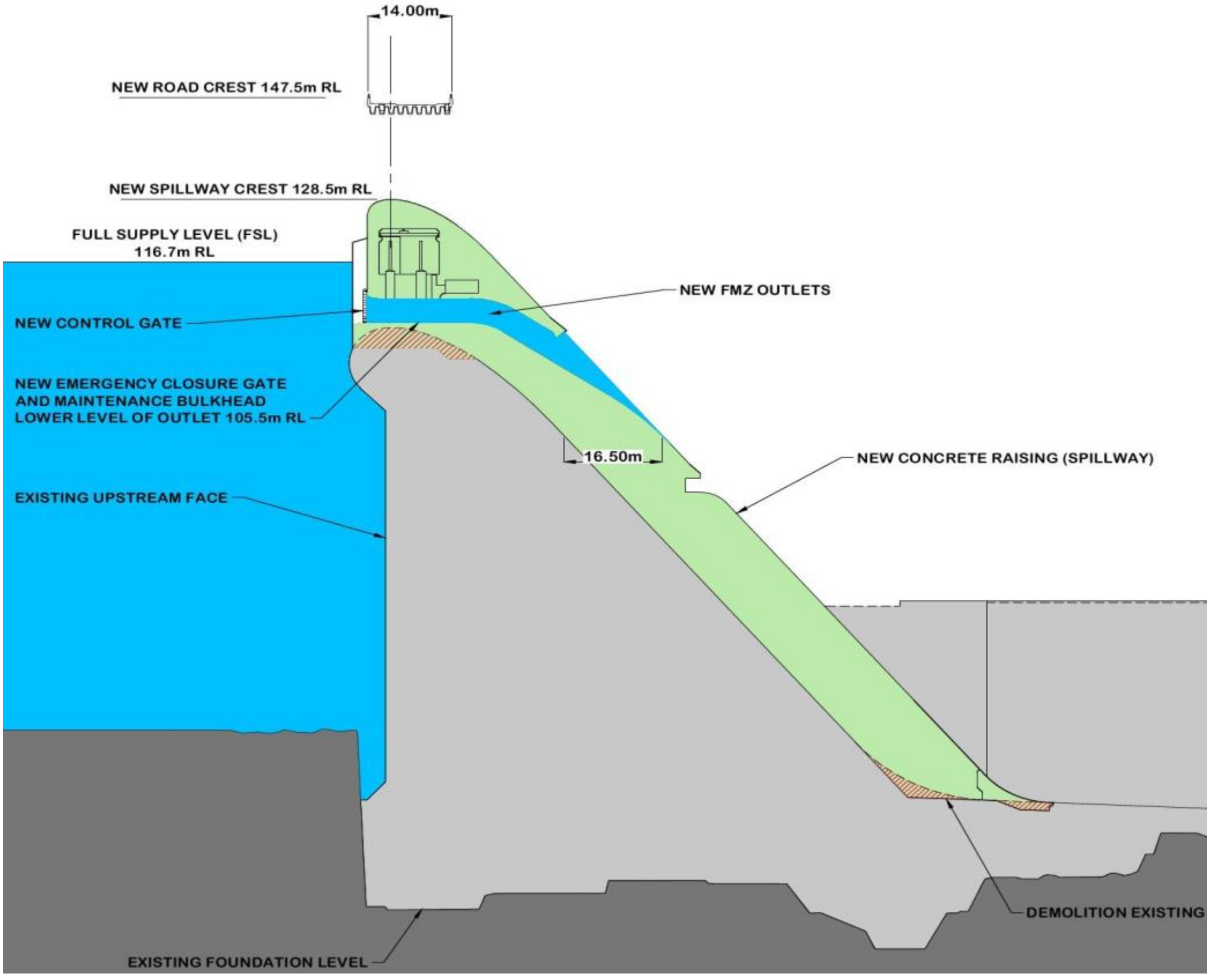

Figure 1 - Cross section of proposed dam raise through the central spillway works[5]

Upstream impact area

Despite the dam being raised by 12 metres, only the area between 2.78 metres and 10.25 metres above the current full supply area (about 1,400 hectares) has been identified as the impact area. No assessment of upstream impacts has been undertaken for the 4,200 hectares outside this area.

The reason given for not assessing the area up to 2.78m above the current full supply level (about 400 hectares) is that it is already subject to flooding when Warragamba Dam is full and spilling. However, if the dam wall were to be raised, flooding of this area will be more frequent and of longer duration.

[5] SMEC. (2021). *Environmental Impact Statement – Chapter 5: Project description, 10 September 2021.* https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSI-8441%2120210917T063810.118%20GMT

The level of 10.25 metres above the current full supply level corresponds more or less to the new 1 in 20 year flood level, which is 10.1 metres above the current full supply level. The area of possible flooding above this level is 3,800 hectares. The Environmental Impact Statement includes no assessment of impacts in the upstream catchment if the Flood Mitigation Zone is required to store a larger than 1 in 20 year flood. That is, the Environmental Impact Statement does not assess the impacts of the full area inundated by raising the dam.

Offset requirements

The upstream impact area has a direct effect on project offset requirements. If the 4,200 hectares currently excluded are assessed for impact the offset requirements will increase.

Operation of the Flood Mitigation Zone

The discharge of water stored in the Flood Mitigation Zone will be controlled by the Flood Mitigation Zone outlets.

The Environmental Impact Statement presents contradictory information regarding operation of the Flood Mitigation Zone. On one hand, it states that two options are currently being investigated for release of water from the Flood Mitigation Zone. The first option is to install gated conduits which enable the discharge rate of water to be varied and controlled. The second option is to install slots, through which water would flow uncontrolled.[6]

On the other hand, it states that to reduce impacts on downstream flooding, releases from the Flood Mitigation Zone will be varied depending on downstream conditions:

> *Flood mitigation zone releases are made after the flood at the downstream location has peaked; with a slight delay and a temporary fall in river levels whilst downstream peak is confirmed* [sic]. *The FMZ is then discharged at a rate that does not cause the river to exceed the previous flood level peak and is gradually reduced in stages.* [7]

For the discharge from the Flood Mitigation Zone to be varied, gated conduits (or a similar outlet arrangement that permits variable discharge) must be constructed as part of the upgraded project.

The rate of discharge of water from the Flood Mitigation Zone has a direct impact on the duration, depth, and extent of upstream and downstream flooding. It is a fundamental input into the hydrological modelling that predicts flooding. The Environmental Impact Statement

[6] SMEC. (2021). *Environmental Impact Statement – Chapter 29: EIS Synthesis, Project justification and conclusion, 10 September 2021.* https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSI-8441%2120210917T063820.884%20GMT

[7] SMEC. (2021). *Environmental Impact Statement – Chapter 15: Flooding and hydrology, 10 September 2021.* https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSI-8441%2120210917T063814.176%20GMT

provides no specific information regarding what discharge rates have been used in the hydrological modelling.

Response to questions

1. *We understand that there are three main elements to a dam that will determine the extent of upstream flooding and downstream flood mitigation:*

    a. *the height of the dam / size of the flood mitigation zone (FMZ);*

    b. *the size and location of the openings, including whether or not they have operable gates; and*

    c. *how the openings are operated.*

    Is this correct?

Response:

This is correct. The elements listed are three of the main determinants of upstream and downstream flood mitigation. Important additional considerations are the volume in the dam, the wetness or dryness of the catchment and the floodplain downstream of the dam (antecedent conditions), forecast inflows and releases made from the dam during the flood event. Releases from the dam are a function of the capacity of the outlets, and whether discharge can be varied to minimise the risk of downstream flooding.

The Environmental Impact Statement does not describe how the openings will be operated. At this stage, the key parameter for the project designers to determine is the rate of discharge required from the outlets. The rate of discharge is an essential input to determining; a) downstream flooding (in combination with catchment conditions at the time of the flood); and b) flooding extent and duration upstream of the raised dam.

2. *Do you think that the EIS provides sufficient detail about the operating procedures to enable an accurate prediction of the likely extent/duration of upstream flooding and downstream flood mitigation?*

Response:

The Environmental Impact Statement does not provide sufficient detail about the operating procedures to enable an accurate prediction of the likely extent or duration of upstream flooding and downstream flood mitigation.

The Environmental Impact Statement presents contradictory information regarding the Flood Mitigation Zone outlets. In parts it states it is yet to be determined if the outlets should provide variable discharge or not, that is, if the outlets should be gated conduits or slots. In other parts, it describes gradually reducing discharges from the Flood Mitigation Zone to minimise downstream flooding, which would necessarily require outlets with variable discharge. The type of outlet has a direct impact on the discharge rates that can be achieved from the Flood Mitigation Zone, which in turn are critical inputs to the hydrological modelling.

The Environmental Impact Statement states that the maximum discharge from the outlets will be 230 gigalitres per day. However, it provides no specific information regarding the discharge rates assumed in the hydrological modelling, and the catchment conditions, at the time of flooding.

The assumptions in the hydrological modelling are critical to understanding if the hydrological outputs are a reasonable prediction of upstream flooding and downstream flood mitigation. It is not clear that the worst-case scenario for upstream or downstream flooding has been modelled. The outputs of the downstream modelling are precise but the assumptions that were used are hidden.

3. *If the second and third elements in the above list have not been described in detail, what impact does this have on the ability to accurately predict the likely extent/duration of upstream flooding and downstream flood mitigation?*

Response:

If the second and third elements in the above list have not been described in detail it is not possible to accurately predict the likely extent or duration of upstream flooding and downstream flood mitigation, or whether the scenarios presented are realistic.

It is not clear in the Environmental Impact Statement what downstream conditions and Flood Mitigation Zone discharge regime have been assumed in the determination of upstream and downstream flooding extent and duration. Appendix H1; Flood Risk Analysis does not discuss the operation of the dam in sufficient detail.

In the absence of this information, it is not possible to say if the upstream and downstream flood levels provided in the Environmental Impact Statement are suitable for assessing the impacts of the project.

Summary

It is difficult to forecast all the likely conditions that dam operators will face, and it is not unusual in projects of this kind that precise management procedures and protocols are lacking. However, many assumptions have been used and these are not provided.

Therefore, it is difficult to see how some conclusions are reached. Chapter 4, Project Development and Alternatives, Section 4.4.1.5 (pp 15-16) is one example. It considers the case for lowering the Full Supply Level by 12 metres:

> *The overall impacts of post flood releases for the lowering the FSL by 12 metres, would be similar to those for dam raising.*

There is no information provided that allows this to be seen as more than an assertion. Without the assumptions and information behind the statement it is hard to see how it can be true.

In the EIS there is an imbalance between precise conclusions about downstream effects and less precise descriptions of upstream effects. Because the assumptions used are not provided, an outside observer, no matter how qualified, cannot determine how many of the conclusions and descriptions in the EIS are reached.

Authors

Patrick Brown

Patrick is a civil engineer with over 10 years' experience in the design, construction and management of water infrastructure including dams, pipelines and pump stations. He worked with Melbourne Water and later as a design engineer with KBR consulting. Patrick's experience encompasses asset management including dam safety risk assessments; concept, functional, and detailed design of dam upgrades; and construction supervision and contract superintendence.

Patrick completed two overseas missions to central Africa as a water and sanitation specialist with Médecins Sans Frontières. Patrick's first mission was to identify the causes of cholera outbreaks in the Democratic Republic of the Congo, taking measures to improve water supply and eliminate the spread of the disease. On his second mission he was responsible for logistics and operations at the main trauma hospital in the Central African Republic.

Patrick has a Bachelor of Civil Engineering and a Bachelor of Arts.

Maryanne Slattery

Maryanne is a former Chartered Accountant and Auditor. She worked in the corporate sector in Sydney before moving to the Murray-Darling Basin Commission (later the Murray-Darling Basin Authority) in 2005, where she worked on water accounting, water policy and management. Between 2012 and 2015 she planned and developed a template for delivering large-volume environmental flows in the River Murray. While with the Murray-Darling Basin Commission/Authority she worked closely with river operators, modellers and engineers in River Murray Operations.

After leaving the Murray-Darling Basin Authority Maryanne was the Senior Water Researcher for The Australia Institute from 2017 to 2019.

Maryanne has a Bachelor of Economics (Accg).

Bill Johnson

Bill has extensive experience negotiating and managing environmental flows from the large dams in the Macquarie and Gwydir Rivers in Northern NSW. He worked closely with WaterNSW river operators and modellers, community groups and government agencies. In the Macquarie this included releases from the Flood Mitigation Zone of Burrendong Dam. He established the first environmental water advisory group in New South Wales and represented the NSW environment agency on the Macquarie River Customer Services Committee. He worked on the NSW water sharing plans before moving to the Murray-Darling Basin Authority to work on the Basin Plan.

Bill has a Bachelor of Science and a Master of Resource Science (Thesis: *Adaptive management of a complex social-ecological system; the regulated Macquarie River in south-eastern Australia*).

4. Conduct of proponent in Project assessments

As the Warragamba Dam raising Project has progressed, there have been numerous instances of inadequate commitment and insincerity in the assessment process.

A full assessment of a 17 metre dam wall raising has not been undertaken

Given that the proponent is requesting planning approval to build structural abutments to 17 metres above the height of the present dam, it should not limit its assessment to 14 metres. It is otherwise in breach of SEARs requirement 3.1 that "*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*".

Inconsistencies of flood return interval in the EIS

There are clear inconsistencies throughout the EIS in regard to the flood return threshold used to assess the downstream benefits and upstream impacts of the Project. The use of the 1 in 20 flood extent as a metric to assess upstream impacts in contrast to the 1 in 100 flood metric used to assess downstream flood mitigation benefits represents a grotesque inconsistency.[1] It demonstrates the biassed and preferential nature of the EIS favouring the proponents desired downstream outcome.

Lack of clarity regarding upstream inundation extents and durations

Prior to the release of the EIS, the proponent and Infrastructure NSW continued to make misleading claims about the extent and duration of inundation in areas upstream of the dam wall that would be impacted by the Project. These included:

- Stating on their website that there will only be 550 hectares of world heritage land inundated upstream during a flooding event.[2]
- Stating in a public release that "*in large floods, areas within the national park and world heritage area upstream of Warragamba Dam flood now. With flood mitigation, upstream areas may be temporarily flooded for a longer period, such as days, to one or two weeks. The extent of this increase in temporary inundation will depend on the size of the flood*".[3]

[1] EIS Chapter 4: Project development and alternatives, pg 4-51.
[2] Retrieved from: http://bitly.ws/kraW.
[3] Macarthur Advertiser (2018). See here: http://bitly.ws/krb9.

In the EIS currently on exhibition, similar claims have also been made regarding upstream inundation. They include:

- That a total of approximpatly 1,400 hectares of land upstream would be "impacted" by the Project;[4]
- That 304 hectares of Greater Blue Mountains World Heritage listed bushland, including 36 hectares of declared wilderness areas, would be impacted by the project[5]
- That 1,303 hectares of National Park lands would be impacted by the Project;[6]
- That the Kowmung River, a declared Wild Rivers, would not be impacted by the Project;[7]
- That upstream inundation caused by the Project would only last a matter of hours to days.[8]

Such claims are intended to mislead the public about the true nature of the upstream environmental and cultural impacts. The published flood heights in the WaterNSW Preliminary EIS for the Project show that there would likely be over 5,000 hectares of land inundated by a 14 metre dam wall raising. The Preliminary EIS also states that upstream inundation events will last for up to five weeks at a time.

The NSW Government's draft Non-Aboriginal Heritage Impact Assessment details the extent of damage the proposed raising of Warragamba Dam wall would have on the site (Appendix A). The document shows that 1,303ha of bushland that sits within the GBMWHA would be inundated, with 5,7274ha of bushland within the national park also set for flooding. The impacted area within the World Heritage site holds the highest significance to the biodiversity of the area. Appendix (A) further states "*the proposed action would result in permanent changes within around 1,303 hectares of the Greater Blue Mountains Area, which constitutes around 0.12% of the World (and National) Heritage Property*".

These conclusions regarding flood heights have now been removed from the Non-Aboriginal Heritage report (exhibited EIS Chapter 17) and demonstrate significant differences from the figures reported in the draft chapter of the EIS.

It is clear that the extent and duration of upstream inundation is a matter that the proponent wishes to minimise so as to lower biodiversity offsetting costs and to reduce the political pressure associated with the Project's upstream environmental impacts. However, it can be seen that the proponent is clearly adopting a deliberate tactic to mislead the public and the decision maker as to the nature, extent and duration of upstream inundation through defining the "upstream impact area" of the Project as the "*area between the likely inundation level with the Project (10.25 m above FSL, RL 126.97 mAHD) and the likely inundation level for the existing dam (2.78 m above FSL, RL 119.5 mAHD)*".[9] The justification for this determination is

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[4] EIS Appendix F1: Biodiversity Assessment Report – Upstream, pg. 14
[5] EIS Appendix J: World Heritage Assessment Report, pg 72.
[6] EIS Chapter 20: Protected and sensitive lands, pg 20-41.
[7] EIS Chapter 20: Protected and sensitive lands, pg 20-18.
[8] EIS Appendix J: World Heritage Assessment Report, pg 81.
[9] EIS Appendix F1: Biodiversity Assessment Report – Upstream, pg 15.

vaguely explained with insufficient detail to understand why areas below 119.5 mAHD and above 126.97 mAHD are discounted. The basis of this justification is also contradicted by statements made in the draft Upstream Biodiversity Assessment Report which explicitly identified the area up to a 1 in 5 year flood event (120.3 mAHD) as that which would experience the greatest potential biodiversity impacts due to the Project, which is discussed further on in this section.

In a meeting between the Colong Foundation for Wilderness and the Department of Planning, Industry and Environment in November 2021, it was stated that the ‘upstream impact area’ was an assessment method put forward by WaterNSW following criticism that the draft EIS only considered impacts as ‘indirect’. The active involvement of the proponent in determining its own offset liability through redefining the nature and extent of impact is a clear conflict of interest. The ‘upstream impact area’ defined in the exhibited EIS is not clearly based on objective scientific evidence, and excludes a substantial amount of threatened species from being considered in offsetting costs.

The way in which the proponent has defined the ‘upstream impact area’ is contrary to both the Precautionary Principle and SEARs requirements 13.1, 13.2 and 6.1.

Instead, the upstream impact area of the Project should be considered as the area that sits between the present Full Storage Level of Warragamba Dam and the PMF of the 17 metre raised dam. This is the full extent of the area that would experience impacts if the dam raising Project were to go ahead.

No post-bushfire surveys undertaken

The unprecedented climate-induced bushfires that burnt over 80% of the Greater Blue Mountains World Heritage Area (over 1,000,000 hectares) during the 2019/2020 Australian summer have meant that previous data and surveys concerning species distribution and habitat for south-eastern Australia no longer provides an adequate representation of the present-day ecology. This is so for all ecological and Aboriginal Cultural Heritage surveys that were undertaken for the Project before the 2019/2020 Australian summer bushfires. Many of the incised gorges and river valleys that would be inundated by the proposal remain unburnt and have likely become critical refugia to the survival of particular species and ecosystems. Other locations within the impact area were significantly burnt and have become far more sensitive to disturbance from artificial inundation.

The proponent has refused to undertake post-fire assessments of the the study area, despite the Commonwealth Government requesting the proponent to do so:

"The Australian Government has requested that Water NSW undertake an analysis of the impacts of the 2019-20 bushfires given that approximately 70 per cent of the predicted temporary inundation area resulting from the proposal was burnt in the bushfires".[10]

Despite the devastation these fires caused, no post-bushfire field surveys were undertaken to assess the cumulative impact the Project would have in exacerbating bushfire impacts as requested by the World Heritage Committee.[11] The refusal of the proponent to undertake post-bushfire field surveys, instead undertaking less-accurate modelling, is evident in both EIS Appendix F1 and in verbal evidence given by Project Director, David Harper, to the Select Committee on the Proposal to Raise the Warragamba Dam Wall:

"Fortunately for the EIS, all that survey work had actually been done well before the fires so that was all captured… The [New South Wales] guidelines do not stipulate that you need to do any more if you have already undertaken the survey prior to the bushfire".[12]

For the Precautionary Principle to be met for the Project, post-bushfire field surveys need to be completed.

Previous concerns raised by multiple Government agencies

Overwhelming concerns have been expressed by NSW and Commonwealth agencies regarding the EIS methodologies and findings during the 2020 adequacy review process (Appendix B). Unfortunately it would appear that little has changed in the EIS since the adequacy review was completed.

Insensitive and tokenistic cultural assessment

Gundungurra Traditional Owners have repeatedly voiced their unequivocal opposition to the Project, expressly stating that they will not provide their Free, Prior and Informed consent (FPIC) for it to proceed (Appendix G).

In evidence presented to the Select Committee on the Proposal to Raise the Warragamba Dam wall, allegations were made that Gundungurra Traditional Owners were offered employment and access to cultural sites by NSW Government officials in an attempt to gain consent for the Project.[13]

When SMEC Engineering held their first consultation meeting about Warragamba Dam wall raising Project in 2018, Traditional Owners were given just four days' warning by SMEC of

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[10] Australian Government report to the World Heritage Centre on the state of conservation of the Greater Blue Mountains, December 2020.
[11] UNESCO World Heritage Committee 44 COM 7B.180.
[12] David Harper, Warragamba Dam Raising Project Director (New South Wales) in evidence given to New South Wales Parliament, June 2020
[13] Sydney Morning Herald (2020). Retrieved from: http://bitly.ws/g284

the consultation meeting being held in northern Sydney,[14] more than a three-hour drive in peak-hour traffic from the Blue Mountains.

We provide examples from the evidence given by Traditional Owners to the Select Committee on the Proposal to Raise the Warragamba Dam wall below:

Evidence given by Ms Kazan Brown

"*Throughout the process, New South Wales Government representatives and their consultants have been demeaning and condescending. In many cases, they have simply ignored our questions and concerns. Their meetings with us have been nothing but tokenistic. It was clear from the beginning that they were going through their own motions of meaningless consultation. The disrespectful attitude towards our culture was demonstrated when the author of a report spent one day out of 72 in the field examining the areas to be impacted by the dam wall raising."*[15]

Evidence given by Ms Sharyn Halls

"For us we do not accept the EIS. I do not also accept the process. We have no faith in the process and that is why we have not gone to meetings and been online. Water did an update to the ILUA committee about last month. They did it and it was not really an informative meeting; it was just to say that there are meetings going on and we should be doing the meetings. The other thing around that is that we really feel that the time extension, as I said before, is not enough even though it has been extended to the end of November. We do not have the resources that everyone else has to have a lot of people going through an EIS. We have to do this ourselves and we need to be able to get around and talk to people as well and see how they feel about the EIS. Okay, we have been invited to meetings but there is no point going to a meeting if you have no faith in the meeting process. I guess that is where I will stand at the moment. But I have other things to say during this."[16]

Evidence given by Mr Daniel Chalker

"I personally have gone to every meeting that I have known about and been notified about. I did all but three days in the field during the site assessment. But recently, through circumstances, I have moved on. I was working under Cubbitchbarta at that time. I have moved on from that in recent circumstances. From that point the process, the archaeologists, SMEC and WaterNSW have left me out of this process. I believe that is a deliberate action because of my opinions and my knowledge from a cultural sense. I believe that they have not been adequate in including all of community. They are abiding by their statutory obligation, and that is it. Reading through the EIS that has been put forward for you to consider, it is an underwritten statement of what is actually there."[17]

[14] The Guardian (2018). Retrieved from: http://bitly.ws/krdF.

[15] Select Committee on the Proposal to Raise the Warragamba Dam Wall, Fourth Hearing (Corrected), 6 November 2020, pg 7. Available from: http://bitly.ws/g2a4.

[16] Select Committee on the Proposal to Raise the Warragamba Dam Wall, Sixth Hearing (Uncorrected), 8 November 2021, pg 13. Available from: http://bitly.ws/krep.

[17] Select Committee on the Proposal to Raise the Warragamba Dam Wall, Sixth Hearing (Uncorrected), 8 November 2021, pg 3. Available from: http://bitly.ws/krep.

Reputation and conduct of lead EIS consultant

SMEC Engineering is the lead EIS consultancy firm engaged by WaterNSW to undertake the EIS for the Project. The tendering process for selection of the company remains confidential, although we understand that the company has since requested significant variations to its initial contract with the proponent given the significant delay and controversies that have arisen since the EIS process began in June 2017.

SMEC Engineering's parent company, the Surbana Jurong Group, was banned from participation in World Bank Projects in consequence of bribery and corruption allegations in 2017. The attached submission from 18 Asian, African and Russian environmental and Indigenous NGOs to the Select Committee on the Proposal to Raise the Warragamba Dam Wall details human rights abuses that have taken place during assessments of dam projects in Southeast Asia, Mongolia and Africa.

We are of the view that it is highly unlikely that the proponent did not know of SMEC Engineering's previous overseas conduct before awarding the company the contract to undertake the Warragamba Dam Raising EIS.

Submission No 229

INQUIRY INTO PROPOSAL TO RAISE THE WARRAGAMBA DAM WALL

Organisation: Rivers without Boundaries International Coalition

Date Received: 10 September 2019

Submission to Inquiry into the Proposal to Raise the Warragamba Dam Wall

Dear Committee,

Please accept this joint submission to the NSW Legislative Council's Select Committee Inquiry into the Proposal to Raise the Warragamba Dam Wall. We consent to having this submission and our names being published in full.

The Snowy Mountains Engineering Corp (SMEC), the engineering firm tasked with completing the Environmental and Cultural Assessments for the Warragamba Dam wall raising in Australia, has an established history of abusing Indigenous rights across the globe. These abuses have taken place as part of environmental and cultural assessments for other dam projects, notably in Southeast Asia, Mongolia and Africa. We detail these instances below. These instances of misconduct call into question how the firm has been chosen as the lead consultant for the Warragamba Dam Raising project by the NSW Government.

In 2013 SMEC faced criticism from the scientific community and regional civil society for its involvement in the **Don Sahong Dam project in Laos**. SMEC did not respond to requests regarding the Cambodian, Vietnamese and Thai governments' calls to the Lao government for the Don Sahong dam to be submitted to the Mekong River Commission's intergovernmental prior consultation procedure.[1] The construction of the Don Sahong Dam project threatens Mekong fisheries, the main source of livelihoods and food security for communities in Laos and populations living downstream of the dam in Cambodia. The construction of the dam has further driven poverty and environmental degradation in an area that is highly sensitive to such impacts[2]. SMEC did not ensure adequate consultation for populations affected by the project, including those in Cambodia. SMEC did not respond to concerns from civil society or to questions regarding the project's failures to comply with requirements under the 1995 Mekong Agreement.

In 2015 SMEC faced further controversy for undertaking the Environmental and Social Impact Assessment for the **Mong Ton (or Tasang) Dam in Myanmar, which is predicted to eventually displace as many as 300,000 indigenous people** - with over 100 villages and towns to be flooded. This dam also threatens the existence of 104 migratory species of fish that are crucial to the livelihoods of groups living along the Salween River. Significant funding for the project came from Chinese state-owned companies[3].

The Mong Ton Dam was proposed amid ongoing armed conflict and serious human rights abuses throughout Myanmar, including within the indigenous states of the country where Mong Ton will be constructed and cause extensive impacts on the river system. The Salween River has been described as the lifeblood of millions of ethnic people in Myanmar, with its interruption and destruction by damming leading to death of culture[4]. SMEC took a blatantly pro-dam position in their assessments, downplaying the negative impacts of the project. In a concerning tactic, SMEC "did not even bother visiting four of the villages they were supposed to carry out assessments in…[Their] EIA/SIA process [was] simply a sham, aimed to rubber-stamp the Mong Ton dam plans, rather than objectively assess the project's actual impacts"[5].

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[1] https://www.business-humanrights.org/en/cambodia-vietnam-thailand-govtscall-on-laos-to-submit-don-sahong-dam-to-an-intergovernmental-assessment-citing-potentially-high-impact-on-fisheries#c103094
[2] https://www.internationalrivers.org/campaigns/don-sahong-dam
[3] https://apjjf.org/-Peter-Bosshard/4243/article.pdf
[4] http://www.mizzima.com/news-domestic/shan-representatives-deliver-dam-petition-australian-consultants-yangon
[5] https://asiancorrespondent.com/2015/06/burmese-villagers-say-they-are-being-misled-on-tasang-dam-project/

This dam project has not only jeopardised the ways of life for a significant number of unique ethnic groups that are Indigenous to the borderlands of Myanmar, it also has allowed the government to militarise these areas and commit further abuses against the groups. The dam is set to destroy "ancestral lands of ethnic peoples in Myanmar struggling to protect their indigenous rights, culture livelihoods, and traditional way of life.[6]" The dam itself will provides little benefit to local communities or even the state of Myanmar, with 90% of the hydropower generated intended for sale to Thailand and China. Like the Don Sahong Dam project, funding and engineering support for this dam also came from Chinese state-owned companies[7].

Following approval from Myanmar Government, SMEC started the environmental and social impact assessment process in October 2014. SMEC's involvement in the Mong Ton Dam has been controversial from the outset, with strong opposition from communities, civil society, among others.

Between July and September 2015, civil society organisations and networks continued to express major concerns over Mong Ton Dam, including calling on SMEC to withdraw from the project. In August, Shan community representatives presented 23,717 signatures to SMEC Myanmar office, stating opposition to building dams on the Salween River. In September, an open letter was sent to SMEC calling on them to withdraw from the project. Endorsed by over 200 organisations and networks, the letter also stated their refusal "to participate in this highly flawed [EIA] process that threatens to exacerbate conflict and undermines peace building in our country."

Local activists reported "SMEC's consultations are entirely insufficient. The first consultation was only two hours. You cannot discuss anything in two hours. And they announced this consultation via a tiny ad in one of the last pages of the newspaper"[8]. The activist also reported that military authorities in Shan State sent a tank through the villages "to remind them to participate in the consultations" run by SMEC[9].

Since 2003 SMEC has been engaged to conduct site investigations, prepare a detailed design and supervise construction for the 11MW Taishir hydro power project located on the **Zavkhan river in the western area of Mongolia**. While Synohydro was the contractor for construction, the transfer of expertise in all aspects of the project to the Mongolian state-owned Energy Authority was central to SMEC's role[10] of designer and general supervisor. Taishir HPP has 3 turbines with 3.5MW capacity, but in real the maximum output from turbine reaches only 2.5MW due to the incorrect modifications of equipment when it was being built and tested[11]. The project involves a large reservoir of almost 1 cubic kilometre volume on a small river, and the "hydrology risk" has not been carefully considered prior to project commitment. This resulted in extended reservoir filling duration due to drought means and deferred revenue to the owner, extending resource commitments of other parties[12].

The Zavkhan River is the sole source of water for several hundred families of indigenous nomadic herders in the area, with their community living along the Zavkhan River. According

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[6] https://thediplomat.com/2017/01/chinas-myanmar-dam-hypocrisy/
[7] https://www.sciencedirect.com/science/article/pii/S0301479708002739
[8] https://www.tandfonline.com/doi/full/10.1080/07900627.2016.1179176
[9] https://www.tandfonline.com/doi/full/10.1080/07900627.2016.1179176
[10] https://www.waterpowermagazine.com/news/newssmec-selected-for-mongolian-project

[11] https://www.seforall.org/sites/default/files/Mongolia_RAGA_EN_Released.pdf
[12] https://www.waterpowermagazine.com/projectprofiles/projectprofilesextreme-dam-building/

to local officials and community elders the herders were severely affected by losses of large portions of their herds while dam was filling in 2007-2015 as all flows in Zavkhan River was contained in dam to fill reservoir for several years[13]. This effect was not anticipated by dam designers and supervisors and led to massive outmigration of herders from ancestral lands. Since the hydropower station has begun to generate energy, herders reported large losses of livestock during winter when the dam releases its largest flows to support operation of the power station at peak level. The indigenous herders have since reported that their livestock have fallen through undermining of ice sheets by the dam's fast release of water. They have also reported that their winter shelters for livestock (yurts and living quarters) have been flooded during peak winter flows, with the herders having to relocate their livestock and communities during these times. Herders claim that their cultural sites have been drowned by the reservoir, including portions of historic monastery lands[14]. Their losses during filling and operation of the dam have not been compensated.

In Africa since 2016 SMEC also acted as Project Management Consultant in assisting Uganda Electricity Generation Company Limited (UEGCL) in overseeing the performance of various contractors for a 183 MW Isimba Hydropower Project located on the Nile River[15]. Isimba project is being developed by a company-subsidiary of the China Three Gorges Co, which is a company that uses money from the Exim-bank of China at a site with important cultural and natural values, that had previously been set aside as conservation offset land during construction of Bujagali hydro[16].

In 2017 SMEC was debarred by the World Bank from working in development and aid projects in Sri Lanka, India and Bangladesh following allegations of bribery and corruption. The Australian Federal Police raided their Sydney offices to investigate claims that SMEC "staff allegedly bribed officials to secure a $2.3 million aid-funded sewerage project in Sri Lanka in 2011 and…a $2.2 million power plant project in Bangladesh in 2007"[17].

Given the appalling track record SMEC Engineering has with indigenous consultation and environmental assessments for large dam projects, we saw it as necessary to enlighten the Parliamentary Inquiry of our experiences of SMEC Engineering. Given the media articles[18] detailing the nature of consultation with Blue Mountains indigenous peoples to date, it would seem SMEC Engineering and its sub-contractors are continuing to disregard indigenous rights and serious environmental damage that dam projects cause globally.

We call on the committee of inquiry to reject SMEC Engineering's Cultural and Environmental Assessments for the Warragamba Dam wall raising project, and that a company with appropriate credentials be put forward to re-do all relevant assessments.

Signatories can provide verbal evidence to the inquiry by telephone link if required.

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[13] http://www.ipsnews.net/2013/07/river-diversion-project-spells-disaster/
[14] http://www.sric.org/enr/docs/20170729_Taishir_Presentation.pdf
[15] https://www.smec.com/what-we-do/projects/Isimba-Hydropower-Project

[16] http://www.isimbadam.com/

[17] https://www.smh.com.au/business/australian-companies-linked-to-bribe-scandals-in-sri-lanka-and-congo-20160823-gqyzlp.html

[18] https://www.theguardian.com/australia-news/2018/mar/25/warragamba-dam-wall-plan-would-flood-50-aboriginal-heritage-sites & https://www.theguardian.com/australia-news/2019/aug/14/warragamba-dam-level-report-deadline-too-short-traditional-owners-say

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EarthRights International (Thailand and International)

Shalmali Guttal
Executive Director, Focus on the Global South (Mekong region)

Mekong Watch (Japan and Mekong region)

International Accountability Project (Mekong region and international)

Conflict of interests of accredited assessor

In evidence presented to the Select Committee on the Proposal to Raise the Warragamba Dam Wall, Ms Rachel Musgrave, the former accredited assessor and primary author of the Upstream Biodiversity Assessment Report (BAR), stated that she had resigned from her position at SMEC Engineering as a result of a dispute between herself, the company and WaterNSW. Ms Musgrave did so after refusing to change the impact assessment approach taken for the Project. She believed that her continuing involvement in the EIS after the impact assessment approach had been changed would risk her accreditation under NSW Biodiversity Offsets Scheme.[18] Ms Musgrave was then replaced as the accredited assessor for the project by Mr Kevin Roberts, an individual who immediately prior to his appointment as the accredited assessor was under secondment by WaterNSW (the proponent) to coordinate the development of the EIS.

Ms Musgrave described a discretionary approach to the definition of impact that was undertaken at the direction of WaterNSW and the senior leadership within SMEC Engineering. Her expert scientific advice was ignored and the EIS was amended without her permission. Both SMEC Engineering and WaterNSW overruled Ms Musgrave's expert view so as to minimise the biodiversity offset costs of the Project.[19]

Ms Musgrave's evidence overwhelmingly suggests that significant efforts were made to favour the proponents' position during the preparation of the EIS.

Proponent's handling of procedural malpractice complaints

Throughout the 102 month-long EIS assessment process, several accusations of procedural malpractice have arisen through the Select Committee on the Proposal to Raise the Warragamba Dam Wall and the media. They have included:

- An accusation by the Traditional Owner, Ms Kazan Brown, that inducements were offered to her in exchange for support for the Project proceeding.[20]
- Evidence given by SMEC Engineering subcontractor, Dr Ross Crates, that his scientific advice in the exhibited EIS had been significantly edited without his consent.[21]

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[18] Select Committee on the Proposal to Raise the Warragamba Dam Wall, Sixth Hearing (Uncorrected), 8 November 2021, pg 17-18. Available from: http://bitly.ws/krep.
[19] Discussed in Select Committee on the Proposal to Raise the Warragamba Dam Wall, Sixth Hearing (Uncorrected), 8 November 2021, pg 18-19. Available from: http://bitly.ws/krep. See also The ABC (2021). Retrieved from: http://bitly.ws/g282.
[20] Select Committee on the Proposal to Raise the Warragamba Dam Wall, Fourth Hearing (Corrected), 6 November 2020, pg 5. Available from: http://bitly.ws/g2a4.
[21] Select Committee on the Proposal to Raise the Warragamba Dam Wall, Sixth Hearing (Uncorrected), 8 November 2021, pg 11. Available from: http://bitly.ws/krep.

- Evidence given by SEMC Engineering employee and accredited assessor, Ms Rachel Musgrave, that she was forced by the proponent and SMEC Engineering to amend her expert advice regarding the upstream impacts within the Upstream BAR.[22]
- Evidence given by Mr Micheal Jackson, archaeological sub-contractor to Niche Environment and Heritage that he was threatened by SMEC Engineering regarding disclosure of malpractice he witnessed during his work on the EIS before giving evidence to the Select Committee on the Proposal to Raise the Warragamba Dam Wall.[23]

SEARs requirement 4.3 states that "*The Proponent must describe the timing and type of community consultation proposed during the design and delivery of the Project, the mechanisms for community feedback, the mechanisms for keeping the community informed, and procedures for complaints handling and resolution.*" The proponent has not detailed the mechanisms it has employed to undertake investigations of these serious complaints. However, the nature of the complaints made about the proponent and its lead consultant (SMEC Engineering) indicate the frequent dismissal of the views of those who have provided expert advice inconsistent with approval of the Project.

Given this pattern of conduct by the proponent, there is a need for the Department of Planning, Industry and Environment to undertake an external investigation into these allegations and the treatment of third-party contractors and stakeholders who have been involved in the Project. Any investigation undertaken must be independent of both the proponent and Infrastructure NSW.

Selective editing and manipulation of language within the exhibited EIS

In evidence provided to the Select Committee on the Proposal to Raise the Warragamba Dam Wall, former SMEC subcontractor , Ross Crates, alerted the Committee to the editing of his work in the Upstream BAR and MNES Chapters of the EIS as they relate to the critically endangered Regent Honeyeater.[24] These changes watered down the significance of the local population of birds and the impact that inundation would have on their survival as a species. The editing was not conducted with the author's knowledge or consent. This example of the manipulation of expert contributions during the editing process casts doubt on the credibility of statements presented across the entirety of the final EIS and demonstrates a bias in favour of the proponent.

A comparison of the published EIS with draft versions leaked to the media further demonstrates the process of selective editing undertaken by the proponent to systematically downplay the upstream impacts of the Project.

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[22] Select Committee on the Proposal to Raise the Warragamba Dam Wall, Sixth Hearing (Uncorrected), 8 November 2021, pg 17-18. Available from: http://bitly.ws/krep.
[23] Select Committee on the Proposal to Raise the Warragamba Dam Wall, Fourth Hearing (Corrected), 6 November 2020, pg 11. Available from: http://bitly.ws/g2a4.
[24] Select Committee on the Proposal to Raise the Warragamba Dam Wall, Sixth Hearing (Uncorrected), 8 November 2021, pg 11. Available from: http://bitly.ws/krep.

One of the most extensive changes between the draft and published reports concerns the metrics used as the basis for establishing the "upstream impact area". The draft report measurements and findings were based on areas defined by the 20% AEP, 1% AEP and PMF, in accordance with SEARs requirements.[25] The change in reporting divorces the assessment from the extent of impact that would occur under the full range of flood AEP scenarios.

The exhibited Upstream BAR has critical sections describing the impacts that changed extent, frequency and duration of flood events would have on plant communities removed, or are presented significantly differently to the draft EIS. Importantly, the following statements were removed from the exhibited EIS:

- *"For more frequent events, the landscape would have less ability to recover to its previous condition and there are **likely to be permanent changes** to the vegetation communities in these areas."*
- ***"...the area that would experience the greatest potential biodiversity impacts due to the Project would be up to about the 1 in 5 chance in a year flood level** – as this and smaller flood events are 'relatively' frequent in comparison to other flood events, and therefore any vegetation could be subject to multiple occurrences of temporary inundation within its capacity to regenerate over time."*[26]

These statements from the earlier draft of the EIS indicate that the area below 119.50 AHD (2.78 above FSL), which is now excluded from the upstream impact area in the exhibited EIS, will experience the greatest potential impacts on biodiversity given the relative frequency of inundation. They are in stark contradiction to the current EIS, which states that this area should not be considered part of the "upstream impact areas" as it "already experiences temporary inundation".

It is unclear what processes led to this substantial change in the definition of the "upstream impact area" within the EIS, aside from a vague description of Monte Carlo modelling. How was the area between 2.78 and 10.25 metres above FSL identified as the "upstream impact area" and the area below 119.50 mAHD (2.78 above FSL) excluded? Were further field surveys conducted or particular pieces of expert advice received that resulted in this critical change to the EIS? The onus rests upon the proponent to justify how and why this conclusion was changed and ultimately reached in the exhibited EIS.

The OEH guidelines for flora and fauna survey effort required under the Framework for Biodiversity Assessment (FBA), which were included in draft versions of the Upstream BAR, have been removed from Tables 5-9 and 5-10 in the exhibited EIS. While these guidelines are reported in the MNES (Tables 6-2 and 6-3), the exclusion of the guideline survey efforts in the Upstream BAR prevents the reader from comparing the effort undertaken to the effort that should be expected, which was significantly short of the OEH guidelines. Such fragmentation of

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[25] SEARs Section 8.2.
[26] EIS Appendix F1: Biodiversity Assessment Report – Upstream Draft (2020) , pg. 40.

information can mislead the reader and decision makers. It again demonstrates a disingenuous and biassed approach to the reporting of assessments by the proponent. The figure below provides an excerpt of the tables reporting threatened flora surveys from the draft Upstream

A. Draft Upstream BAR

Table 5-9. Threatened flora surveys completed and recommended survey effort

Scientific name	Common name	Survey type	Recorded	SMEC effort (km/hr)	Guidelines required effort (km/hrs)
Acacia clunies-rossiae	Kanangra Wattle	Parallel field traverse, Incidental	Yes	20/40	2,982/1,983
Bossiaea oligosperma	Few-seeded Bossiaea	Parallel field traverse, Incidental	Yes	20/40	2036/1,357
Callistemon linearifolius	NettedBottle Brush	Parallel field traverse, Incidental	Yes	10/20	798/520
Eucalyptus benthamii	Camden White Gum	Parallel field traverse, Incidental	Yes	48/96	439/281

B. Exhibited Upstream BAR

Table 5-9. Threatened flora surveys completed for the study area

Scientific name	Common name	Survey type	Recorded	SMEC effort (km/hr)
Acacia clunies-rossiae	Kanangra Wattle	Parallel field traverse, Incidental	Yes	20/40
Bossiaea oligosperma	Few-seeded Bossiaea	Parallel field traverse, Incidental	Yes	20/40
Callistemon linearifolius	Netted Bottle Brush	Parallel field traverse, Incidental	Yes	10/20
Eucalyptus benthamii	Camden White Gum	Parallel field traverse, Incidental	Yes	48/96
Eucalyptus glaucina	Slaty Red Gum	Incidental	Yes	5/10
Grammitis stenophylla	-	Incidental	Yes	0.25/1

BAR (A), and the exhibited EIS (B).
Manipulation of wording and exclusion of statements indicating the severity of impact of temporary inundation is evident throughout the exhibited EIS Upstream BAR and MNES Chapters when compared to the draft EIS.

Of note, the description and detailed tables assessing the tolerance of vegetation to waterlogging and submergence, included in the draft, has been excluded in the exhibited EIS. This assessment found that only 38 species were possibility tolerant, 33 of which would only tolerate short-term waterlogging, and only 4 possibly tolerant to submergence. Table 7-4 of the draft EIS is an extensive table that covers 7 pages (excerpt below),[27] detailing each native species assessed as being possibly tolerant to waterlogging or submergence. This substantial amount of information is excluded from the published EIS, with section 7.1.2 ‘Effects of temporary inundation’ only providing general information on flood stress.

[27] EIS Appendix F1: Biodiversity Assessment Report – Upstream Draft (2020) , pg. 217.

Table 7-4. Native species possibly tolerant to waterlogging and submergence

Species	Tolerance to waterlogging	Tolerance to partial submergence	Tolerance to complete submergence	Plant functional group	Landscape associations (+ = tolerant, * = less tolerant)	Most typical PCT associations
Key: Atw: Amphibious fluctuation tolerators: Woody species; Tda: Terrestrial: Damp species; Tdd: Terrestrial: Occasionally damp, rapidly drained species.						
Acacia floribunda	Very short term possible - only when in rapidly draining soil	Very short term possible - only when in rapidly draining soil	-	Tdd	Riparian+, alluvial+, lower floodplain+	1081, 1086, 1105, 1246, 1284, 1292, 832, 840, 860, 870, 877, 941
Acmena smithii	Very short term possible - only when in rapidly draining soil	Very short term possible - only when in rapidly draining soil	-	Tdd	Riparian+, alluvial+, lower floodplain+, protected gullies/slopes*, rainforests*.	941, 877, 875, 769, 1292 and 1105
Adiantum aethiopicum	Very short term possible - only when in rapidly draining soil	Very short term possible - only when in rapidly draining soil	-	Tdd	Riparian+, alluvial+, lower floodplain+, protected gullies/slopes*, rainforests*.	1081, 1086, 1105, 1246, 1284, 1292, 832, 840, 860, 870, 877, 941, 769, 875

A comparison of the draft Upstream BAR to the exhibited report also demonstrates the selective editing downplaying the impact on particular threatened species. Statements of reduced viability and possible extinction that were included in the draft have been removed for a number of species. The exclusion of these statements evades recognition of the extent of impact that would be incurred by these vulnerable, endangered and critically endangered species. The table below provides a comparison of the detail provided in Table 5-15 of a 2020 draft compared to Table 5-15 of the exhibited EIS.

Genus species	DRAFT - Justification for inclusion as matter of further consideration	FINAL EIS - Justification for inclusion as matter of further consideration
White Box Yellow Box Blakely's Gum Woodland	Species is listed as Critically Endangered thus meets the requirements for inclusion as per Section 9.2.4.1 of the FBA. The species would have its viability significantly reduced in the IBRA subregion if it is impacted upon by the development.	Species is listed as Critically Endangered thus meets the requirements for inclusion as per Section 9.2.4.1 of the FBA.
Anthochaera phrygia	Species is listed as Critically Endangered thus meets the requirements for inclusion as per Section 9.2.4.1 of the FBA. The species would have its viability significantly reduced in the IBRA subregion if it is impacted upon by the development.	Species is listed as Critically Endangered thus meets the requirements for inclusion as per Section 9.2.5.1 of the FBA.
Epacris sparsa	Threatened species has been specifically nominated in the SEARs as a species that is to become extinct or have its viability significantly reduced in the IBRA subregion if it is impacted upon by the development.	Threatened species has been specifically nominated in Attachment C of the SEARs.
Eucalyptus benthamii	Threatened species has been specifically nominated in Attachment C the SEARs. The species would have its viability significantly reduced in the IBRA subregion or may become extinct if it is impacted upon by the development.	Threatened species has been specifically nominated in Attachment C of the SEARs.
Hakea dohertyi	Threatened species has been specifically nominated in Attachment C the SEARs. The species would have its viability significantly reduced in the IBRA subregion if it is impacted upon by the development.	Threatened species has been specifically nominated in Attachment C of the SEARs.
Solanum armourense	Threatened species has been specifically nominated in Attachment C of the SEARs. The species would have its viability significantly reduced in the IBRA subregion if it is impacted upon by the development.	Threatened species has been specifically nominated in Attachment C of the SEARs.

5. World Heritage and National Heritage obligations, impacts and assessment

When the proponent and Infrastructure NSW settled upon the Project in the 2017 Hawkesbury-Nepean Flood Risk Management Strategy, there was not a single mention of the significant impacts raising Warragamba Dam would have upon the World Heritage and National Heritage values of the Greater Blue Mountains. To this day, there is an ongoing institutional ignorance about the impact of temporary inundation upon the Greater Blue Mountains, eloquently demonstrated by the reductive conclusions drawn by the proponent regarding the impacts to the Outstanding Universal Values (OUV) of the Greater Blue Mountains World Heritage Area (GBMWHA) contained within the EIS Appendix J World Heritage Assessment.

World Heritage assessment

The conclusions of the EIS regarding the impacts to World Heritage cannot be sustained when subject to even moderate scrutiny. The proponent's conclusions are as follows:

"While the Project could potentially impact the GBMWHA, these impacts would not be significant and would not result in a material loss or degradation of the Outstanding Universal Value of the GBMWHA as:

- *the upstream impact area comprises 0.03 percent of the total area of the GBMWHA; the remaining 99.97 percent would not be affected by the Project*
- *comprehensive mitigation, monitoring and offsetting measures have been identified which would ensure that any impacts on the GBMWHA are minimised, detected and rehabilitated, and which would contribute to the maintenance and enhancement of the Outstanding Universal Value of the GBMWHA.*

Overall the Project is not considered to be inconsistent with the management obligations and principles for World Heritage properties specified in the World Heritage Convention and the EPBC Act".[28]

These conclusions are incorrect and are contrary to strong and prolific advice provided to the proponent by the UNESCO World Heritage Committee, the Commonwealth Department of Agriculture, Water and Environment (Appendix B), The International Council on Monuments and Sites (Australia),[29] the Greater Blue Mountains World Heritage Advisory Committee (Appendix C), Heritage NSW (Appendix B), and the Select Committee on the Proposal to Raise the Warragamba Dam Wall (Appendix D).

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[28] EIS Appendix J: World Heritage Assessment Report, pg. 162.
[29] Select Committee on the Proposal to Raise the Warragamba Dam Wall, Fourth Hearing (Corrected), 6 November 2020. Available from: http://bitly.ws/g2a4.

The fundamental error of the proponent is to use the proportionally small percentage of the impacted area of the GBMWHA to justify its destruction. Instead, the proponent needs to assess the values that are contained within the impacted area to assess the actual impact of the Project on the GBMWHA. Such an analysis on the impact of the Project on OUV has been undertaken by Professor Jamie Kirkpatrick of the University of Tasmania and is provided in Appendix (E). He concludes that the Project would likely have a significant impact on the OUV of the GBMWHA .

We note the severe underestimate of impacted World Heritage lands within the EIS which has occurred as the result of the matters discussed in section 4 of this submission. This area of impacted GBMWHA is instead much closer to 1,000 hectares in size.

Given the above facts, it is clear that the proponent did not sufficiently or adequately "*identify and assess any direct and/or indirect impacts (including cumulative impacts) to the heritage significance of: items listed on the National and World Heritage lists*" in the EIS as required by SEAR 10.1(d).

The proponent has ignored the will and advice of the UNESCO World Heritage Committee

The World Heritage Committee considered the proposal to raise the Warragamba Dam wall at its meetings in 2019. Decision 43 COM 7B.2 adopted by the World Heritage Committee at its 43rd Ordinary Session in 2019, stated:

"1. Having examined Document WHC/19/43.COM/7B.And,
2. Recalling Decision 28 COM 15B.15, adopted at its 28th session (Suzhou 2004),
3. Notes with concern that the State Party recognizes that the proposed raising of the Warragamba Dam wall is expected to increase the frequency and extent of temporary inundation of the property upstream of the dam;
4. Considers that the inundation of areas within the property resulting from the raising of the dam wall are likely to have an impact on the Outstanding Universal Value (OUV) of the property,
5 Recalls Decision 40 COM 7, in which it considered that the construction of dams with large reservoirs within the boundaries of World Heritage properties is incompatible with their World Heritage status, and urged States Parties to "ensure that the impacts from dams that could affect properties located upstream or downstream within the same river basin are rigorously assessed in order to avoid impacts on the OUV", and requests the State Party to ensure, in line with its commitment, that the current process to prepare an Environmental Impact Statement (EIS) for the proposal fully assesses all potential impacts on the OUV of the property and its other values, including Aboriginal cultural heritage, and to submit a copy of the EIS to the World Heritage Centre for review by IUCN, prior to taking any final decisions regarding the Project".[30]

The World Heritage Committee again considered the proposal to raise the Warragamba Dam wall at its meetings in 2021. Decision 44 COM 7B.180 adopted by the World Heritage Committee at its 44th Session, stated:

[30] UNESCO World Heritage Committee, 43 COM 7B.2. Available at: http://bitly.ws/g277.

"1. Having examined Document WHC/21/44.COM/7B.Add,
2. Recalling Decision 43 COM 7B.2, adopted at its 43rd session (Baku, 2019),
3. Expresses its utmost concern about the unprecedented fires that affected large parts of the property and significantly impacted some areas and habitats, and commends the State Party for its immediate fire-fighting responses, including those targeting specific attributes of the Outstanding Universal Value (OUV) of the property, such as the Wollemi pine stands;
4. Welcomes the information provided by the State Party regarding the immediate management responses to the 2019-2020 bushfires, including the assessment of direct and indirect impacts, plans for longer-term actions and the consideration of funding commitments to ensure long-term recovery, and requests the State Party to submit to the World Heritage Centre, for review by IUCN, an update on the process of assessing the impacts of fires on the OUV of the property and its recovery prospects, as soon as this significant information has been collated;
5. Takes note of the information provided by the State Party regarding the ongoing preparation of the Environmental Impact Statement (EIS) for the Project proposal to raise the Warragamba Dam wall, reiterates its request to the State Party to ensure, in line with its commitments, that the current process to prepare the EIS fully assesses all potential impacts on the OUV of the property and its other values, including Aboriginal cultural heritage, and also requests the State Party to thoroughly assess whether raising the wall could exacerbate bushfire impacts on the property and affect the medium- and long term recovery prospects of key species and habitats within the predicted temporary inundation areas, and to submit the EIS to the World Heritage Centre, for review by IUCN, prior to its final approval".[31]

The proponents' misinterpretation and misrepresentation of these two decisions by the UNESCO World Heritage Committee is of serious concern. In particular, the proponents claim that Decision 40 COM 7 excludes flood mitigation dams is misleading and absurd.[32] Flood mitigation dams are an ongoing threat to World Heritage properties around the globe and present a substantial threat. Further, the mere fact that current Warragamba Dam was in existence prior to the World Heritage declaration does not give any form of justification for the heightening of the dam wall as has been suggested by the proponent.[33]

In addition, the proponent has not understood the seriousness in which the UNESCO World Heritage Committee views the Project as a significant threat to the OUV of the GBMWHA. The fact that the proponent has undertaken an incomplete and improper assessment of the impacts to World Heritage does not discount that the UNESCO World Heritage Committee view the Project as "*likely to have an impact on the Outstanding Universal Value (OUV) of the property*". Indeed, assessments undertaken on World Heritage impact found that the quality of OUV components would be diminished due to the impacts of the Project.[34] The proponent should expect the Committee to make further decisions regarding the Project regardless of any EIS material that it publishes about its interpretation of impacts.

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[31] UNESCO World Heritage Committee 44 COM 7B.180.
[32] EIS Appendix J: World Heritage Assessment Report, pg 116.
[33] EIS Appendix J: World Heritage Assessment Report, pg 116.
[34] EIS Appendix J: World Heritage Assessment Report, pg 85-90.

IUCN World Heritage Assessment Guidelines have not been addressed

While the proponent has claimed in the EIS that it has met the World Heritage assessment guidelines, it has not. We address the claims made by the proponent by relevant principle number.

1. A rigorous Environmental Assessment early on in the decision-making process was not undertaken. Before the SEARs were issued to allow an EIS to be undertaken, the proponent published its intentions to proceed with the raising of the Warragamba Dam wall in the Hawkesbury-Nepean Valley Flood Risk Management Strategy.[35]
2. Experts with World Heritage, protected area and biodiversity knowledge were not involved in the assessment process. After contacting 25 Australian experts in eucalyptus, we have concluded that no scientist with expertise in the OUV of the Greater Blue Mountains was ever engaged in the Project
3. The Precautionary Principle has not been applied to assess the impacts, either direct and indirect, upon the OUV of the GBMWHA. This is contrary to NSW, Commonwealth and IUCN policy on environmental assessments.
4. Reasonable alternatives to the Project have been dismissed from the inception of the Project in 2017, as discussed in Section 13 of this submission.
5. Offsets do not constitute mitigation measures as indicated in the IUCN Policy on Biodiversity Offsets[36]
6. A standalone chapter has been provided in the EIS on World Heritage impacts, however it is heavily reliant on references to other EIS chapters in attempting to justify its conclusions.
7. The assessment has only been partly disclosed. Relevant studies undertaken by the proponent on the impacts of temporary inundation and hydrological modelling have not been disclosed
8. There is no proposal by the proponent for an independently audited Environmental Management Plan

The Project is contrary to World and National Heritage Management Principles

The relevant World Heritage Heritage Management Principles[37] are:

1.01. "The primary purpose of management of natural heritage and cultural heritage of a declared World Heritage property must be, in accordance with Australia's obligations under the World Heritage Convention, to identify, protect, conserve, present, transmit to future generations and, if appropriate, rehabilitate the World Heritage values of the property…

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[35] Infrastructure NSW, *Resilient Valley, Resilient Communities: Hawkesbury-Nepean Valley Flood Risk Management Strategy*, January 2017. Available from: http://bitly.ws/krqK.
[36] IUCN Policy on Biodiversity Offsets. Available from: http://bitly.ws/krok.
[37] Environment Protection and Biodiversity Conservation Regulations 2000, Schedule 5.

3.04 "An action should not be approved if it would be inconsistent with the protection, conservation, presentation or transmission to future generations of the World Heritage values of the property."

Neither of the two relevant EPBC Heritage Heritage Management Principles are consistent with the Project. The Project would not *"protect, conserve, present or transmit values to future generations*", and is entirely inconsistent with *"the protection, conservation, presentation or transmission to future generations of the World Heritage values of the property*."

The relevant National Heritage Management Principles[38] are:

1. *"The objective in managing National Heritage places is to identify, protect, conserve, present and transmit, to all generations, their National Heritage values.*
2. *The management of National Heritage places should use the best available knowledge, skills and standards for those places, and include ongoing technical and community input to decisions and actions that may have a significant impact on their National Heritage values.*
3. *The management of National Heritage places should respect all heritage values of the place and seek to integrate, where appropriate, any Commonwealth, State, Territory and local government responsibilities for those places.*
4. *The management of National Heritage places should ensure that their use and presentation is consistent with the conservation of their National Heritage values.*
5. *The management of National Heritage places should make timely and appropriate provision for community involvement, especially by people who:*
    (a) have a particular interest in, or association with, the place; and
    (b) may be affected by the management of the place.
6. *Indigenous people are the primary source of information on the value of their heritage and the active participation of indigenous people in identification, assessment and management is integral to the effective protection of indigenous heritage values.*
7. *The management of National Heritage places should provide for regular monitoring, review and reporting on the conservation of National Heritage values."*

The Australian Government has issued Management Principles for National Heritage places. They "provide a guiding framework for excellence in managing heritage properties" and "set the standard and the scope of the way places should be managed in order to protect heritage values for future generations". Management plans are "consistent" with the Principles. However, given that the Greater Blue Mountains National Heritage Area does not have a management plan developed for the site, the EIS must meet the requirements of the National Heritage Management Principles.[39]

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[38] Environment Protection and Biodiversity Conservation Regulations 2000, Schedule 5B.
[39] *Environment Protection and Biodiversity Conservation Act 1999,* Section 324U.

The EIS has not addressed these principles in making its assessment as is required. However, the Project cannot be consistent with National Heritage Management Principle 1, 3, 4, and 6 given the damage that would be caused to the National Heritage Area and its associated values.

The Project is contrary to EPBC Act requirements regarding World Heritage and National Heritage

The EPBC Act states[40] that the Commonwealth Minister for Environment cannot make a decision that would be inconsistent with:

a) *"australia's obligations under the World Heritage Convention; or*
b) *the Australian World Heritage Management Principle; or*
c) *a plan that is has been prepare for the management of a declared World heritage property under section 316 or as described in section 321; or*
d) *the National Heritage management principles; or*
e) *an agreement to which the Commonwealth is party in relation to the National Heritage place; or*
f) *a plan that has been prepared for the management of the National Heritage place under section 324S or as described in section 324X."*

It is our view that the Project is not consistent with any of the above requirements of the Commonwealth Environment Minister, and hence the Project should and cannot be approved.

[40] *Environment Protection and Biodiversity Conservation Act 1999*, s137. Available at: http://bitly.ws/krwz; *Environment Protection and Biodiversity Conservation Act 1999*, s146H. Available at: http://bitly.ws/krwP.

6. Wilderness, National Park, Wild River and SCA impacts and assessment

This section of The Colong Foundation for Wilderness submission has been written by former NSW National Parks Area Manager Ian Brown. It is attached below.

Review of

Chapter 20: Protected and sensitive lands

Warragamba Dam Raising EIS

Ian Brown 14 December 2021

1.0 Introduction

This paper reviews the EIS chapter on *Protected and Sensitive Lands*, with particular reference to these matters:

- World Heritage
- National Heritage
- NPW Act reserves
- Wilderness
- Wild rivers
- Critical habitat (areas of outstanding biodiversity)

This paper examines a number of statutory provisions, legal instruments, guidelines and plans that relate to these categories of land, how they inform the impacts of the Project, and how the EIS has dealt with those impacts.

The main comments and findings are summarised below, followed by a detailed examination of the issues.

2.0 Main comments & findings of this review

SEARs and EIS requirements

The EIS falls short of requirements in several respects:

- It uses an unvalidated methodology to measure the extent and duration of upstream inundation impacts.
- It does not include maps which *clearly indicate the proposed high water mark line and current high water mark line, as well as protected area boundaries* (SEARs) and wilderness.
- Collectively, these shortcomings mean that the EIS does not *provide sufficient information for a decision* (SEARs), as it is required to do.

Extent of 'protected and sensitive lands' to be impacted

- The EIS uses a flawed methodology to measure the extent of inundation impacts.
- The EIS devalues those parts of protected areas which are not within the GBMWHA, even though those areas are contiguous with the WHA and extend and support the OUV and integrity of the WHA.
- The EIS does not state the total extent of protected areas within the upstream impact area, which is 1607 hectares (total according to the flawed methodology used).
- The EIS takes a reductionist approach to protected area impacts, considering each in isolation. This can downplay impacts. For instance, a key fact not acknowledged in the EIS is that an area of protected lands to be impacted by the Project, of an extent that has not been resolved in the EIS, has the highest level of protection possible in Australia, comprised of multiple layers, that is:
    - Special Area (catchment)
    - National Park
    - Wilderness
    - World Heritage
    - ILUA

World Heritage and National Heritage

(Note: The GBMWHA is also National Heritage, and the only place of both classifications relevant to the EIS)

- The Project is inconsistent with several provisions of the statutory GBMWHA Strategic Plan, including wilderness and wild rivers, biodiversity, water quality, Aboriginal cultural heritage and aesthetics.

NPW Act reserves

- All NPW Act reserves to be impacted have plans of management in force under the NPW Act.
- Causing impact to plant and animal communities for a purpose unrelated to the purposes of reservation of these areas would be inconsistent with the NPW Act and plans of management and, for wilderness areas, the Wilderness Act.
- The plans of management are statutory. The plans do not authorise the Project, and hence it is not permitted by the plans.
- However, it is noted that the plans of management have been 'turned off' for this state significant project, and that recent amendments to the NPW Act (section 153B) permit temporary inundation within the Warragamba catchment special area.
- The EIS seems to assume that c.4km of the lower Kowmung River is excluded from both Blue Mountains NP and the Kanangra-Boyd Wilderness. This is not shown on the maps in the EIS and no reference is provided. This must be definitively resolved before any approval is given for the project.

Wilderness

- The EIS treatment of wilderness impacts is misleading, inadequate and not supported with evidence.
- The EIS fails to include maps of affected wilderness.
- The EIS misrepresents and downplays wilderness quality in the areas impacted.
- The extent of impact is affected by the uncertainty (see above) around the national park and wilderness boundary in the lower Kowmung River.
- Deliberate inundation of wilderness is inconsistent with the Wilderness Act.

Wild Rivers

- The Kowmung River is a declared wild river under the NPW Act.
- The EIS minimises wild river impacts due to what seems to be a flawed wild river declaration that potentially excludes the lowest c.4km of the Kowmung River.
- The EIS uses an unvalidated methodology in assessing upstream flood impacts.
- Deliberately inundating and impacting a wild river and riparian vegetation is inconsistent with the purposes of wild river declaration under the NPW Act.

Critical habitat (areas of outstanding biodiversity value)

- Not relevant, nil in affected area.

3.0 Detailed examination of issues

Each issue is discussed, with comments and findings in blue.

3.1 Protected and sensitive lands, SEARs and EIS requirements

'Protected and sensitive lands' for the EIS to consider are identified under Key Issue 13 in the standard Secretary's Environmental Assessment Requirements (SEARs SSI 8441). The list includes lands managed under the NPW Act and lands (or waters) identified as 'Critical Habitat' under the TSC Act or EPBC Act.

EIS Requirement 2 under Key Issue 10 is:

"*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*."

The maps in EIS Chapter 10 do not meet this standard, as they are at a scale that is inadequate to distinguish these three boundaries. In fact, only the protected area boundaries are clearly shown. The maps also do not show the boundary of Blue Mountains National Park excluding the lower Kowmung River.

In terms of land-based items, the standard SEARs mention Wilderness Areas (NPW Act), wild rivers (NPW Act) and ILUAs (Native Title Act) under Key Issue 10. Heritage. The standard SEARs do not mention Special Areas (Water NSW Act) as a matter to be addressed. Other lands listed in the general SEARs are not directly relevant to the Project.

Attachment A to the standard SEAR's (2017/7940) provide guidelines for assessment of the Project specifically relevant to the EPBC Act and according to the *New South Wales Bilateral Agreement relating to environmental assessment (February 2015).* As the Project has been declared a 'controlled action' under the EPBC Act, three items have been identified as 'controlling provisions' which must therefore be considered by the proponent:

- World Heritage Properties (being the GBMWHA)
- National Heritage places (also being the GBMWHA)
- Listed threatened species and communities.

Under these provisions, impact assessment documentation (ie. the EIS) must provide "*sufficient information for a decision*", as well as "*an assessment of the relevant impacts of the action on the matters protected by the controlling provisions, including:*

> *i. a description and detailed assessment of the nature and extent of the likely direct, indirect and consequential impacts, including short term and long term relevant impacts;*
> *ii. a statement whether any relevant impacts are likely to be unknown, unpredictable or irreversible;*
> *iii. analysis of the significance of the relevant impacts; and*

iv. any technical data and other information used or needed to make a detailed assessment of the relevant impacts".

It is considered that the EIS *does not* provide information to this standard with respect to a number of impacts on protected/sensitive lands, including:

- The extent of protected and sensitive lands to be impacted
- Clear maps showing the relationship between protected area and wilderness boundaries, the current full supply level and the expected maximum level.

Comment: The EIS falls short of meeting SEARs requirements in several respects.

3.2 Which 'protected and sensitive lands' will be impacted, and to what extent?

With regard to the 'upstream impact area', the EIS notes that:

"[the] *Project involves providing capacity to facilitate flood mitigation by increasing the crest levels of the central spillway by approximately 12 metres, the auxiliary spillway by 14 metres and temporary storage of flood waters above FSL for up to two weeks*." (page 20-9).

With regard to the definition of the upstream impact area in relation to the new height of the dam wall and spillway, the EIS explains:

"*Assessment of potential impacts in the upstream study area has focussed principally on the area between 119.5 mAHD (2.78 metres above full supply level, FSL) and 126.97 mAHD (10.25 metres above FSL), referred to as the 'upstream impact area'.* (page 20-7)

The derivation of this definition is described in Appendix J of the EIS. Its lower limit corresponds to a theoretical maximum level of impact caused by floodwaters backed up by the *current* dam level. The upper limit is again a theoretical maximum level of inundation of the raised dam. This methodology is unverified, and is being assessed by others.

The EIS addresses the inundation impacts of the Project within its own stated methodology. As argued elsewhere, this minimises the extent of the area of impact.

In terms of the SEARs/EPBC Act and the Attachment A 'controlling provisions', it is noted that the GBMWHA is the *only* land classification for which impacts need to be addressed. Although substantial additions to the constituent WHA reserves have occurred since World Heritage listing in 2000, especially around Lake Burragorang (to Nattai and Blue Mountains national parks), these are not currently part of the WHA. Nor are these constituent WHA reserves (and thus any additions) listed in their own right as National Heritage. However these areas, as protected areas managed under the NPW Act, are captured within the SEARs in Key Issue 10 Heritage and form part of the GMBWHA 'integrity' listing criteria.

Based on the EIS methodology, the EIS states the extent of NPW Act protected areas within the upstream impact area in Table 20-16 (page 20-41). It is apparent from the associated maps that the quoted extents for Nattai and Blue Mountains include only those areas which are not part of the WHA (ie. later additions). This area is more than double the affected WHA extent. The table does not provide a combined total for the extent of all protected areas within the upstream impact area as defined by the EIS, which is 1607 hectares, comprised as follows:

- NP within GBMWHA = 304 ha
- NP not within GBMWHA (NP added since 2000) = 819 ha
- (Total NP = 1123 ha)
- Other protected areas (SCAs) = 484 ha
- Total protected areas within upstream impact area = 1607 ha

Comment: This arithmetic plays down the impact on the GBMWHA and its OUV, because the additional parts of NPs which are not WH clearly possess the same values as adjacent areas within the WHA, being contiguous and of equivalent integrity. The same could be said of at least some parts of the SCAs. These connected areas also support the integrity of the GBMWHA listing. The affected non-WHA NP lands amount to more than double the affected WHA.

Vegetation communities and wildlife movements do not stop at lines on maps. Further, it has been intended that NP additions would be nominated for inclusion in the WHA, a largely routine process. This has not yet happened due to government inertia.

GBMWHA Strategic plan

The Strategic Plan for the GBMWHA (2009) is a statutory plan under Schedule 5 (Australian World Heritage management principles) of the *Environmental Protection and Biodiversity Conservation Regulations 2000*.

The Plan includes the following Strategic Management Objectives:

- *identify, protect, conserve, present, transmit to future generations and, where necessary, rehabilitate the World Heritage values of the GBMWHA*
- *manage the broad range of values, both World Heritage and non-World Heritage, ensuring that achieving the long-term conservation of the reserves' World Heritage values is the over-riding principle.*

The Plan includes the following Key Issues and associated Objectives, Desired Outcomes and Management Responses which are relevant to the impacts of the Project:

<u>Integrity</u>
Objective: *to maintain, and wherever possible, improve the current and future integrity of the GBMWHA.*
Management Responses:

- *1.1 Ensure that statutory plans of management of all GBMWHA reserves are reviewed and amended to specifically address World Heritage objectives and meet the requirements of the Australian World Heritage management* *principles and this Strategic Plan and that they contain provisions for evaluating and monitoring their effectiveness.*

- *1.8 Maintain and enhance the wilderness and wild river quality and values of the GBMWHA through formal declaration and appropriate management programs.*

Comment: The Project damages wilderness and wild river quality and fails to adequately consider wilderness impacts (see below).

<u>Major impacts</u>
Objective: *To reduce the potential for major impacts to adversely affect the integrity of the GBMWHA.*
Management Responses:

- *2.1 Ensure that environmental impact assessments for proposals that may affect the GBMWHA (whether or not on the reserves themselves) adequately address potential and existing impacts on World Heritage values and are carried out in accordance with the principles of the EPBC Act and, where required, referred to the Australian Government Minister for the Environment.*
- *2.4 Where there is doubt about the potential impacts of an action on World Heritage values the precautionary principle shall be applied; every effort will be made in consultation with the relevant parties to minimise any risk of adverse impacts.*

Comment: Neither of these principles have been met.

<u>Biodiversity</u>
Objective: *To conserve the GBMWHA's biodiversity and ensure the ecological viability and capacity for ongoing evolution of its World Heritage and other natural values is maintained.*
Desired outcome: *Terrestrial and aquatic ecosystems and their associated ecological processes, species, populations and genetic diversity are all protected and conserved in-situ.*

Comment: The Project impacts biodiversity.

<u>Water catchment protection</u>
Objective: *To maintain and improve the water quality and water catchment values of the GBMWHA.*
Desired outcome: *Any adverse impacts on water quality and quantity within the GBMWHA arising from park management activities, upstream land uses or visitor use are eliminated or, at least, minimised.*

Comment: Damage to vegetation from inundation will have water quality impacts.

<u>Cultural heritage</u>
Objective: *To identify, formally recognise and protect the cultural heritage values of the GBMWHA.*
Desired outcome: *The cultural heritage values of the GBMWHA are retained and better understood, and their significance is formally recognised at State, National and World Heritage level as appropriate.*

Comment: Substantial impacts will occur to Aboriginal cultural heritage from the Project.

Landscape, natural beauty and aesthetic values
Objective: *To protect the landscape, natural beauty and aesthetic values of the GBMWHA.*
Desired outcome: *Any adverse impacts on the natural beauty and aesthetic values are prevented, eliminated, or at least minimised.*
Management response:

- *7.4 Ensure that the impact of new developments within and adjacent to the GBMWHA on the area's scenic and aesthetic values are considered, including any adverse impacts associated with lighting.*

Comment: The Project will have aesthetic impacts through damage to vegetation in areas inundated.

Overall comment re Strategic Plan: The Project is inconsistent with the provisions of the statutory Strategic Plan in several respects.

3.5 NPW Act reserves

The boundary of Blue Mountains NP in the vicinity of the lower Kowmung River is not resolved with certainty. The EIS assumes the river corridor is excluded from the park from the Coxs River junction to a point c.4 km upstream from the junction.

All NPW Act reserves relevant to the 'upstream impact area' have statutory plans of management in place:

- Blue Mountains NP (2001)
- Kanangra-Boyd NP (2001)
- Nattai Reserves (2001) (covering Nattai NP, Bargo, Burragorang, Nattai & Yerranderie SCAs)

Comment: These plans have not been reviewed in detail in relation to the impacts of the Project, however it is clear that damaging plant and animal communities for a purpose unrelated to the purposes of reservation of these areas would be inconsistent with the NPW Act and plans of management and, for wilderness areas, the Wilderness Act.

3.6 Wilderness

Parts of two declared wilderness areas lie within the 'upstream impact area': Kanangra-Boyd and Nattai. The EIS says (20.1.8, page 20-6):

"Some areas of the GBMWHA potentially impacted by the Project are in the Nattai and Kanangra-Boyd Wilderness Areas and would experience increased temporary inundation due to the operation of the Project."

The EIS goes on to argue that Ministerial consent is not required for this development, because there is no "wilderness protection agreement or conservation agreement…under section 15 of the Wilderness Act". The area of wilderness impacted is not quantified.

The conclusion that Ministerial approval is not required would appear to be strictly correct, however it is clear from Section 8 and Section 10 of the Act that such agreements are only intended to be made in relation to the protection of declared wilderness that is *not* within lands reserved or dedicated under the NPW Act.

The two wilderness areas involved are entirely within national park. The Wilderness Act implicitly assumes that impacts and developments on declared wilderness within national parks do not require direct Ministerial consent because such activities are subject to the statutory provisions of the Wilderness Act and the NPW Act, including the management principles for national parks and wilderness.

The two relevant "Management principles for wilderness areas" in Section 8 of the Wilderness Act are:

(a) to restore (if applicable) and to protect the unmodified state of the area and its plant and animal communities,
(b) to preserve the capacity of the area to evolve in the absence of significant human interference

It is abundantly clear that the deliberate inundation of wilderness with associated impacts is not consistent with these principles, nor national park management principles.

The EIS (page 20-32) acknowledges the importance of wilderness quality to the values of the GBMWHA and goes on to say that the affected areas of wilderness: *"occur at the fringes of the GBMWHA which are already subject to influences from adjoining land uses and would likely not be regarded as areas of significant wilderness value, particularly with reference to the values applying to areas designated as wilderness under the* Wilderness Act 1987.*"*

The EIS provides no map of the affected wilderness to justify this assessment, nor any evidence to support the judgmental statement that the "*affected areas of wilderness*" "*would likely not be regarded as areas of significant wilderness value"*. The EIS does not quantify the area of affected wilderness nor show the areas on maps. These areas have been duly identified and declared as wilderness. Section 6(1)(a) of the Wilderness Act provides that an area of land cannot be identified as wilderness unless the "area is, together with its plant and animal communities, in a state that has not been substantially modified by humans and their works or is capable of being restored to such a state". No further criterion of value is required. It is inappropriate for the EIS to denigrate the wilderness value of declared wilderness, especially in the absence of any analysis.

Further, the EIS comment about the impact of "adjoining land uses" is not supported with any evidence, and is in fact incorrect. The areas in question are around the margins of Lake Burragorang, and therefore on the internal fringes of the GBMWHA, away from rural and other developed lands. The only "adjoining land use" relevant to the two wilderness areas is water supply, which is comprised of stored water, lake margins and adjoining bushland. Some of these areas are riparian communities critical to the integrity of streams and their "plant and animal communities". All wilderness affected by the Project is largely intact and remote from most impacts that can diminish wilderness quality.

Comment: The EIS treatment of wilderness impacts is misleading, inadequate and possibly unlawful

3.7 Wild rivers

The Kowmung River is a declared wild river for the purposes of the National Parks and Wildlife Act 1974 (NSW).

The Act says:

"The purpose of declaring a river or part of a river as a wild river is to identify, protect and conserve any water course or water course network, or any connected network of water bodies, or any part of those, of natural origin, exhibiting substantially natural flow (whether perennial, intermittent or episodic) and containing remaining examples, in a condition substantially undisturbed since European occupation of New South Wales."

Allowing any length of the Kowmung River to be artificially inundated would be contrary to this fundamental purpose.

Deliberately inundating and impacting riparian vegetation is inconsistent with the purposes of wild river declaration under the NPW Act, specifically the purpose to "*protect and conserve*" the river (Section 61(4)).

Comment: The EIS downplays wild river impacts. The Project is inconsistent with the wild river declaration of the Kowmung River.

3.8 Critical habitat (areas of outstanding biodiversity value)

Nil within the affected area (EIS 20.3.5, page 20-18)

7. Fauna impacts

This section of The Colong Foundation for Wilderness submission has been written by zoologist Dr Martin Denny and is attached below. For further information regarding the impacts and assessment on aquatic fauna, we refer to the submission made by Dr John Harris.

ASSESSMENT OF FAUNA ASPECTS OF ENVIRONMENTAL IMPACT STATEMENT – WARRAGAMBA DAM RAISING by Dr Martin Denny

1. INTRODUCTION

The Colong Foundation for Wilderness requested an assessment of the Environmental Impact Statement (EIS) for the Warragamba Dam Raising, concentrating on any fauna aspects. The EIS is a large, multipart and very complex document that covers a wide range of issues associated with the raising of the dam wall and flooding events upstream and downstream from the wall, as well as the effects of constructing the proposed higher dam wall. The following documents were read and any topics related to the fauna within the study area and to any assessments of impacts were noted.

Chapter 1: Introduction

Chapter 2: Statutory Framework

Chapter 5: Project Description

Chapter 8: Biodiversity Upstream

Chapter 9: Downstream Ecological Assessment

Chapter 10: Biodiversity Construction Area

Chapter 11: Aquatic Ecology

Chapter 12: Matters of National Significance

Chapter 14: Biodiversity Offsets

Chapter 15: Flooding and Hydrology

Chapter 29: EIS Synthesis, Project Justification and Conclusion

Appendix F1 Upstream Biodiversity Assessment Report

Appendix F1-L Part 3 Surveys

Appendix F1-L Part 8 Threatened Species

Appendix F2-I Part 1 Survey Area

Appendix F2-I Part 7 Threatened Fauna Records

Appendix F2 Downstream Biodiversity

Appendix F3 Construction Area BAR

Appendix F3 Aquatic Ecology

Appendix F5 Matters of National Environmental Significance - Biodiversity

Appendix F6 Biodiversity Offset Strategy

Appendix L Part 1: Biodiversity Values Maps

Appendix N2 Geomorphology Technical Assessment

SEARS (revised)

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2. FAUNA WITHIN THE UPSTREAM AND DOWNSTREAM STUDY AREAS

There is considerable detail within the various chapters and appendices, much based on satisfying legislative and regulatory conditions. However, all the analysis undertaken and the conclusions arrived at are based on knowledge of the fauna species known or have the potential to occur. Data on fauna presence within the Warragamba Dam study area comes from three sources; existing records of sightings within the Warragamba Dam Catchment, modelling potential species presence based on abiotic factors and importantly, the results from recent fauna surveys within or near the study area.

A list of threatened fauna species predicted to occur in the upstream study area is provided in Appendix G, Appendix F1: Biodiversity Assessment Report. This lists 96 threatened species and their likelihood of occurrence. Appendix G lists species under the *NSW Biodiversity Conservation Act* and *Federal EPBC Act*, including migratory species. This number is broken down using different legislative guides. Table 12-5 in Chapter 12: Matters of National Significance, lists 34 EPBC listed species that are potentially present. The full list is further sorted in Tables 12-12 and 12-13 into ecosystem credit species (6) and candidate species credit species (19) i.e. 25 credit species. This sorting is under the Framework for Biodiversity Assessment used to implement offsets policy. However, Appendix F1: Biodiversity Assessment Report Upstream Tables 5.3 and 5.4, list 29 Ecosystem Credit Species and Table 5-5 lists 24 Species Credit Species. Also, Table 5-12 gives 25 Ecosystem credit species recorded in the study area, Table 5-13 gives 4 Species credit species recorded and Table 5-14 lists 12 Species credit species presumed present in the study area. To add to the confusion Table 7-4 in Appendix F1: Biodiversity

Assessment Report Upstream (Description of potential Project impacts on fauna species credit species) lists 16 species.

There are other lists of threatened species that also have different total numbers. Table 12-28 in Chapter 12: Matters of National Significance (12.8 Assessments of significant impact) gives 21 threatened species, as does Appendix F5: MNES – Biodiversity, Appendix A (Assessments of significance). SEARS (revised) Attachment A, Attachment 1 – Protected matters relevant to the Warragamba Dam Raising Project, gives fauna species listed under Protected Matters significant impacts and under Protected Matters (Part 3). There are 3 species under significant impacts and 21 under Part 3 i.e. a total of 24 threatened species associated with Warragamba Dam raising. Chapter 12: Matters of National Environmental Significance addresses Threatened Fauna in section 12.12.2.2 stating that the "Project would have a significant impact on 11 Threatened Species listed under the EPBC Act". However, Table 12-33 only lists 8 such species.

Known and potential Threatened species associated with the Downstream study area is also given as a mixture of lists. No Credit species are addressed in this part of the study area but Table 6-6 in Appendix F2: Downstream Ecological Assessment, gives a list of 44 Threatened Species whereas Table 6-7 gives an assessment of significance under the *EP&A Act* that lists only 9 of these threatened species. Appendix F Assessment of Significance (*EP&A Act*) only assesses 4 Threatened Species. Table 5-6 giving locations of threatened species recorded in the survey area lists 15 species and Table 5-7: Threatened fauna previously recorded in the survey area, lists 32 species.

From all these different numbers of threatened species occurring or likely to occur in the Warragamba Dam Raising study area there is a requirement for some form of targeting of those species considered important. Considering the Upstream area, there are 96 threatened species, 34 EPBC listed species and a varying number (24, 25, 16, 29) of ecosystem or species credit species. Table 5-10 in Appendix F1: Biodiversity Assessment Report – Upstream (Summary of fauna survey effort for the study area) names those species that were targeted during fauna surveys. There are 15 Threatened species targeted during the fauna surveys of the upstream study area. 96 threatened species is reduced to 15.

The downstream fauna surveys are a bit broader with Table 4.2 in Appendix F2: Downstream Ecological Assessment providing a summary of targeted fauna survey effort. This table lists 5 threatened species plus threatened microchiropteran bats and wetland birds as survey targets.

The selection of species targeted by the fauna surveys is at an absolute minimum and does not allow for a comprehensive assessment of the biodiversity of the study area nor provide adequate information to undertake a calculation of impacts and offsetting.

3. WHERE ARE THE EXPERT REPORTS?

The argument for eliminating so many species from the candidate list and the surveys is within the Framework for Biodiversity Assessment (NSW Biodiversity Offsets Policy for Major Projects). Step 3 in the Policy Determine whether the candidate species is present an assessor must establish whether any species that remains a candidate is present on a development site, or is likely to use the potential habitat on the development site, by either:
(a) assuming it is present (development sites only), or
(b) undertaking a threatened species survey in accordance with Section 6.6, or
(c) obtaining an expert report in accordance with Subsection 6.6.2.

Subsection 6.6.2 describes using expert reports instead of undertaking a survey. An expert report may be obtained instead of undertaking a threatened species survey at a development site. The rules for an expert report are:

- An expert report must only be prepared by a person who is accredited by the Chief Executive of OEH under section 142B(1)(b) of the TSC Act, or a person who, in the opinion of the Chief Executive of OEH possesses specialised knowledge based on training, study or experience to provide an expert opinion in relation to the biodiversity values to which an expert report relates.
- The expert report must document the information that was considered, and/or rejected as unsuitable for consideration, to reach the determination made in the expert report.
- An expert report can only be used instead of a survey for species to which species credits apply.
- An expert report must set out whether:

(a) for development sites – the species is unlikely to be present on the development site – in this case no further assessment of the species is required, or
(b) for all development sites – the species is likely to be present on the site – in this case the expert report must provide an estimate of the number of individuals or area of habitat to be impacted by the development or the

management actions (according to the unit of measurement identified for the species in the Threatened Species Profile Database).

There are some Expert Reports in the EIS. Appendix F3: BAR Construction Area gives expert reports for Pterostylis saxicola and six frog species. Appendix F2: Downstream biodiversity assessment and Appendix F1: BAR Upstream only addresses Pterostylis saxicola. Chapter 8: Biodiversity – Upstream, states that expert reports were prepared for three amphibian species: Giant Burrowing Frog, Red-crowned Toadlet and Stuttering Frog. However, these are not given in Chapter 8. The Expert Reports for the six frog species are only for the Construction Area

There are limited 'expert reports' for fauna given in the EIS, and these only cover frogs and the Construction Area. Instead, tables that document the authors' opinion of the likelihood of occurrence of species credit species upstream (e.g. Appendix G, Appendix F1: BAR) are used.

4. FAUNA SURVEY METHODS AND SURVEY EFFORTS

Even if all species were targeted, some have been eliminated from further assessment as it is concluded that they do not require further consideration. Table 5-5, Assessment of potential presence of species credit species in Appendix F1: Biodiversity Assessment Report – Upstream lists those species that could occur in the study area. Some in the list are eliminated from further consideration as they are considered outside their range or there is not the preferred habitat. If the authors had looked at the Environment NSW (now DPIE) online species profiles they would have found comprehensive information concerning indicative distribution of most threatened species. Maps for each species shows known and predicted distribution, the predicted distribution is based on modelling a number of biotic and abiotic factors to arrive at a probability of occurrence.

Of those eliminated in Table 5-5 there are a number that are predicted to occur in the Burragorang IBRA sub-region. These are the Green and Golden Bell-Frog, Booroolong Frog, Cumberland Plains Land Snail, Stuttering Frog and Littlejohn's Tree Frog. Table 5-6, Threatened species requiring further consideration lists the White-fronted Chat but states that this species does not require any further consideration, as there are no records or suitable habitat in the study area, yet it is mapped as predicted within the Burragorang Sub-region. Greater Glider is listed in Table 5-5 but is eliminated from any further consideration as it is not listed as a Threatened Species in NSW although it is Federally listed under the EPBC Act and in Queensland. However, the Greater Glider is one of the target species to be surveyed in Table 5-10. It is difficult to determine whether the EIS deals with State and/or Federal legislation.

Considering the importance of the Warragamba Catchment and downstream as well as the potential impacts from the raising of the dam wall and ensuing management it would be imperative that a thorough and comprehensive survey of fauna was undertaken. Unfortunately, this has not occurred with the Warragamba Dam Raising project.

Table 1-2. Adopted Project definitions for upstream biodiversity assessment (Appendix F1: BAR – Upstream) provides the sizes of the study area and the field survey area. The upstream study area comprises the area between full supply level (FSL) and the Project PMF. This equates to an area of about 5,280 ha. The field survey area is an area within a representative 1 in 100 chance in a year event (1% AEP) with the Project plus nine percent climate change. This equates to an area of about 3,740 ha. However the upstream impact area is defined as the area between the likely inundation level with the Project (10.25 m above FSL, RL 126.97 mAHD) and the likely inundation level for the existing dam (2.78 m above FSL, RL 119.5 mAHD). The size of this area is about 1,400 ha.

It is difficult to tease out which area was used for the surveys. The definition of the Study area is the area directly affected by the development and any additional areas likely to be affected by the development, either directly or indirectly. The study area should extend as far as necessary to take all potential impacts into account, for the purpose of an assessment under Subsections 9.2.4 and 9.2.5. For this assessment, the PMF (no climate change) with Project is the study area. This is taken to be 5,280 ha and is shown in Figure 5.2 in Appendix F1. However, Appendix B: Threatened species habitat polygons gives a 550m Linear Assessment Buffer without explanation. It could be interpreted to be an actual boundary to the field survey area. Section 3.3.2 Percentage native vegetation cover in the landscape in Appendix F1 states “Native vegetation occupies 17,177.28 hectares of the 550-metre linear assessment buffer and is predominately large, intact patches of native forest of at least four vegetation formations”. Is this the actual size of the survey area?

How do you document the fauna within such a large study area? Obviously, comprehensive surveys are important to provide an estimate of fauna populations and to be used to predict possible impacts and management strategies. The NSW Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities - Working Draft and the survey guidelines for birds, mammals, reptiles and frogs issued under the EPBC Act all give guidelines for undertaking fauna surveys. Although Section 5.5.2.2 in Appendix F1 states that these were 'considered' it appears that the relevant guidelines were not followed (however, in Section 8.2.7 Fauna Surveys Chapter 8: Biodiversity - Upstream it states "Fauna field surveys were based on the survey effort recommendations of Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities)

All guidelines recommend that the study area be stratified to ensure rigorous sampling. The NSW guidelines state "Stratification is necessary to ensure that the full range of potential habitats and vegetation types will be systematically sampled. The survey area should be initially stratified on biophysical attributes (eg. landform, geology, elevation, slope, soil type, aspect), followed by vegetation structure (eg. forest, woodland, shrubland), and then floristics (eg. species)". Although Section 5.5.2.2 states that fauna field surveys were undertaken with particular reference to major sampling stratification units, no description of which sampling units were used to stratify the study area. There are several stratification units that are described in the EIS and could be used e.g. soils, broad vegetation communities, Mitchell Landscape units and IBRA Sub-regions but none seem to be applied in the setting out of the fauna surveys.

Stratification units are important when estimating survey effort. Survey effort can be calculated as the time spent or the number of traps etc in a set area of a stratification unit. The NSW survey guidelines gives effort as per stratification unit. For example, Table 5.8 in the guidelines gives the suggested survey methods and effort for non-flying mammals as:

Method	Effort per stratification unit up to 50 hectares, plus an additional effort for every additional 100 hectares	Animal sampled
Small Elliott traps	100 trap nights over 3-4 consecutive nights	small mammals

Although there is no description of stratification of survey sites it is still possible to compare the survey effort of the Warragamba Dam Raising surveys with that recommended in the State and Federal guidelines.

Table 5-10 gives a summary of fauna survey effort for the study area and the following text gives a description of each method used. The times given in Table 5-10 (Dates) indicate that the majority of surveys were undertaken during summer with some surveys extending into autumn. No winter and little spring sampling - movement during winter-spring are important aspects of breeding ecology yet have been ignored i.e. no seasonal sampling.

Commenting on each survey method listed:

1. Spotlighting and call playback for Koala, Greater Glider and Squirrel Glider. The survey effort was a total of 15 hours. The sites used are shown in Appendix F1-L: Part 8 threatened species survey locations. There is no information about how long any call broadcast went, what form of broadcasting equipment was used (power in decibels) or what protocol was used (time of broadcast then time for listening, this is important for ethics approval). NSW guidelines state for spotlighting transects that there should be "2 x 1 hour and 1km up to 200 hectares of stratification unit, walking at approximately 1km per hour on 2 separate nights". If it takes 2 hours to undertake spotlighting and call broadcasting for each 200 ha stratification unit, then the 15 hours spent would have covered 7.5 units i.e. 1,500 ha, a lot less than the study area.
   Guidelines for call broadcasting (playback) recommend 2 sites per stratification unit up to 200 hectares, plus an additional site per 100 hectares above 200 hectares. Each playback site must have the session conducted twice, on separate nights. There is no information about the extent of call broadcasting nor what calls were broadcast. No information is given on the results from the surveys i.e. what was observed, the habitat covered.
2. Arboreal hair tubes for Squirrel Glider and Brush-tailed Phascogale. Hair tubes were placed in groups of 10 at each site with a total of 130 tubes i.e. 13 sites were surveyed. The sites are shown Appendix F1-L. The NSW guidelines state that 3 tubes are placed in each of 10 habitat trees up to 100 hectares of stratification unit, for at least 4 days and 4 nights. If each site was a 100ha stratification unit then 1,300ha was surveyed. No information is given on the results from the surveys, particularly the results from the analysis by Barbara Triggs.
3. Ground hair tubes for Southern Brown Bandicoot and Spotted-tail Quoll. Hair tubes were placed in groups of 10 at each site with a total

of 100 tubes i.e. 10 sites were surveyed. The sites are shown in Appendix F1-L. The NSW guidelines state that 3 tubes are placed in each of 10 habitat trees up to 100 hectares of stratification unit, for at least 4 days and 4 nights. If each site was a 100ha stratification unit then 1,000ha was surveyed. No information is given on the results from the surveys, particularly the results from the analysis by Barbara Triggs.

4. Arboreal cage traps for Squirrel Glider and Brush-tailed Phascogale. There is no information about the number of traps used or the length of time they were used.
5. Amphibian surveys for Giant Burrowing Frog, Red-crowned Toadlet and Stuttering Frog. The surveys were in the form of searches in suitable habitat. The sites are shown Appendix F1-L. The NSW guidelines give precise survey efforts for amphibians:

Table 5.3 Suggested survey methods and effort for frogs

Method	Suggested minimum effort	Survey period
Systematic day habitat search	One hour per stratification unit	Varies according to the seasonal peak of activity of target species
Night habitat search of damp and watery sites	30 minutes on two separate nights per stratification unit	See above
Nocturnal call playback	At least one playback on each of two separate nights	See above
Night watercourse search	Two hours per 200m of water body edge	See above

The survey effort for the amphibian surveys undertaken at Warragamba Dam upstream is given as 40 minutes. Unless there has been a misprint, the extent of survey effort is extremely small as it should be at least 2 hours per stratification unit. Also, no call broadcasting was undertaken, an oversight as the Giant Burrowing Frog and Red-crowned Toadlet respond to calls.

6. Diurnal bird surveys for the Regent Honeyeater. It is assumed that more than the Regent Honeyeater was recorded, and that specialised survey techniques were used only for this species. It is stated that census points were used, this infers point count surveys. However, as the figures in Appendix F1-L show, the bird surveys were transects.
7. Ultrasonic call detection for Large-eared Pied Bat. The call detectors were employed for at least 2 nights per site, the problem with this and other survey methodology descriptions is that no discrete sites are shown on the figures, just scattered points. The guidelines state that 2 sound activated recording devices utilised for the entire night (a minimum of four

hours), starting at dusk for two nights per 100 hectares (or portion thereof) of stratification unit targeting preferred habitat. This appears to be followed, however the extent of survey effort is not known without the number of sites and stratification details. Also, the analysis of the calls by Brad Law should be provided.

8. Remote sensing cameras for Southern Brown Bandicoot, Spotted-tailed Quoll, Brush-tailed Rock-wallaby and Rosenberg Goanna. Again, there is no information about the number of cameras used although their locations are given in Appendix F1-L. No information is given about the time they were in use nor about the results from the cameras.
9. KSAT for Koala. The methodology used here follows an established protocol but, again, there is no information about the number of sites, the results from the surveys and the results from the scat analysis by Barbara Triggs.
10. Nest boxes for the Eastern Pygmy-possum. These were placed on 12 sites for a total of 1,220 trap nights i.e. about 100 days at each site. The sites are located in Appendix F1-L and Figure 5.2. There are no guidelines to the number of nest boxes to be used in surveys and the length of time to be used. However, survey effort relative to stratification and overall study area is unknown.

A review of Table 5-10 shows that the survey efforts are inadequate for such a large and important area, information that is important for a complete assessment of the methodology is missing and the range of survey methods do not cover or inadequately cover all target species listed. The lack of stratification and seasonal sampling places the survey methodology under doubt and not up to the standard required under the State and Federal guidelines.

5. INADEQUACIES OF FAUNA SURVEYS

What else is missing?

- Although Elliott traps are plotted on Appendix F1-L and Figure 5.2 there is no description in Section 5.5.2.2 and in Table 5-10. Consequently, there is no information about the size of traps, number of traps and length of time used in the study area. Ground Elliott traps would be used by the New Holland Mouse and arboreal Elliott traps are used by the Eastern Pygmy-possum and Squirrel Glider.
- No surveys for nocturnal birds are included. Although there are 4 owl species that are listed as Threatened, all have been filtered out and are not

considered target species in the fauna surveys. Thus there are no night surveys for owls nor any call playbacks.
- The Rosenberg's Goanna was the only reptile surveyed, even though the Broad-headed Snake occurs near the study area. A limited number of reptile species were located by sight, all large species.
- No pit-fall traps were used, even though they are good for capturing the Eastern Pygmy-possum as well as New Holland Mouse and a number of reptile and amphibian species.

Viewing Figure 5-2 in Appendix F1 with the threatened fauna survey locations, shows a totally inadequate approach to a detailed survey for a large and important area. The figure shows a scatter of dots, representing 8 survey techniques and 4 lines representing transects. The dots and lines are clustered in the north and south of the study area.

Although the descriptions of the survey methods refer to 'sites' no such discrete area is delimitated in Figure 5-2. Sites appear to be each dot or line. However, the *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities* make particular reference to the size of the survey sites, broad scale vegetation communities and major sampling stratification units. Section 5-6 Habitats within the site (Appendix F1), gives a breakdown of the main habitat types within the study area and Table 5-11 shows the proportion of fauna habitat types within the study area as a percentage. However, no relationship between the proportion of habitat types and survey effort is provided, as there is none for any stratification units.

Possibly the major revelation from studying Figure 5-2 is the totally inadequate cover of the study area by fauna surveys. Approximately only half of the study area has been surveyed leaving the remainder undocumented. Inspecting Figure 5-2 and Appendix F1-L: Part 8 threatened species survey locations, shows that all of the survey locations were close to existing tracks. The rationale for this lack of survey effort in other areas is that the land not surveyed was relatively inaccessible due to the steep-sided walls along the Warragamba gorge and rough country with no access tracks in upstream areas. Such an approach is just not good enough, as this project would affect land of great sensitivity and conservation importance.

There are many methods of surveying inaccessible areas, including helicoptering survey teams into such areas. In 1992, fauna and vegetation surveys were undertaken at Warragamba Dam for a previously proposed dam wall raising (Mount King Ecological Surveys, 1992. *Warragamba Dam EIS - Dam Site Environmental Studies Flora and Fauna,* Bathurst: Mount King Ecological

Surveys). During these surveys Sydney Water (now Water NSW) supplied a barge to ferry a vehicle and equipment across Burragorang Lake to areas without road access.

In addition, small boats were used to access areas where water transport was the only methods e.g. access to some of the small islands in the Lake and most importantly access to areas along the Gorge. Within the steep cliff-lines along the Gorge are small gullies formed from old creek-lines. These gullies are biologically rich as described in Chapter 8: Biodiversity – Upstream. Table 8-10 describes Alluvial woodland and Dry rainforest as occurring within the creek-lines entering the Gorge. Alluvial woodland is identified as a priority animal habitat within the Warragamba Special Area and Dry rainforest is a habitat generally occurring in small patches in sandstone gullies where the sides are steep with a southerly aspect. The Dry rainforest provides suitable sheltering, breeding and foraging habitat for the threatened Eastern Pygmy-possum and Brush-tailed Rock-wallaby.

The 1992 surveys utilized a small boat to access some of the gullies entering the Gorge. These gullies which are considered biologically rich are sometimes called 'dells' similar to that used in the United Kingdom to describe small rich areas. In the Blue Mountains the term is applied to small gullies incised within sandstone outcroppings that have a high conservation value.

It seems remarkable that a similar effort was not used in the current fauna survey. The use of additional resources would have provided a better overall picture of the conservation values of the Warragamba Upstream catchment.

Studying the survey methodology provided in Appendix F1, it is apparent that the fauna surveys for the Upstream study area are totally inadequate. Some of the inadequacies are:

- **The number of target species is extremely small**
- **the study area was never stratified correctly,**
- **no seasonal sampling occurred**
- **sites were not defined or described,**
- **the survey efforts for most of the techniques used are below that required by the State and Federal guidelines,**
- **several survey techniques are not used,**
- **little or no information is provided about the methods used and the results from those methods,**
- **the area surveyed was only about half the total study area, and**

- **the important gullies along the Gorge (dells) were not surveyed.**

Overall, the fauna survey report is embarrassing to read and could be used as an example of a bad survey and report in a course teaching survey methodology.

6. DOWNSTREAM FAUNA SURVEYS

The downstream study area is not a discrete area like the upstream study area, as there are numerous waterways and swamps, as well as a mosaic of human occupied land. Consequently the survey sites were scattered intentionally and the methods adapted to the conditions. Table 9-7 in Chapter 9: Downstream ecological assessment lists 14 threatened species that are called target species (Appendix F2: Downstream Ecological Assessment has a similar description of survey methods). This listing of so few species is considered inadequate for an area with such a variety of habitats and records of threatened species. Table 9-12 Threatened species potentially in survey area, lists 46 species.

Survey methods used in the downstream study area are infrared cameras, hair funnels, ultrasonic call detection, diurnal bird surveys, call playback and spotlighting and koala spot assessment technique. This is similar to that used in the upstream surveys, with the omission of amphibian searches, cage traps, Elliott traps and nest boxes. Survey efforts were variable with some similar to that in the upstream area (diurnal bird counts, spotlighting and call playback) some less (hair tubes, ultrasonic call detection) and remote sensing cameras had a higher survey effort in the downstream area. Overall, the survey efforts are less than that recommended under State and Federal regulations.

7. PLATYPUS (*Ornithorhynchus anatinus*)

The Platypus is addressed in Chapter 12: matters of national significance (Section 12.7.6.1), where it is described and impacts from the project are assessed. Although the status of the Platypus is given as ‘Near Threatened’ on the IUCN Red List of Threatened Species and provisionally included on the list of animals requiring urgent management intervention following the 2019-2020 bushfires, it has far important conservation credentials in terms of population status.

The platypus is legally protected in all states where it occurs, and is listed in South Australia as Endangered. Recently (12 January 2021), *Ornithorhynchus* *anatinus* (Platypus) was listed as having an extinction risk of being vulnerable, in the category of threat of Victoria under the Flora and Fauna Guarantee Act 1988. Currently the species' risk of extinction is being assessed against IUCN and *EPBC* criteria. Based on this assessment, there is evidence of past and projected declines in platypus populations which support the listing of the platypus Federally as Vulnerable under the IUCN Red List and the *EPBC Act 1999* (A National Assessment of the conservation status of the platypus. University of NSW, Australian Conservation Foundation, World Wildlife Fund and Humane Society International 2021).

According to Chapter 12: Matters of national significance (12.7.6.1) the platypus was located upstream of the study area in the Wollondilly River. There are additional records for the Kedumba, Kowmung and Coxs Rivers as well as within Lake Burragorang downstream of the Kowmung River confluence. The species has also been recorded in the Nepean River. The distribution of records from the Atlas of Living Australia database in or near upstream of Warragamba Dam are shown in the following figure.

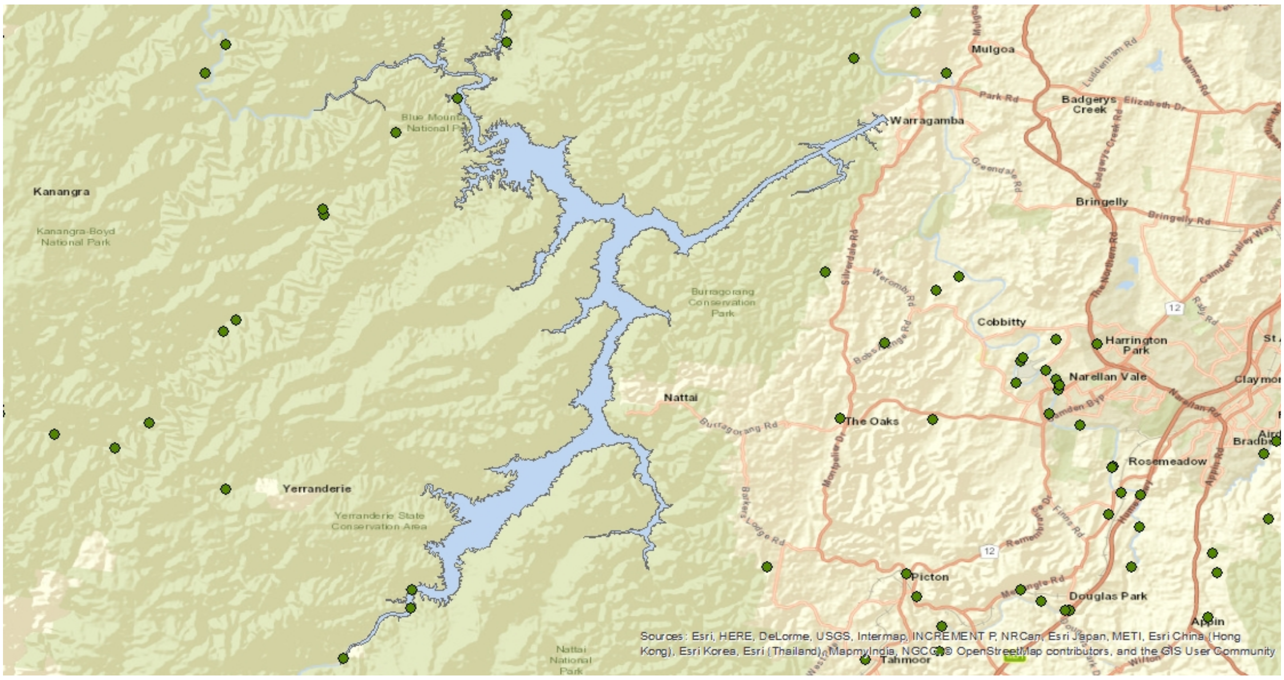

Figure: Distribution of platypus records in and around the Warragamba upstream catchment (*Atlas of Living Australia occurrence download at https://biocache.ala.org.au/occurrences/search?q=lsid%3Aurn%3Alsid%3Abiodiversity.org.au%3Aafd.taxon%3Aac61fd14-4950-4566-b384-304bd99ca75f&qualityProfile=ALA accessed on 13 November 2021***)**

The following descriptions of platypus ecology and behaviour are based on a number of papers listed at the end of this report.

The platypus feeds predominantly on benthic invertebrates, appearing to be quite non-selective in its choice of food items. It also requires the banks of water bodies for construction of its resting and nesting shelters (mainly burrows in earth banks) and so is dependent on both the riparian and aquatic environments of freshwater systems. As a result of this dual dependency the platypus is exposed to a range of threatening processes affecting Australian river systems.

Upstream increases in water levels, associated with dam construction and operation that change relatively shallow and productive lotic stream and river environments into deep, less productive lentic ones may be a main impact on platypus populations. Platypuses appear to be unable to forage successfully for small food items at depths greater than about 5-10 metres and are only occasionally reported from deep areas of water storage impoundments. Increased proximity of burrows to the water or the flooding of burrows by rising water levels are also potential impacts.

Platypuses normally dive for short periods (up to 90 seconds during feeding activity) to collect their food. It is strongly suspected that diving to great depths would not permit the animals to collect sufficient food before having to return to the surface. It is proposed that benthic production of lakes decreases with increased mean depth in a hyperbolic fashion and measurements in one natural lake showed that the standing crop of benthic species decreased dramatically below a depth of about 3 metres. Artificial water storages tend to support quite a depauperate benthic fauna in terms of species diversity.

Although platypuses are known to move more than 4km, it is unlikely that the animals displaced by rising water levels will re-establish in adjacent areas. Animals displaced from a disturbed part of their home range would come into competitive interactions with individuals already resident in adjacent areas.

What does all this information mean for platypus populations as a result of the Warragamba Dam Raising Project?

If the maximum rise in the dam's water levels can be as much as 10m, then such a rise above existing levels would result in the loss of foraging habitat, particularly in the upper reaches. As described above, platypuses do not dive deeply, normally less than 3 metres. A platypus would be unable to fulfil its energy needs from diving to obtain benthic food organisms at depths approaching 10m. In addition, it has been found that the quantity and quality of benthic fauna at depths below 3m is low. The raising of water levels predicted for rivers entering the upstream zone of the catchment are given in Chapter 15: Flooding and hydrology.

Figure 15-31 gives the depth-duration curves for a series of rivers in the upstream section. The data for Wollondilly River show that, at location 2 water levels rise from 138m to 154m i.e. 16m rise for the Probable Maximum Flood (PMF) that would stay for 6 days. At Location 4 the rise is 21m over 8 days. Similar values are available for Coxs River (14m over 7 days) and Kowmung River (12m over 6 days). It is estimated that these rises would take place between half to 1.3 days. Table 15-34 gives the overall changes to temporary inundation levels. These range for 2.9m for a 1 in 5 year flood to 12.3m for the PMF.

These figures show that there will be the potential for an impact upon acquisition of food by platypuses currently occupying streams where they enter Lake Burragorang at its current water level. A large part of their foraging habitat will be lost as well as the inundation of any steam-side burrows. The flooding of burrows during the breeding season (September – March) could result in the death of dependent nestlings confined to these burrows. It is recommended (Grant, T.R. and Denny, M.J.S. 1991) that construction work affecting a river be commenced, where possible, prior to breeding or after young have left the nesting burrows and are dispersing.

Appendix N2: Geomorphology Technical Assessment provides a description of the potential impacts from the raising of the dam wall and the consequent flooding upstream. A study of the Upstream Zone (Section 5 Environmental assessment – operation phase) concluded that the main risk to Upstream Zone watercourses was from elevated erosion of terrace deposits during inundation events and an elevated erosion of shoreline banks resulting in a higher mass of eroded soil (not a change in rates of erosion), would be focussed on north, west and south arms.

Figure 49 gives the potential impacts from fine sediment deposition in the upstream rivers indicating the ecological impacts. These include damage to filter feeding organisms and decreased numbers of invertebrate species i.e. a negative impact upon benthic organisms and loss of food for platypuses.

Section 6 Conclusions, states:

The potential risks associated with the Project have been assessed, and mitigation measures proposed to reduce the potential impacts of the project. Five 'medium' rated residual impacts remain after mitigation, including:

- Out of bank erosion in the Upstream Zone, including Brimstone Creek, Green Wattle Creek, Nattai River, Tonalli Creek, Wollondilly River
- Out of bank erosion in the Upstream Zone, including Butchers Creek, Coxs River, Kedumba River, Kowmung River (lower), Laceys Creek
- Out of shoreline erosion in the Lake Zone, at the Central, South and West Arms
- Elevated erosion of shoreline banks in the Lake Zone, at the North, South and West Arms
- Cumulative bank erosion impact in the downstream reaches caused by prolonged FMZ flows

The Platypus is an iconic Australian mammal that is held in high esteem by most people. Although not yet listed as Threatened in NSW, it is in South Australia and Victoria and will probably be listed Vulnerable Federally. It is a species that will be severely impacted by the raising of the dam wall, with increased water levels, bank erosion and sedimentation, both Upstream and Downstream. It is stated that it is unlikely that the animals displaced by rising water levels will re-establish in adjacent areas. A detailed study of local distribution and mitigation strategies is an important part of its management within the Warragamba Dam Catchment.

8. CONCLUSION

The Upstream and Downstream study areas cover a wide variety of habitats and diverse fauna. The Upstream area is within land that is considered of high conservation value and is known for its high biodiversity and the relatively untouched vegetation. This study area is located within 5 conservation areas, as well as a declared Wilderness and World Heritage Area (Appendix F1: BAR – Upstream 3.1.1 General Location). Any modification of the natural environment of the Upstream area as result of the raising of Warragamba Dam wall will mean a reduction in its biodiversity values. Similarly, the Downstream study area contains a high variety of wetland, swamps and water courses that support a wide range of waterbirds and shore birds, many of which are migratory. Again, the changes predicted in downstream water flows will affect the areas biodiversity values.

Assessment of the potential impacts upon the biodiversity values of both areas is based upon a mechanism developed mainly under the Biodiversity Conservation Act. By a series of 'filters' most fauna species are eliminated from the assessment process, with only 15 Threatened Species are targeted during the fauna surveys. The remainder (81) are considered not sufficiently important to be included in the surveys. Much of the assessment of the importance can be considered subjective e.g. Appendix F1: BAR – Upstream Appendix G Likelihood of occurrence and Table 5-5. Assessment of potential presence of species credit species. The assessment of impacts upon terrestrial fauna has been reduced to 15 species by a process that is driven by the allocation of 'credit values' and offsetting. There is no assessment of the overall biodiversity values of the Upstream area nor on the potential impacts to such values from the wall raising. Considering the international reputation of the area it is necessary that such an assessment be undertaken.

The following points are described in detail above and are summarised here:

- The selection of species targeted by the fauna surveys is at an absolute minimum and does not allow for a comprehensive assessment of the biodiversity of the study area nor provide adequate information to undertake a calculation of impacts and offsetting.
- There are limited 'expert reports' given in the EIS and none contain the points required by the Framework for Biodiversity Assessment for an expert report.
- The fauna surveys for the Upstream study area are totally inadequate. Some of the inadequacies are:
  - The number of target species is extremely small
  - the study area was never stratified correctly,
  - no seasonal sampling occurred
  - sites were not defined or described,
  - the survey efforts for most of the techniques used are below that required by the State and Federal guidelines,

- several survey techniques are not used,
- little or no information is provided about the methods used and the results from those methods,
- the area surveyed was only about half the total study area, and
- the important gullies along the Gorge (dells) were not surveyed,
- surveys occurred during drought and after large areas were burnt

➢ Overall, the fauna survey report is embarrassing to read and could be used as an example of a bad survey and report in a course teaching survey methodology.

➢ The Platypus will be severely impacted by the raising of the dam wall, with increased water levels, bank erosion and sedimentation, both Upstream and Downstream.

Dr Martin Denny BSc (Hons) PhD Fellow Royal Society of NSW, Fellow Royal Zoological Society of NSW, Fellow Ecological Consultants Association of NSW and Visiting Research Fellow Centre for Ecosystem Science UNSW

29th November 2021

References used in platypus profile:

Grant, T.R. 1981. Platypuses and dams - questions and hypotheses. in Riney, T. (ed.). *Wildlife Management in the Eighties*. Monash University, Clayton

Grant, T.R. 1991 The biology and management of the Platypus (*Ornithorhynchus anatinus*) in NSW. NSW NPWS, Hurstville

Grant, T.R. and Temple-Smith, P.D. 2003 Conservation of the platypus, *Ornithorhynchus anatinus:* Threats and challenges Aquatic Ecosystem Health & Management, 6(1):5-18

Grant, T. 2004 Depth and substrate selection by platypuses, *Ornithorhynchus anatinus*, in the lower Hastings River, New South Wales. *Proceedings of the Linnean Society of New South Wales* 125, 235-241

Grant, T.R. and Denny, M.J.S. 1991 Distribution of the platypus in Australia with guidelines for management. Final report to Australian National Parks and Wildlife Service

8. Flora impacts

Eucalyptus diversity is the primary listing criteria for the Greater Blue Mountains World Heritage Area. It is therefore of paramount importance that the impacts of the Project upon flora are fully appreciated and accounted for in the EIS through (a) application of the Precautionary Principle and (b) adequate floristic surveys. Unfortunately neither of these approaches have been adequate or properly applied in the EIS.

The Precautionary Principle underpinning both the NSW EP&A Act[41] and the Commonwealth EPBC Act[42] has not been applied in assessing impacts to flora for the Project. This has manifested itself through:

a) Baseless assumptions regarding the flood tolerance of particular flora species
b) Insufficient floristic surveys
c) Refusal nevertheless to undertake expert reports on threatened flora species
d) Definition in the Biodiversity Offset Strategy of a significantly reduced 'upstream impact area' that is not based on robust or verifiable scientific conclusions (this is further discussed in section 11 of this submission)

The assumptions made regarding flood tolerance of particular species are not scientifically rigorous or peer reviewed. In particular, the studies undertaken by Hydrobiology (2020) on flood tolerance of Queensland plant communities and CSIRO (2018) on Eucalyptus Benthamii's purported flood tolerance cannot in any way inform the conclusions of the EIS . Both studies are based on variables that are entirely different to those present in the impact area and do not conform to the basic requirements of scientific inquiry.

Indeed, the Hydrobiology (2020) study is based upon species found in a subtropical ecosystem several thousand kilometres north of the study area. It must be noted that neither of these studies have been provided in the EIS for review by the public. Why this is the case is unknown. It can only be assumed that the proponents have chosen not to publish the reports because of the absurdity of their scientific method.

Given the proponent admits that "*impacts associated with the Project are difficult to quantify*",[43] the repeated conclusions made in Upstream BAR of the EIS that "*Temporary inundation resulting from the Project may adversely impact this species*" cannot be sustained. If the Precautionary Principle is correctly applied, full loss of both flora and fauna species within the full inundation area must be assumed.

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[41] *Environmental Planning and Assessment Act Regulations 2000*. Available at: https://bit.ly/3Fd6GmG
[42] *Environment Protection and Biodiversity Conservation Act 1999*. Available at: http://bitly.ws/kpcG.
[43] EIS Appendix F1: Biodiversity Assessment Report – Upstream, pg 195.

The floristic surveys undertaken for the Project are inadequate. As seen in Appendix F1 of the EIS, only 20x50m plots and transect sites were examined over the 5,300 hectare study area. This represents just 1 hectare of survey across the total area. While the presence of multiple species has been assumed across the impact area, this is not a substitute for on-ground surveys to deduce presence and distribution of species that exist in the impact area. For example, it was not known that Eucalyptus Glaucina existed within the Greater Blue Mountains World Heritage Area until the species was found during the conduct of floristic surveys for the Project. Other species may well exist within the impact area but their presence has not been assumed given limited scientific knowledge about their distribution. The likely reductions in the distribution of particular species across eastern Australia increase the need for comprehensive post-fire floristic surveys

Despite only 1 hectare of the study area having floristic surveys undertaken, no expert reports on eucalypt species are included in the EIS. This runs contrary to the Framework for Biodiversity Assessment (FBA) and the Precautionary Principle.

For these reasons, the EIS does not meet the basic requirements of a biodiversity assessment set by the SEARs, the EP&A Act, the FBA and the EPBC Act. The biodiversity assessments must be redone.

For further information regarding the impacts to flora and the compliance of the EIS with the SEARs in this regard, we refer to the submission made by Wollondilly Shire Council and the associated expert report by Dr Steve Douglas.

9. Cultural heritage impacts

The tangible and intangible cultural heritage impacts of the Project are profound. We note that the Gundungurra people of the Blue Mountains have stated they do not give Free, Prior and Informed Consent (FPIC) for the Project to proceed (Appendix G). The Australian Government supports the United Nations Declaration on the Rights of Indigenous Peoples in which FPIC is detailed.

For further information regarding cultural heritage impacts and the compliance of the EIS with the SEARs in this regard, we refer to the submission made by Traditional Owner, Kazan Brown and the associated expert reports attached to her submission by Paul Irish and Val Attenbrow.

For further information regarding the failure of the EIS to comply with the Burra Charter, SEARs, EPBC Act and the World Heritage Convention concerning cultural heritage impacts, we refer to the submission made by the International Commission on Monuments and Sites (ICOMOS) Australia.

10. Geomorphological impacts

This section of The Colong Foundation for Wilderness submission has been written by geomorphologist Dr Peter Mitchell. It is attached below.

Warragamba Dam: Review of Appendix N2: Geomorphology

On behalf of the Coolong Foundation for Wilderness.

Dr P.B. Mitchell OAM 12 December 2021

Author's qualifications:

I am a retired academic who taught pedology, geomorphology and environmental science in the School of Earth Sciences at Macquarie University and the Department of Geography at the University of Canterbury (NZ). I also have more than 30 years experience consulting on geomorphology, pedology, archaeology, and environmental matters for local government, State agencies, and consulting archaeologists.

I have had the opportunity to read and review the document *Appendix N2: Geomorphology Technical Assessment of the EIS for Warragamba Dam Raising* (SMEC 10 September 2020). I have looked at other parts of the EIS but not in the same detail, and I have considered this document against the *SEARS requirements: Soils and landforms*.

Summary points of criticism

1. The author(s) of the EIS Appendix N have adopted a remarkably narrow definition of 'geomorphology' and consequently their approach to the preparation of this document has left important questions unanswered.
2. Several of the methods employed in collecting data and making geomorphic assessments are neither appropriate to the needs of the project nor are the results reliable. Of particular note are the air photo analyses and the survey of bank strength.
3. The report falls short as a comprehensive literature review. The reference list is incomplete and contains very few works older than 2000. In 1997 the Hawkesbury Nepean Catchment Management Trust compiled a widely distributed data base containing some 500 references on geomorphology relevant to the river, few of these are cited. The appendices to Appendix N do not list any cited references.
4. The document contains a number of errors of fact, and has discussed several items that are not relevant to the project.
5. The report is poorly structured and expressed. It contains expression errors, sequencing errors, technical terms are misused, cited references are missing and frequently do not support the claims made. Spelling mistakes, punctuation, and incomplete headings all indicate that proof reading has been inadequate.

Does it meet SEARS?

This is difficult to judge as SEARS does not identify 'geomorphology' as a topic but includes 'landscapes' under the key issue of 'soil'. Considering the content of Appendix N, plus Chapters 15 and 22, most of the points required by SEARS are presented but in my opinion these assessments do not provide sufficient reliable information or draw firm conclusions that would enable a decision maker to adopt an informed opinion.

Specific points of criticism listed in their textual sequence:

P8. It is debateable whether the Hawkesbury-Nepean valley has the highest flood risk in NSW as most northern NSW rivers have higher peak discharge from larger catchments in higher rainfall environments. The statement is only 'true' if flood risk is equated with the potential for property damage because the valley has a much greater density of urban area than elsewhere. To be acceptable this statement should be backed by a reference.

P9. With the design shift in dam height being moved from 14 to 17m to take account of modelled effects of climate change it is not possible to claim that, 'the possible height and duration of upstream inundation remains consistent with what was originally proposed in 2016.' The additional 3m is to take account of a larger volume of water held behind the dam and that must mean that the maximum inundation level and consequently the GIA must also be 17m above the present FSL.

There are several odd references here (and elsewhere in the EIS) to the 'dam abutments'. The normal meaning of an abutment is that part of the valley wall against which the dam is constructed, in other words the side foundation. It isn't possible to 'thicken and raise' these.

P24. The author's definition of fluvial geomorphology is surprisingly narrow. To equate the term with running water processes and channel shape is to restrict it far more than is needed for this study. It is also more limited than conventional definitions.

The EIS should be dealing with all geomorphic processes and forms that are likely to be affected by the project in any way. This should include lacustrine processes on the lake shore and within the water body, mass movement and slope processes that may affect sediment delivery to the streams and lake, and any biotic processes, including the role of fire in the catchment, that may affect the geomorphology. Some of these relationships may be covered in other chapters or appendices but they should at least be cross-referenced in this one.

P28. Definition of the GIA appears to extend well upstream of any likely impact area in the Upstream Zone, it fails to acknowledge that the Lake zone has two boundaries (the operational FSL and the upper limit of the FMZ), and the downstream zone (Figure 13) does not indicate the limits of likely effects in any of the tributary streams. These figures are not consistent with the study area boundaries depicted in Figure 3.

Figure 14 is a repeat of Figure 1 and no more informative.

Delineation of the upgradient limit in the upstream zone is defined by the PMF. But the PMF would affect the entire catchment to the head of first order streams and this is certainly not what the GIA sets out address. Similarly, the limits of interest in the downstream zone are more sensibly set as the limits of backflow in the tributaries, although there is little discussion of likely effects in these. That could have been more conveniently done on Figure 13.

'Webs Ck is 5km upstream from Hawkesbury'? I suppose this means Wisemans Ferry and is an example of inadequate proofing.

P29 '.mitigations' is not a noun – should be 'mitigation actions'

P35. H-N Catchment two paragraphs of introduction that are simply lifted from NSW Government 2013. This reference does not appear in the Reference list but has many phrases in common with NSW DoPIE 2019. Some of it is simply wrong, eg., Turrimetta Headland is not within the catchment and even it were, it is well out of the Downstream zone already defined as ending at Wisemans Ferry. At this point in the document none of this explanation is necessary.

P36. Figure 17 is very general and provides almost no information of relevance to the objectives of this study. Why not a map showing geology within the GIA? Incidentally the named map units are not 'sediment' but suites of sedimentary rock.

Fredericks 1994 is hardly an expert source for a statement about soil fertility derived from Hawkesbury Sandstone.

P37. Sandstone, shale, greywacke, and siltstone, are not 'metasediments' and need not be 'ancient'.

'Rainfall is affected by drought' – it is surely reversed. Katoomba does not have the 'highest rainfall' but the highest average rainfall. Likewise, some place near Goulburn would have the lowest average rainfall.

The line describing thunderstorms was written with respect to storms over Sydney – well and truly outside the GIA.

Rainfall erosivity is an index property, hillslope erosion is a process and sediment source. Both parameters apply all over the catchment and I would be more interested to learn if sediment yield is greater in one sub-catchment or another. There are some hints that this is the case in other Chapters.

P38. How is Land Use important in the GIA? Is it really necessary to know about the native pastures (which are not a land use but a land cover) right out at Goulburn and Tarago? These areas may provide more or less, and perhaps different sediment to the channels in the GIA but as nothing is expected to change out there as a result of the project, is there any merit in presenting it?

P40. Most of this water management information is of little relevance to the GIA. It would be more important to discuss the weirs immediately downstream of the dam.

P41. Where did sub-head <u>a. Air photo analysis</u> suddenly come from? It appears to be a subset of the preceding discussion about water management but clearly isn't. Then the text goes on to <u>b. Wollondilly River long profile</u>. The structure of the document has failed at this point these should all be part of <u>3.2 Site Investigations</u> as per the Table of Contents. This is an example of inadequate proof reading, readers should not have to solve these layout puzzles.

P41-43. In assessing the air photo analyses it is essential to refer to the images as well as Table 5 but with them separated in Appendix C (of Appendix N2!) these are a pain to find without indexed pagination and difficult to interpret. Where exactly are these air photo sites?

Considering site US01, I can see nothing more than differences in stream flow and water level, not changes in vegetation cover as claimed. The sediment on the left bank appears to be stable bedload gravel. This standard of the air photo interpretation is inadequate. Considering another site at random; US07 shows both a variation in flow and patterns of braiding in the channel and 2013 appears to show a fan of new sediment dumped by a right bank tributary at the bridge. In 2019 this was vegetated but the main channel had widened presumably as a result of the circa 2013 flood and most of the in-channel vegetation was destroyed. None of those changes are mentioned.

'Eyots' is not a word in common use in Australia – it does not appear in McDonald et al., which is normally accepted as the standard for reports of the kind. The levee mentioned looks more like a mid-channel bar.

P43. An annoying search for an appendix item. If the methodology has to be read in order to understand the text then it should be in the body of the report.

Having found it, there is another issue, it appears that none of the references cited in the Appendices are listed anywhere – pretty poor practice. It also appears that it isn't possible to decide if the sawtooth bed elevations in this river profile are real or an artefact of the methodology. That uncertainty has not prevented the author from designating zones of erosion and deposition. Just because one section of the channel is steeper than another does not mean that it is an erosion zone, in a stream like this it is quite likely to be a bedrock controlled reach. Do individual peaks and hollows on the plot match bedrock patterns or pool/riffle sequences? If they do, and that should have shown up in the River Styles analysis, and then we would have a useful plot that can be related to geomorphology and to potential geomorphic change. If they don't, or if we do not know, then the whole thing is next to worthless.

P44. The mouth of Lake Burrogorang? Animals have mouths, rivers can have mouths providing your perspective is from the sea but this point, which is actually a zone, would be better described as the intersection point of the contributing streams and the FSL.

Discussion of high slope/low slope is uninformative.

P46. Table 8 depicts overall gradients not totals. If this data isn't related to geomorphic features or potential change it is without value.

P47-51. These figures could have/should have been the baseline data for this report. What is the source of these maps? They appear to be from a DoPIE data base which does not seem to be referenced. They are certainly not from Brierley and Fryirs 2005. The correct reference to the River Styles description paper is Fryirs and Brierley 2005 but that work did not deal with this catchment. Without knowing what went into the maps it is very difficult assess them, made even more challenging when some of the categories make little sense for the parameter mapped. For example; Figure 23, Conservation, and Strategic are not measures of 'recovery potential', they may be measures of value but that is different. In Figure 26 can a stream have 'None' condition? This is presumably worse than 'poor' but what does it mean?

P55. Table 9 is not a 'literature review' but simply a brief summary of literature content, not all of which is relevant to the project. The concept of drought dominated versus flood dominate flow regimes which is cited as CSIRO 2000 was originally developed in the Nepean-Hawkesbury system by Erskine and Warner (1998) and has since been seriously questioned by several authors because identification of the 'cycles' was dependent on the starting times selected. Discussion of this matter should be included. This whole table is simply 'cherry picking' and fails to pull the points together in any coherent way. For example; reference to Birch et al. (1998) is irrelevant as that study is well outside the GIA, the points made by Tomkins et al., 2007 are all important in understanding the geomorphology and deserve serious discussion, in contrast the points selected from Shakesby et al., and Blake et al., are almost superficial in the context of geomorphic change in the GIA as defined.

P62. It is hardly reasonable to claim that the lake bed morphology is dominated by the drowned V-shaped valley. This only true of the gorge section downstream of Brereton Point. There is a much greater area of lake floor in the former wider valley in which the braided channels are found. It is this area between MOL and FSL that lake level fluctuations have the greatest geomorphic effect and where all of the coarser sediment delivered by tributary streams will accumulate. The original geomorphic elements in this area are not described but they are surely a great deal more than just the river channel. For example, there must have been various types of bars, benches, levees perhaps, and several levels of terrace. Some of the described morphological features in the lake appear to be natural slope and valley floor features that may have been modified by mass movement processes probably triggered by varying water levels in the lake. These are to be expected. but the interesting questions are; will they continue, will they be aggravated by the new management regimes, and what might eventually be the end result?

P64. What is the geomorphic significance of TSS? Basically, this is a water quality management issue as TSS will vary with flood events and will commonly stratify in the reservoir as can be seen in Figure 27. Is it anticipated that TSS will change under the new flood management routine? If so how and what might be done about it?

In this discussion there is no mention of the possible effects of catchment fires on TSS, and the relative importance of algae versus mineral matter is barely hinted at, but could be quite important. Where does this fit into geomorphology?

Sediment loads are much more than TSS and the most important component will be bedload sediments delivered by the tributaries and dumped in the zone where these streams enter the lake. These dumps will have geomorphic form which should be described and an attempt made to quantify the volume delivered over past decades of reservoir operations. The result would only be ball-park but would provide a good indication of future change. The task of collecting and collating this data is not horrendous and should be possible using a combination of air photo or LIDAR analysis combined with walkover spot survey. It should have been done.

P69. A large part of this discussion is outside the defined area of interest, and again I note that turbidity is not the only measure of sediment load. Having provided this data how is it expected to change under the new management regime? Surely that is the point of including it.

P70. It is hard to imagine how any of these wetlands will be affected by changes in the reservoir management, as they are all distant from the area that will be occasionally inundated by retained flood waters. They may well be affected by climate change but that is not part of this document. Inclusion of this material under the guise of it being a SEARS requirement is nonsense. Of much greater importance would be assessment of wetland environments within the GIA but the document does not even admit to their existence upstream other than the river channels.

The ‘bathtub’ effects downstream have very strong influences on wetlands on the floodplain upstream of Pitt Town and in the artificial wetlands of the Penrith Lakes, but other than listing some of these places there is no discussion of how a changed flood regime might affect them.

Inclusion of aquatic ecology and much of the terrestrial ecology is not appropriate in this Appendix. It is supposed to be dealing with geomorphology and unless that can be shown to be linked to the ecology it is not relevant.

Water quality – again no discussion of the effects of fire in the catchment? It is known to be important (there is a Warragamba literature) and does have geomorphic links to slope processes and increased sediment and ash mobilisation.

‘Steep channels will help the river recover from major erosion events’?? Only in the sense of sediment flushing, but that simply shifts the problem downstream.

P75 There has been virtually no oyster farming in the lower Hawkesbury for decades because of viral diseases, the source used here (not cited) is well out of date.

P76 True, the mine at the head of the Grose is no longer operational but is has left an ongoing legacy of serious acid drainage and metal pollution. But is this relevant to the GIA?

P77. A small number of sites overall and those probably selected by ease of access. A larger sample size would be better and selection that adequately represented the different River Styles reaches would be desirable. Some site numbers are missing from the maps and Appendix G, were these not assessed, if not, why?

Using US-02 as an example the check sheet only provides limited description and doesn’t always match the photographs. For example, it would be desirable to know more about the ‘Complex multi-terraces’. Are they actually terraces or active floodplain, what is their height above the stream and the nature of the soil/sediment/vegetation on them? Measured or even sketched cross sections would be helpful.

The description of; ‘scarcely perceptible flow’ does not match the photos! The bed grain size figures I assume are estimates, no mention is made of the coarse woody debris trapped downstream on the left bank. Pity because this stuff could be important if liberated to move downstream through the GIA during flood management.

Considering US-05 this is described as an upstream sample site but the photos show it to be within the lake and it is plotted within the lake on Figure 32.

P80. Figure 35 is presumably one of the sample sites, but which one? It is surely not typical of the Coxs River? It certainly does not match Figure 34 and the rill eroded bank looks like recent sediment deposited at the head of the lake.

Figure 36b probably does depict fire deposited sediment and it deserves more attention as it illustrates the sort of geomorphic change that can be triggered by fire.

P81. The Wollondilly 'delta' is more like 8km long if you look at it when the lake level is lower (2006, 2007, 2011) and it rarely appears to be triangular. It will certainly be bedded but would need to be trenched to observe that, and the same sort of sediment wedge <u>does</u> occur in the Coxs and Nattai Rivers where they are 11 and 5km long respectively and with different sediment types. I hesitate to use the word 'delta' as the feature forms at all lake levels and is really a form of channel fill with its appearance changing depending on those levels. They are very important geomorphic features because they are the result of decades of bedload sediment accumulation. What will happen here under the new management regime?

P84 The rock avalanche area is already a sediment source and will remain so until well vegetated. I agree it would be worse if dam levels reached the toe of this feature but determining that is just a matter of measuring altitudes, why hasn't it been done?

P85. The geology downstream of the dam is almost entirely Hawkesbury Sandstone, this statement about the influence of metamorphic and granitic rocks is just plain wrong. Some of the gravels may be so described but not the river bed or valley sides. In the reaches from the dam to the Nepean junction there is almost no lateral channel movement. This extended paragraph is hardly credible.

Para 1 claims that the water surface (?) at the end of Fairlight Gorge is only 1m above sea level, but para 2 informs us that the Penrith weir hold water at 14m above sea level. Do I conclude that the river between these points flows uphill?

A fossil floodplain? Presumably this means a terrace? But where is the evidence that it is no longer flooded in extreme events? Is the 22,000 year date from Warner? There are many chronological interpretations in this sequence and all should be presented and judged as to their validity and significance.

P86. All of these fluvial and other geomorphic features would benefit from the addition of a map.

Why is bank strength deemed to be important enough to have this section devoted to it? What is meant by bank strength?

The methodology used for these measurements is highly suspect. The instrument used was designed for quick and dirty assessment of compressive strength of confined samples in engineering works and results are notoriously variable with soil/sediment texture and moisture condition. A large number of measurements will give semi-quantitative guesstimates as averages, provided that other variables are held constant or at least taken into account. This is certainly not the case in a most river banks.

Compressive strength of the bank materials is not even necessarily a good indicator of how a river bank will behave with rising and falling water levels and erosive flow. The nature of the materials and their cohesion needs to be included, and most importantly riparian vegetation should also be considered. Correlating the weakest bank strength with the 'banks' in the gorge section of the river is nonsense as these test areas are not the river bank but the eroded, unvegetated lake shore.

The purpose and the value of this exercise should be questioned.

P90. Reference to 'bed sediments' is misleading in the sample sites on the lake shore as the term bed implies that you are dealing with the river bed. Considering site R-01 this is the margin of the lake and the parallel rills referred to are not rills but wave cut features (mini-cliffs and beaches in a sense) created by rising and falling lake levels and short periods of still-stand. Describing the estimated particle size of the sediment on this or any other lake side site is fine but these results are not an assessment of bed sediments as this material is neither on the stream bed nor does it move as fluvial sediment. Figure 43 unfairly compares river sites with lake shore sites.

What is the significance of all this data with respect to the proposed new operational mode of the lake?

P93 The sediment mat experiment did not produce any results as lake levels were below them for the duration of the study. What about the mats on the Kedumba and Hawkesbury rivers which are not reported?

Installation of mats as depicted in Figure 62, are most unlikely to trap sediment delivered by overland flow as claimed, as they stand proud of the soil surface. The concept is reasonable but very dependent on effective installation. They would also be subject to edge effects, it would be very difficult to identify the contributing source area, and they are unlikely to trap sediment coarser than sand if it was present.

P97. The claim that 'there has been a dramatic reduction in sediment deposition across the catchment over at least the last 20 years' cannot be supported by the cited references (Wasson, Olley and Wasson) as these reports do not deal with the Warragamba catchment and are themselves more than 18-23 years old. Studies cited in the previous para in support of post-settlement sediment deposition in the Wollondilly also do not relate either to that stream, or even to sediment deposition! Pittock and Cornish are about precipitation change, Erskine is a geographic study of channel cut-off in the Hunter, and the very basis of Erskine and Warner's DDR/FDR story has been seriously challenged. If the cited works in this section are of dubious value what reliability can a reader put on the erosion hot spot modelling? I suggest very little.

P100. The heading for this section is misleading as it is not discussing the translocation (shift) of sediment features but changes in the foci of deposition as a result of temporary raised water levels. The important point is surely that more sediment will be deposited higher in the stream at altitudes above FSL and up to the defined limit of the GIA. When these events occur the lake will already be at FSL and the floodwaters will enter more or less stilled deep waters in which there is little chance of sediment mobilisation from the drowned channel floor or the lake bed, unless turbidity currents are generated (which could be possible, but that's another topic). This is obviously a likely major impact of the Project and I would have thought that the best way to assess it is not by modelling and speculation but by quantifying the nature and volume of sediments that have already accumulated in this zone since the dam began functioning in ~1960. Lake Burrogorang presents a near perfect sediment trap where accurate measurement could have been obtained by employing LIDAR survey, some trenching and/or GPR transects, along with grain size determination of representative samples. This suggested methodology is obvious but it has not been attempted.

11. Environmental offsetting

Environmental offsetting does not improve environmental outcomes. The Biodiversity Offset Strategy (BOS) put forward by the proponent in the EIS is yet another example of the ineffectiveness of environmental offsetting in Australia. In determining the environmental offset strategy for the Warragamba Dam raising Project, several matters not considered in the BOS should also be taken into account. They are:

a) The IUCN Policy on Biodiversity Offsets which states that *"offsets must not be used… when impacts will occur in internationally and nationally recognized 'no-go' areas such as impacts on natural or mixed World Heritage Sites".*[44]
b) The Precautionary Principle that underpins both the NSW EP&A Act[45] and the Commonwealth EPBC Act[46] in regard to impact assessments
c) Scientifically robust and verifiable conclusions that could justify the proponet's proposed 'upstream impact area'
d) The independence of the accredited assessor undertaking the offset report
e) Ensuring that the BOS does not facilitate the extinction of particular species

The proponent has had no regard for these matters in compiling the EIS, and in particular the BOS. The IUCN Policy on Biodiversity Offsetting is not mentioned in the EIS. Neither is the Precautionary Principle mentioned in regard to the justification of the proposed 'upstream impact area'.

In several instances the EIS states that the impacts of temporary inundation cannot be quantified[47]. Therefore, full impact should be assumed across all possible operating domains of the dam Project.The need to do so is reinforced by the absence of operating protocols for the Project in the EIS, as detailed in sections 2 and 3 of this submission.

As discussed in section 4 of this submission, a serious conflict of interest appears to have arisen after the resignation of Ms Rachel Musgrave, for some years prior the Project's accredited assessor, from SMEC Engineering The subsequent appointment of Mr Kevin Roberts as her replacement raises serious questions as to a real and/or perceived conflict of interest regarding the accredited assessor. Mr Roberts was a WaterNSW secondee working on the Project's biodiversity assessment immediately before taking on the role as the replacement accredited assessor at SMEC Engineering.

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[44] IUCN Policy on Biodiversity Offsets. Available from: http://bitly.ws/krok.
[45] *Environmental Planning and Assessment Act 1999.* Available at: https://bit.ly/3Fd6GmG
[46] *Environment Protection and Biodiversity Conservation Act 1999*. Available at: http://bitly.ws/kpcG.
[47] EIS Appendix F1: Biodiversity Assessment Report – Upstream, pg 80.

We note that the offset credit report contained within the exhibited EIS appears to be out of date and does not match the offsetting strategy described in the EIS, still carrying the name of Ms Musgrave who appears to have left SMEC before the new BOS was developed.

We also understand that Mr Kevin Roberts, the accredited assessor for the Upstream BAR, has never visited or undertaken surveys within the upstream study area.

Finally, the BOS should not allow or facilitate the extinction of particular species. Unfortunately, the BOS for the Project will facilitate the extinction of both the Regent Honeyeater and Eucalyptus Benthamii. Habitat for these species cannot be offset given the rarity, age and limited natural distribution of both these species.

However, it seems that the formulation and parameters of the exhibited BOS has been driven by an intention to reduce the cost of environmental offsets, resulting in an absence of due-process in determining the actual environmental impact required to be offset to satisfy the Precautionary Principle.

For further information regarding the environmental offsetting strategy and the compliance of the EIS with the SEARs in this regard, we refer to the submission made by Wollondilly Shire Council and the associated expert report by Dr Steve Douglas.

12. Upstream and downstream hydrological modelling

The Warragamba Dam Raising Project relies on hydrological modelling in order to demonstrate the benefits it would have to lower flood risk downstream and assess damage it would cause to biodiversity and heritage upstream. It is crucial, therefore, that this modelling is made understandable to decision makers and the public. Sufficient information must be provided to enable a review of the modelling that underlies the assumptions and uncertainties present. The Colong Foundation for Wilderness has enlisted a number of experts to analyse the hydrological components of the EIS.

Dr Christopher Zoppou and Professor Stephen Roberts of the Australian National University have reviewed the EIS in regard to hydrological behaviour upstream of the dam. Dr Floris Van Ogtrop of the University of Sydney has reviewed the EIS in regard to hydrological behaviour downstream of the dam. These reports were prepared separately and are attached below. However, several consistent criticisms can be made in relation to both the upstream and downstream hydrological modelling in the EIS.

Lack of transparency

Key information regarding the underlying assumptions and model variables has been inadequately explained or not discussed in the EIS hydrology chapters (Appendix H1 and Appendix H2). This makes it difficult, if not impossible, to understand the conditions that have been applied to produce the modelled flood extents presented. No operational protocols have been provided for the Project in the EIS, as discussed in section 3 of this submission.
The concealment of such fundamental information has significant consequences in the assessment and review process, because the results cannot be validated.

Inadequate information provided as to hydrographs

Hydrographs and cross sections are mentioned in discussions of model performance in the EIS and yet no reference is made to where they may be viewed.They appear nowhere at all in the EIS. Given that the hydrographs are used to validate the model and the conclusions drawn from it, they should be provided to allow for the stated conclusions to be reviewed and to support explanations. Again, a valid determination cannot be made on the basis of inadequate information.

Inconsistent discussion of uncertainty

The downstream model results and impacts are expressed in very precise and firm terms. Uncertainties of modelling are not adequately addressed, particularly given the lack of information provided to support such statements. This contrasts to the imprecise determinations made for upstream hydrology and impacts, and greater emphasis placed on uncertainties relating to climate change and flood frequency. Error margins, limitations and uncertainty need to be discussed in greater detail in order to provide decision makers with a clear description of the Project and its likely impacts.

Raising of Warragamba Dam Modelling*

Christopher Zoppou†, Stephen Roberts† and Claire Rogers‡

December 19, 2021

Abstract

Warragamba Dam, which is situated about 65km west of the Sydney, impounds approximately 2027Gl of water in Lake Burragorang. It supplies approximately 80% of the potable water to Australia's largest city, Sydney which has a population of approximately 5.3 million individuals. Currently the Warragamba dam has a full supply level of 116.7m AHD and dam road crest level of 130.47m AHD. It is envisaged that the Dam and spillway should be raised with a road crest level of 147.5m AHD. The justification for raising the spillway crest on the Dam to 128.4m AHD is to improve the flood mitigation capacity of Lake Burragorang by increasing its capacity by 991Gl[17].

The raising of the spillway is reported to impact[20];

- One World Heritage property,
- One National Heritage place,
- Five listed threatened ecological communities,
- 48 listed threatened species, and
- 13 listed migratory species

upstream of the Dam.

This report reviews the modelling undertaken to asses the impact of raising the spillway on flora and fauna and on sites of historical and cultural significance upstream of the Dam. We critique the modelling undertaken, highlight deficiencies in the modelling, propose an alternative modelling approach and undertake our own limited modelling.

*This investigation was funded by the Colong Foundation for Wilderness.

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1 Introduction

The 142m high and 351m long Warragamba Dam is in a narrow gorge on the Warragamba River. The damming of Warragamba River, completed in 1960, flooded the Burragorang Valley creating Lake Burragorang. The Lake is 52km in length and has a maximum water depth of 105m and the Warragamba catchment receives an annual average rainfall total of approximately 840mm[2]. The upstream catchment area comprises about $9,050$ square kilometres includes five main tributaries which drain into Lake Burragorang the; Cox's, Kowmung, Wollondilly, Nattai, and Kedumba Rivers. Kedumba River is considered a relatively small tributary. Wollondilly River provides the largest flow into Lake Burragorang, accounting for over 50% of the inflows from the four major rivers.

The flood mitigation works proposed at Warragamba Dam involves raising the dam wall to provide additional free board for flood retention. Raising the level of the central spillway crest by about 12m and the auxiliary spillway crest by around 14m above the current full supply level would provide a flood storage capacity of approximately 991Gl and is expected to temporarily increase the existing impoundment area from approximately 75km^2 to 94km^2[3]. When the inflows cause the storage levels to rise above the full supply level, 116.7m AHD drum and radial gates are opened to release water downstream over the dam spillway[2].

Raising of the dam wall will increase the frequency, duration, depth and extent of inundation upstream of the dam wall.

The upstream catchment area comprises protected areas including the Greater Blue Mountains World Heritage Area, several national parks (Blue Mountains, Kanangra-Boyd, Nattai), and state conservation areas (Jenolan Karst, Yerranderie, Nattai, and Burragorang), called the Warragamba Special Area. Land uses adjacent to the protected areas include urban development, tourism facilities, grazing, forestry, agriculture, manufacturing, and mining.

The Greater Blue Mountains World Heritage Area is one of the largest and most intact tracts of protected bush land in Australia would experience an increase in the extent and duration of temporary inundation during flood mitigation operations[17].

The diversity of Eucalypt species (*Eucalyptus, Angophora* and *Corymbia*) found within the Warragamba Special Area is one of the highest concentrations found in Australia. The Area is one of the few localities along Eastern Australia and south-west Western Australia supporting between 66 and 74 species of Eucalypts.

A number of treatened and endangered communities within the Area include: White Box (*Eucalyptus albens*), Yellow Box (*Eucalyptus melliodora*), Blakely's Red Gum (*Eucalyptus blakelyi*) Woodland; Nepean River gum (*Eucalyptus benthamii*), Kowmung Hakea (*Hakea dohertyi*), Cumberland Plain Woodland, Shale/Sandstone Transition Forest, Sydney Coastal River Flat Forest, and Southern Highlands Shale Woodlands.

Threatened and vulnerable species of fauna in the Area include; Brown tree creeper, diamond firetail, hooded robin, speckled warbler, turquoise parrot, swift parrot, black chinned honeyeater, little lorikeet, regent honeyeater, green and golden bell frog, stuttering frog, large eared pied bat, squirrel glider, and brush-tailed rock-wallaby.

Figure 1 shows the distribution of threatened flora in the small portion of the study area upstream of Warramanga Dam (extracted from Warragamba Dam Raising: Preliminary Environmental Assessment[20]). A comprehensive list of threatened and endangered flora and fauna in the Warragamba catchment can be found in *Warragamba Dam Raising: Preliminary Environmental Assessment*[20].

Matters of National Environmental Significance identified within Area include [20];

- One World Heritage property,
- One National Heritage place,
- Five listed threatened ecological communities,
- 48 listed threatened species, and
- 13 listed migratory species.

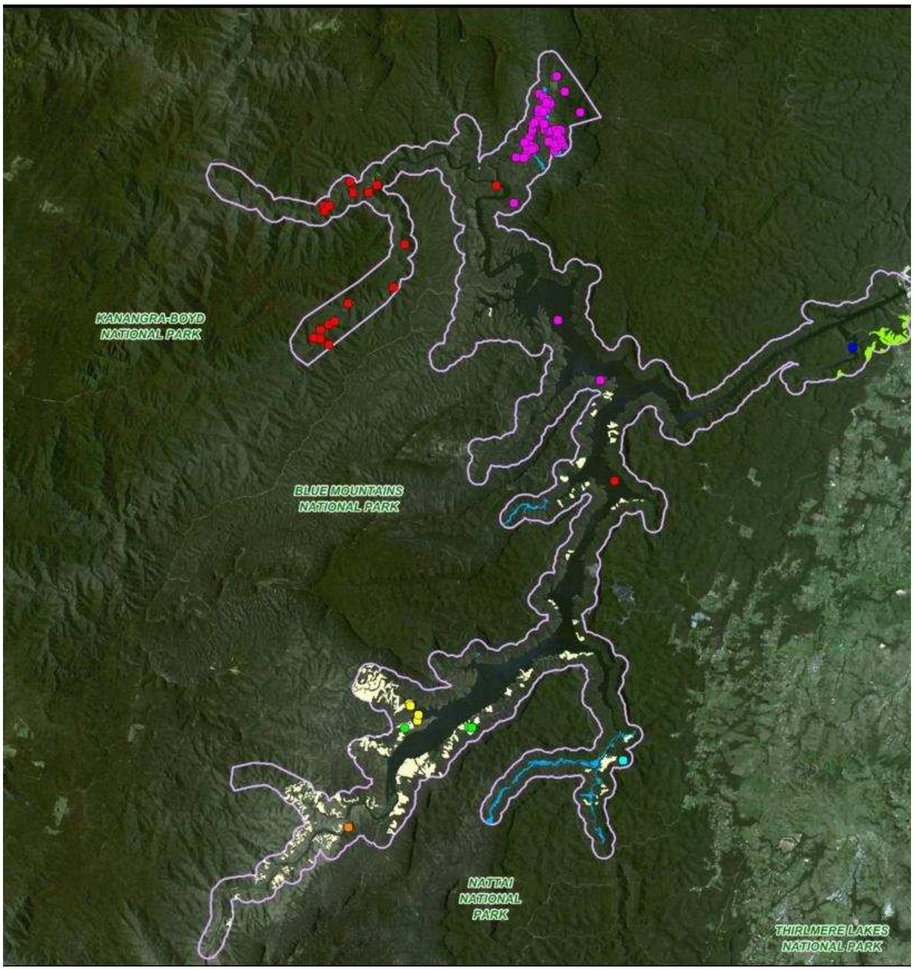


Figure 1: Location of threatened flora surrounding Lake Burragorang, adapted from[20].

2 Environmental Impact Statement Assessment of Flooding Impacts

The major attributes of flooding that contribute to damage to infrastructure and the environment and to the loss of life include;

- volume of water,
- depth of inundation,
- duration of inundation,
- velocity of the water,
- temperature of the water,
- sediment deposition or erosion,
- water quality, and
- debris.

The consultant reports have identified many of these impacts[2].

We have carefully read the consultants reports on the impacts of raising Warragamba Dam and have identified a number of extract from these reports and have provided comments on these throughout this report. These can be found in this report with the extracts provided on the left in italics and our comments to the extract on the right.

Inundation can cause disturbance and slumping of riparian banks which can cause the loss of areas of important vegetation. Changes in flow regimes, including inundation regimes, can provide an opportunity for the establishment of invasive species (i.e. weeds) in native vegetation communities.[20] *inundation events may also promote growth of some vegetation communities, especially eucalypts, through the provision of silts that can be used as effective seed beds.[20]* *Lake Burragorang is a significant sink for upstream sediment loads that would otherwise provide the river downstream its normal sediment loads[2].*	The importance of sediment cannot be underestimated. The report identifies the positive aspect of sediment deposits but this assumes that these events are infrequent and the catchment has time to recover between events. Significant deposition of sediments will impact on micro fauna. Frequent inundation and deposition of sediments will change the structure of the micro fauna by smothering plants and invertebrates.

at least 27 species of freshwater fish are known to occur within the upstream study area (Knight 2010; GHD 2013; Alluvium Consulting Australia 2017). Of these, 20 species are native to Australia and the remainder are introduced species[4]. *macroinvertebrate health showed a general trend of decline at many of the sites in the catchment[4].* *Macquarie perch (Macquaria australasica), which is listed as endangered under both the EPBC Act and FM Act, and the Australian grayling (Prototroctes maraena), which is listed as vulnerable[4].*	The retention of floodwaters with the raising of the Warragamba Dam may change upstream riffles into pool habitat. Riffles are important for aquatic fauna and spawning. The Macquarie perch *Macquaria australasica* and Australian grayling *Prototroctes maraena* spawns in tributaries of Lake Burragorang. The retention of frequently occurring flood waters lasting weeks during spawning, between October and January may disrupt this cycle. Increased slumping of riparian areas during retention and releases accompanying a flood events will cause disturbance to water quality within Lake Burragorang which will impact on aquatic fauna, including the platypus *Ornithorhynchus anatinus*. Operation of the spillway associated with increased flood retention capacity following the raising of the spillway may have an impact on freshwater eels, *Anguilla spp.* migration. These eels currently use the spillway to migrate to and from Lake Burragorang. Prolonged higher discharges may disturb this pattern. High dam discharge can lead to total dissolved gas supersaturation in the downstream river, and fish in the total dissolved gas supersaturation flow can suffer from bubble disease and even die[19].
Flooding in the upstream environment is backwater in nature, with Lake Burragorang acting as a flood storage. Flood storage areas are characterised by deep, low velocity inflows. However, there are localised areas of higher velocities where the major tributaries discharge into Lake Burragorang[2]. *The Project would result in changes in temporary inundation in the main reservoir area. Specifically, it would result in increased extent, duration and frequency of temporary inundation. Because the Project does not impact the volume and velocity of inflows, there would only be marginal changes to velocity profiles under the Project scenarios[3].*	This statement is reasonable. The volume of inflow should not change simply because the Dam is raised. However, MIKE11 only predicts cross-sectional average velocities, so it is not surprising to observe that the predicted velocities are small. The Environmental Impact Statement identifies that localized high velocities as a possible issue. The modelling undertaken does not examine this issue. There is very little information in the literature on the effect on the stability of shrubs and trees by flowing water and the associated saturated soil. Considerable information is available on the stability of trees in severe winds but not due to flowing water. This issue should be addressed. An increase in the inundation area will also increase the volume of debris in the reservoir which will increase the risk of obstructing spillway flows. This is not addressed in the Environmental Impact Statement.
Once affected by flood stress, plants are more susceptible to secondary biotic and abiotic impacts from the surrounding environment. When stressed or recovering from flood stress, plants are less resilient to disease and pathogens[3]. Changes to soil structure and chemistry such as depletion of oxygen, accumulation of carbon dioxide and reactive oxygen species, and changes in pH can also affect hormonal balance and metabolism typically by increasing the proportion of ethylene present within the cells[3]. Consequently, the vegetation within the study area may be susceptible to physical damage from the increased temporary inundation associated with the Project [3].	The Environmental Impact Statement implies that this is not an issue given the predicted duration of inundation for the major floods considered. Is this conclusion valid for multiple flood events occurring in sequence?

water velocities and wave heights are generally low, which reduces the hydrological forces causing erosion[3]. The extent of the MIKE11 model is shown in Figure 2-2. Cross sections are generally located approximately 1 km to 2 km apart and the modelled branches extend up to where gauged inflows are recorded[2].	This is an unusual statement because the reservoir routing is based on level pool routing, it assumes that the water in the reservoir is horizontal. Inflows are distributed instantaneously throughout the reservoir resulting in the attenuation of the inflows and any estimates of the velocities will therefore be significantly underestimated. MIKE11 assumes that the water surface is horizontal at each cross-section and it onjly estimates the cross-sectional average velocity. It would be useful to have provided the cross-sections used in MIKE11 to represent the Lake so the reader could be convinced that the cross-sections for Lake Burragorang are conducive to assume that the velocities could be considered uniform throughout the cross-section. This would be a reasonable assumption if the cross-sections resemble a rectangular profile.

Generally, the Project would result in a decrease in water velocities as there would be a larger backwater area behind the dam. This would result in a decrease in the erosive potential of flows in the tributaries where flows are generally the highest. An increase in erosion potential may occur where vegetation cover is reduced due flood stress[3].	This is a slightly miss-leading statement. Here it is suggested that there is a backwater effect. However, the model chosen, DAMROU assumes there is no backwater effect, it is based on level pool routing. In addition, erosion is not only a result of the flow velocity. Draw-down of saturated soils can also cause slumping of banks.

of combined inflows into Lake Burragorang, selected from the Monte Carlo modelling to be representative of each design event considered are presented in Figure 3-23[2].

This is the most disappointing aspect of this report. What is a representative result? Is it the mean or expected prediction or is it the lowest or highest prediction. This is a single outcome from the possible range of outcomes from the Monte Carlo simulation. This range should be reflected in the area inundated as well as the duration of inundation. For example, the lower water level would correspond to a smaller area inundated but higher velocity of flow. Conversely the higher water level would represent a greater area of inundated and a lower velocity of flow. This is the type of information that should have been reported by the consultants. That is the expected or average area inundated and the upper and lower bounds of the inundated area. If the distribution of the prediction limits is assumed to be Normally distributed it is common to express the 95% prediction limits as the expected value $\pm 2s$, where s is the an estimate of the standard deviation of the predictions.

This is a lost opportunity. The Monte Carlo simulation should provide an approximation of all possible outcomes. With the 95% prediction limits and the expected value, decision makers have the opportunity to make an informed decision based on random process and uncertainty in the model and its parameters. For example in Figure 3-24[2] the peak water level in Lake Burragorang is approximately 131m AHD for the PMF. If this is the expected value it is probable that the model prediction limits would be in excess of this and the duration of inundation would also be longer. This information is available from the Monte Carlo simulation.

It is common practice that when quantifying uncertainty in a model is to provide prediction limits. There are numerous examples in the literature where these limits are provided in flood studies. A cursory examination of the internet reveals numerous examples[1, 9, 12, 13, 22].

This should be rectified as these results are available.

2.1 Modelling Approach Used by the Consultants

Models used by the consultants are DAMROU, RORB, MIKE11 and RUBICON and limited use of TUFLOW.

DAMROU, is a level pool routing model. It involves the solution of the discrete form of the continuity equation, (2a) which is given by[24]

$$S(t+\Delta t) = S(t) + \Delta t(I(t) - Q(S(t))) \tag{1}$$

It simply states that the storage, $S(t+\Delta t)$ at time $t+\Delta t$ is equal to the storage, $S(t)$ in the reservoir at time t plus the net inflow, $I(t) - Q(S(t))$ over the time interval Δt into the reservoir. It assumes that inflows and outflows are distributed instantaneously throughout the reservoir and the water level in the reservoir is horizontal. It is known to significantly attenuate flood levels. These assumptions make it very difficult to obtain predictions of velocity of the water during a flood.

RORB is a runoff-routing model that is based on the solution of the continuity equation, (2a) and a nonlinear storage equation of the form $S = kQ^a$. The parameter k represents the effect of river characteristics such as the hydraulic roughness, bed slope, length of the catchment or channel and cross section geometry. The exponent a, which affects the degree of non-linearity of the catchments characteristics have on a flood. It has been shown to be related to the shape of the river channel with a value of 0.6 for wide rectangular channel and 0.75 for triangular or trapezoidal cross-sections. These parameters need to be calibrated from observed flood events.

In rainfall-runoff models the catchment is sub-divided into sub-catchments. On each sub-catchment rainfall is converted to runoff from that sub-catchment. This discharge is influenced by properties of the sub-catchment, such as its slope, vegetation cover, antecedent conditions and catchment shape represented by the storage equation. Flow for the whole catchment is estimated by accumulating flows from each sub-catchment moving downstream. It does not have the ability to consider the influence of interacting flows between adjacent sub-catchment. For example, flows from a downstream sub-catchment cannot impede flows from a sub-catchment immediately upstream. This however, is only applicable for flows over steep slopes, such as overland flows. It is not applicable for reservoir routing.

RORB cannot model the influence of changes in the geometry, interacting hydrographs or obstacles to the flow that produce backwater effects. That is water levels downstream impleading the flows resulting in an increase in water depth upstream. The reason for this is that it does not include a momentum equation, they are based solely on the continuity equation. This is a common feature of hydrologic models. In RORB, the momentum equations are replaced by the empirical storage equation.

A consequence of using hydrologic methods for routing is that they attenuate the peak discharge and they only involve the discharge. To obtain the water depth from the simulated discharge, empirical rating curves are used which provide a unique relationship between discharge and water depth. It is well known that a flood will produce a looped rating curve, not a unique relationship between the discharge and water depth. The width of the loop is dependent on the shape of the hydrograph defining the flood and properties of the river. This is in contrast to solving the shallow water wave equations where both discharge and water depth are explicitly estimated simultaneously. In this case they are both subject to variations in the bathymetry, geometry, resistance to the flow and properties of the flow.

MIKE11 and RUBICON are a one-dimensional models based on the shallow water wave equations. They have a number of shortcomings. The most significant is that the water surface is horizontal at each cross-section. MIKE11 is used to model flows in Lake Burragorang which is represented by a number of cross-sections. The water surface at each cross-section is horizontal. This does not take into account variation in the cross-section. Most importantly, it only calculates the cross-sectional average velocity. This might be appropriate for a rectangular cross-section but is not appropriate for cross-sections that have variable depth, vegetation and 100's of metres wide. The velocity of the water near the banks will travel slower than away from the bank and water in the deepest part of a channel will flow faster that in the shallow sections of a cross-section. In this case a two-dimensional model is more appropriate, where Lake Burragorang is characterized by elements with dimensions of tens of metres. This allows for variation in bathymetry, vegetation, water surface elevation and flow velocities thought the reservoir.

A slightly different analysis approach was adopted for the upstream area. The MIKE11 model was not used to discretely simulate each of the Monte Carlo design flood scenarios. Rather, the MIKE11 model was used to extract rating curves (flow-height relationships) under different dam raising scenarios. These rating curves were used to calculate level hydrographs from flow inputs (from the RORB model) at all cross-sections for the 20,000 Monte Carlo runs of the existing dam and the raised dam option. These level hydrographs were used to obtain estimates of inundation times upstream of the dam and to give an indication of the change in inundation time between the existing dam and the 14m raised dam option.[2]

A special sub-routine, DAMROU, was added to the RORB program to model flow through the Lake Burragorang Reservoir taking account of the gate operations at the dam. The subroutine was modified as part of the Regional Flood Study to also include simulation of the fuse plug operation on the auxiliary spillway [23].

Using the standard RORB procedure for storages, DAMROU assumed that the surface of the lake is horizontal (level) during the passage of a flood[23].

RORB and DAMROU are hydrological models. According to Ionescu and Nistoran[7] this is inappropriate for the complex geometry of Lake Burragorang. An important limitation of hydrologic models is that they do not consider the propagation of flows through Lake Burragorang. It assumes that the inflows occur instantaneously throughout the Lake because it it base on the solution of (2a) alone. There is no interaction of the hydrographs through the system.

This report explicitly states that level pool routing is used to rout the flows in Lake Burragorang. What is disturbing is the justification of its use.

The flood study reviewed the two-dimensional model TUFLOW HPC (Heavily Parallelised Compute), however it was concluded that modelling of the entire valley was not possible due to topographical constraints such as the gorge upstream of Penrith. While the Hawkesbury-Nepean floodplain is challenging for two-dimensional models, the quasi two-dimensional model developed in earlier studies (RUBICON) can be run fast enough (5,000 times faster than the two-dimensional model) that it can be used in a Monte Carlo environment.	TUFLOW was rejected for modelling the impacts of raising Warragamba Dam as well as Lake Burragorang and the consultants opted for the simpler hydrological model, DAMROU to rout inflows through the Lake Burragorang. This is the most primitive model that could have been used. Downstream of the Dam, the one-dimensional model, RUBICON was used. Their justification for rejecting the more accurate two-dimensional model is the excessive time required to perform the Monte Carlo simulations. This decision would be more difficult to justify if the point estimate method was used instead of Monte Carlo simulation.

A quasi two-dimensional hydraulic model using RUBICON modelling software was therefore developed for the floodplain area downstream of Warragamba Dam.	Although, both MIKE11 and RUBICON solve the shallow water wave equations, there are based on finite difference discretisation of the shallow water wave equations. For modelling rapidly varying flows and interacting with structures such as buildings, a finite volume approach is preferable, which can handle discontinuous flows. ANUGA and TUFLOW are based on the finite volume method and solve the two-dimensional shallow water wave equations.

Another issue that was considered was the time the flood wave took to travel through the reservoir. The standard RORB routing procedure for a reservoir reach simply translates the hydrograph from the top of the reach to the bottom. This assumes that the influence of the inflow travels through the reservoir instantaneously. While this is a reasonable approximation for small reservoirs, the question arose as to whether it was reasonable in this case where the length of the lake from the dam to the head of the Burragorang Valley is 50 kilometres. While this issue would not greatly affect the calculation of flood magnitudes at the dam, it clearly has an impact on the relative timing of flows from Warragamba and the downstream tributaries, especially the Nepean River[23].	It is well known that level pool routing attenuates a flood. That is the peak flow is significantly reduces. The amount of the attenuation is dependent on the size of the reservoir. The implications of using simplified techniques for flood routing in reservoirs of different shapes is illustrated by Ionescu and Nistoran[7]. Hydraulic models are preferred for reservoirs of irregular shape, whereas simplified techniques would suffice for regularly shaped reservoirs. Lake Burragorang has a complicated geometry.

In the 1990s, Sydney Water conducted a literature search on the issue but did not find any substantive information. Theoretical calculations showed that the influence of the flood wave could travel the length of the reservoir in less than one hour (given large parts of the reservoir are greater than 50 metres deep the wave speed would be in excess of 20 m/s), in which case the assumption of instantaneous translation would be reasonable. The hydraulic model of the reservoir also indicated that the adopted approach was acceptable. The standard RORB assumption of zero travel time was therefore retained[23].

We did a brief literature search and found three papers[5, 6, 7] that refute this conclusion. We will demonstrate whether this assumption is indeed justified for Lake Burragorang using a two-dimensional model of the Lake. Doesn't a wave speed of 20m/s (70km/h) imply high velocities in the Lake? Elsewhere in the report the velocities in the Lake are considered negligible. A surface wave of 30cm at this speed is significant and destructive. For example in Figure 3-30[2], a wave velocity of greater than 4m/s and a depth of flow of 30cm would not be suitable for people or buildings. Buildings would require special engineering design and construction for flows between 2-4m/s. What would the impact on vegetation and banks due to wave action with this severity? Fortunately, the quoted wave speed is incorrect. What is quoted is the speed of a small disturbance which is $\sqrt{gh}$, where g = 9.81 gravitational acceleration and h = 50m is the water depth. Therefore, a small disturbance should travel at $\sqrt{490}$ = 22m/s. This is not the speed of the flood that are traveling through the reservoir. The flood wave will travel much slower than this. It demonstrates a lack of understanding of floods and their properties and more importantly adds to the contradictory statements made in the environmental impact statement on the velocities in the Lake.

3 Hydrodynamic Model

Although, the consultants considered the use of simulating the progress of a flood in a Lake Burragorang using a two-dimensional hydrodynamic model, it was dismissed. We will demonstrate that a two-dimensional model can be developed to simulate flooding of Lake Burragorang using limited resources and time. The consultants adopted simpler models with little justification. A comparison between these simpler approaches and results from a two-dimensional would validated their choice.

We have concentrated on the depth of inundation, velocity of the flow and duration of inundation, although other factors could have been considered in modelling two historical floods in Lake Burragorang.

To accurately predict depth of inundation, velocity of the flow and duration of inundation, a two-dimensional hydrodynamic model is required. Justification for the use of a two-dimensional hydrodynamic model is based on the geometry of Lake Burragorang. It is a narrow long reservoir approximately 35kms in length. Comparisons between the use of hydraulic and hydrologic model for routing floods in reservoirs found that hydraulic models are the most appropriate[5, 6, 7].

Hydrodynamic models are based on equations derived from physical laws which include all the salient mechanisms that are thought to describe the behaviour of free surface flows to external forces such as gravitational acceleration. These equations are approximated by numerical techniques that can be solved using digital computers. These models of a physical processes can be readily manipulated to assess the impact of various scenarios on the behaviour of the fluid flow.

The governing equations that are considered appropriate in modelling riverine flooding are the shallow water wave equations.

3.1 Shallow Water Wave Equations

The two-dimensional shallow water wave equations are given by the *continuity* and *momentum* equations in the form of the two-dimensional shallow water wave equations.

The continuity equation can be expressed as

$$\frac{\partial h}{\partial t} + \frac{\partial (uh)}{\partial x} + \frac{\partial (vh)}{\partial y} = 0 \tag{2a}$$

and the momentum equation in the $x-$direction

$$\frac{\partial (uh)}{\partial t} + \frac{\partial (u^2 h)}{\partial x} + \frac{\partial (gh^2/2)}{\partial x} + \frac{\partial (uvh)}{\partial y} = -gh(S_{0_x} - S_{f_x}) \tag{2b}$$

and in the $y-$direction by

$$\frac{\partial (vh)}{\partial t} + \frac{\partial (v^2 h)}{\partial y} + \frac{\partial (gh^2/2)}{\partial y} + \frac{\partial (uvh)}{\partial x} = -gh(S_{0_y} - S_{f_y}) \tag{2c}$$

in which u is the x-component of the depth averaged fluid velocity, v is the y-component of the depth averaged fluid velocity, h is the water depth, g is the acceleration due to gravity and x and y are the co-ordinate directions.

The forcing functions are gravitational effects given by $ghS_{0_x} = gh\partial z_b/\partial x$ and $ghS_{0_y} = gh\partial z_b/\partial y$ where, z_b is the bed elevation. The frictional forces opposing the motion of the water is described by the empirical relationship

$$S_{f_x} = \frac{uhn^2\sqrt{(uh)^2 + (uh)^2}}{h^{10/3}} \quad \text{and} \quad S_{f_y} = \frac{vhn^2\sqrt{(uh)^2 + (uh)^2}}{h^{10/3}} \tag{3}$$

known as Manning's equation, in which n is the Manning resistance coefficient. It is used to represent the resistance to the flow obstacles offer to the flow, such as vegetation and gravel or rocks which imped the flow.

These equations assume that the density of the fluid remains constant and the fluid velocity is uniform throughout the depth of the water.

3.2 Finite Volume Method

The finite volume method is based on the integral form of the conservation equation (2). The discretization of the integral form of (2) ensures that the basic quantities, mass and momentum will always be conserved.

Integrating (2) over an arbitrary element V_i the basic equation of the finite volume method is given by

$$\frac{\partial}{\partial t}\int_{V_i} \mathbf{U} dV + \oint_{S_i} \mathbf{F}\cdot\mathbf{n} dS = \int_{V_i} \mathbf{S} dV \tag{4}$$

in which $\mathbf{n} = (n_1, n_2)$ is the unit outward vector normal to the boundary S_i, and dV and dS are the area and arc length of an element respectively. This law states that the time rate of change in $\mathbf{U} = [h\ uh]^T$ inside a control volume V_i, depends on the total flux of material $\mathbf{U}$ through the surface S_i plus the sum of sources within an element. The integrand $\mathbf{F}\cdot\mathbf{n}$ is the normal flux across the boundary of an element.

Within each element or control volume, $\mathbf{U}$ is assumed to be constant and the flux, $\mathbf{F}(\mathbf{U})$ across each edge, j of the element, i is determined by the states, $\mathbf{U}$ in the neighbouring elements separated by edge j.

Using the *rotational invariance* property of the two-dimensional shallow water wave equations, then

$$\mathbf{F}(\mathbf{U})\cdot\mathbf{n} = \mathbf{T}_\mathbf{n}^{-1}\mathbf{E}(\mathbf{T}_\mathbf{n}\mathbf{U}). \tag{5}$$

where

$$\mathbf{T}_\mathbf{n} = \begin{bmatrix} 1 & 0 & 0 \\ 1 & n_1 & n_2 \\ 0 & -n_2 & n_1 \end{bmatrix}$$

aligns the normal $\mathbf{n}$ with the x-axis.

In discrete form the basic equation for the finite volume method becomes

$$A_i \frac{d\mathbf{U}_i}{dt} + \sum_{j\in N(i)} \mathbf{T}^{-1}_{\mathbf{n}_{i,j}} \widetilde{\mathbf{E}}(\mathbf{T}_{\mathbf{n}_{i,j}}\mathbf{U}_i, \mathbf{T}_{\mathbf{n}_{i,j}}\mathbf{U}_j) L_{i,j} = A_i \mathbf{S}_i \tag{6}$$

where A_i is the area of the element i, $N(i)$ is the number of elements which share a common edge with element i, j is the index of the side of the element i, $L_{i,j}$ is the arc length of side j of element i, $\mathbf{S}_i$ is the sources and sinks associated with element i and $\widetilde{\mathbf{E}}(\mathbf{T}_{\mathbf{n}_{i,j}}\mathbf{U}_i, \mathbf{T}_{\mathbf{n}_{i,j}}\mathbf{U}_j)$ is an estimate of the flux across the boundary separating two neighbouring elements. This is estimated using the approximate Riemann solver, such as that described by Kurganov, Noelle and Petrov[10]. There are a number of other solvers that could have been used[28].

This approach results in an explicit scheme which has a restriction on the time step that is dependent on the size of each cell and the water depth. Although the time step can be small the numerical scheme solves a relatively simple local problem on each cell rather than a global problem. This makes the solution of the equations adaptable to multiple processors using modest computer resources.

The major advantages of this formulation are; (*i*) the underlying principle is simple, (*ii*) flexible meshes, such as triangles or quadrilaterals which suit problems with complex geometries can be employed and (*iii*) an integral conservation law is used. Therefore, the solution may be smooth or discontinuous and is conservative.

At the centroid of each element the Manning's resistance coefficient must be specified. Only the bed elevation is required at the vertex of each element. The initial conditions, the water depth and momentum (the depth averaged velocity multiplied by the water depth) must be specified at the centroid of each element and these are evolved with time subject to external forces or provided as boundary conditions. The boundary conditions can consist of an obstacle to the flow, specifying inflows, discharge or water elevation as a function of time, are specified along an edge of an element or a combination of elements. There are other boundary conditions that could also be implemented.

The two-dimensional shallow water wave equations, (2) are solved at the centroid of each element in the domain providing water depth and momentum profiles over time. Details of the solution of (2) using the finite volume method in two-dimensions can be found in Zoppou and Roberts[27].

There are a number of commercial and public domain software that are capable of solving the two-dimensional equations. These include the public domain software, ANUGA and the commercial package TUFLOW. Both are two-dimensional finite volume codes that solves the shallow water wave equations on arbitrary grids.

ANUGA is developed by the Australian National University (ANU) and Geoscience Australia (GA). It is open source code written in the Python programming language and the programming language *C* for computationally intensive components. ANUGA is capable of simulating flows from dam breaks, riverine and estuarine flooding, storm surges and tsunami inundation over dry land and around structures such as buildings. The user must specify the domain's geometry, which is represented by a mesh of triangular elements, the topography and bathymetry, frictional resistance, initial values for the water level and velocity, boundary conditions such as rainfall, tide and stream inflows. Mesh triangles are symbolically tagged to indicate boundary regions, such as gauging station of a dam or regions with different parameters, such as the Manning friction coefficients.

ANUGA also incorporates a mesh generator that allows the user to set up the geometry of the problem interactively as well as tools for interpolation and surface fitting.

4 Modelling of Lake Burragorang

This study is limited by the available time and access to data. However, it demonstrates what is possible with limited resources in implementing a two-dimensional hydrodynamic model to simulate flows through Lake Burragorang. This is despite the claim by the consultants;

The current study provides boundary conditions that can be used in the development of more detailed flood models. These more detailed models may be two-dimensional models with fine grids that will better represent the local flood behaviour[2].

This conclusion implies that the analysis using DAMROU is considered as inadequate. Indeed, the RORB results would be useful in performing a more detailed risk assessment of flooding using a two-dimensional modelling approach.

Table 1: Location of the gauging shown in Figure 2 upstream and downstream of Warragamba Dam.

Location	Latitude	Longitude	Catchment Area km^2
Coxs River at Kelpie Point (212250)	−33.876944	150.254014	1450
Kowmung River at Cedar Ford (212260)	−34.145556	150.424725	733
Woolondilly River at Jooriland (212270)	−34.227659	150.252792	4560
Nattai River at Causeway (212280)	−34.145556	150.424782	446
Warramanga Wier (212241)	−33.876944	150.606389	9010
Warramanga Dam (212243)	−33.891111	150.591111	9010

4.1 Areal Extent of Modelling of Lake Burragorang

We are only interested in inundation upstream of Warragamba Dam and its impact on the environment. Therefore, the models extends from Warragamba Dam to the gauging stations on the Coxs, Nattai, Wollondilly and Kowmung Rivers. The location of the gauging stations upstream and downstream of the Dam are shown in Figure 2 and their co-ordinates given in Table 1. The Causeway on Nattai River is approximately 48km from Warragamba Dam, Jooriland on Wollondilly River, approximately 67km from Warragamba Dam, Cedar Ford on Kowmung River, approximately 70 km from Warragamba Dam and Kelpie Point on Coxs River, approximately approximately 55km from Warragamba Dam.

4.2 Geometry of Lake Burragorang

The perimeter of Lake Burragorang was established using bathymetric data obtained from Water, New South Wales[21]. The contour level 130m AHD was digitizing and refined forming the boundary of Lake Burragorang and represent the current limits of the model. Using the computer package Triangle. developed by Shewchuk[16], the surface of Lake Burragorang is subdivided into 16782 triangles. Figure 3 shows a small portion of the Lake with the generated triangular mesh defining its shape. These triangles represent the maximum flood extent of Lake Burragorang for this study. For floods that exceed the contour level 130m AHD, this region must be extended. At each vertex of the triangular mesh, representing the Lake, the elevation of the bed is required. Radial basis functions were used to estimate these values using the bathymetric data[21], shown in Figure 2.

The 2021 flood resulted in a downstream flow at Warragamba Weir of approximately 1:25 AEP, and the 1990 flood a 1:30 AEP event[14]. For the 1990 flood the initial water level at Warragamba dam was 115.831m AHD reaching a maximum height of 118.191m AHD. For the 2021 flood the initial water level at Warragamba dam was 115.894m AHD reaching a maximum height of 118.687m AHD.

4.3 Manning's *n*

The Manning's equation is an empirical relationship describing the resistance offered to the flowing water by obstacles, such as the bed of channel or reservoir, vegetation and anthropologic obstacles.

For this study, the bed of Lake Burragorang is assumed to consist of fine sediments and gravel. Along the shoreline and in the flood prone areas there is a range of vegetation types. Figure 4 shows the distribution and type of vegetation surrounding Lake that is in the flood zone considered in this report.

The predominant vegetation types in the flood zone surrounding Lake Burragorang are stands of Escarpment Grey Gum (MU14), Nattai Sandstone Dry Shrub Forest (MU26), Sandstone Moist Blue Gum Forest (MU8) and Sheltered Escarpment Blue Gum Forest (MU13). Other species are listed in Table 2.

The resistance offered to the flow by the vegetation is is captured by the Manning's coefficient n. Using photographs of vegetation types in the Warragamba Special Area taken and classified by the National parks and Wildlife Service[15], and the reference photographs[18], values for Manning's n range from 0.02 – 0.05, see Table 2 reflecting the diversity of the vegetation and natural bed materials.

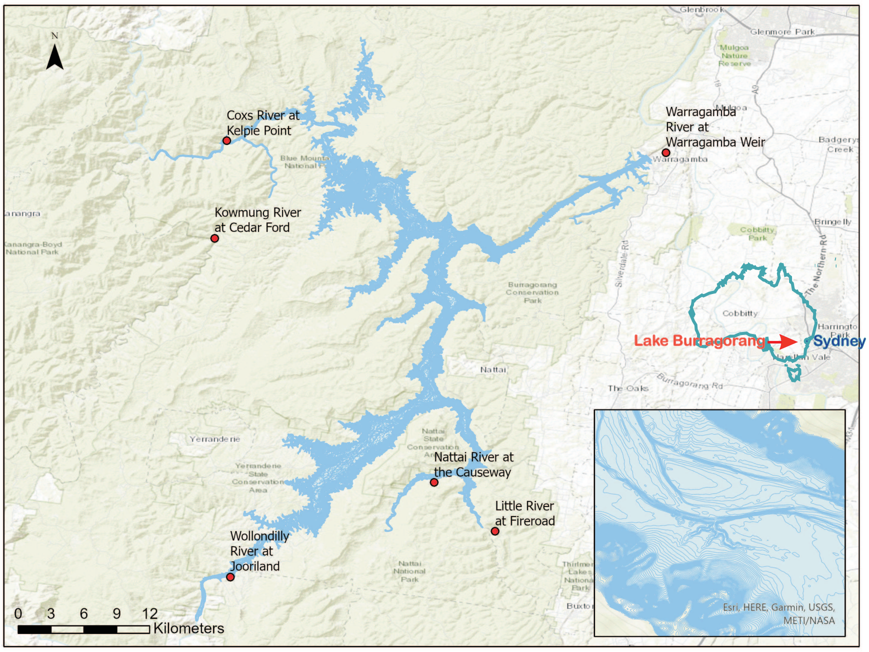


Figure 2: Lake Burragorang bathymetric data[21].

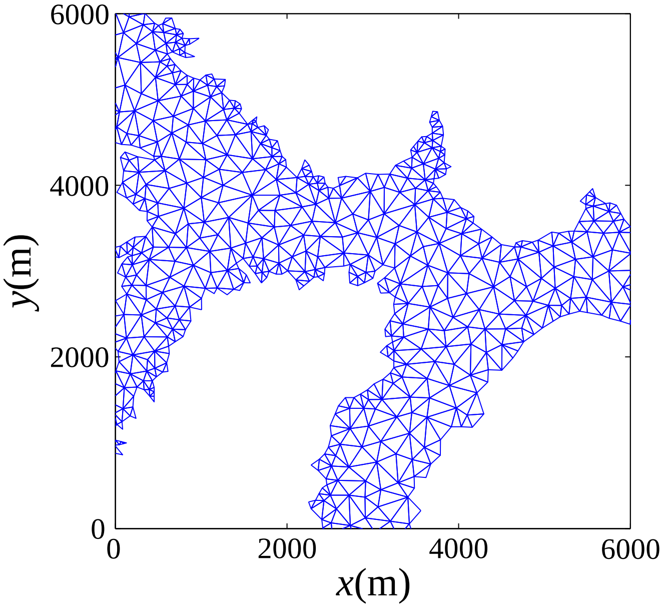


Figure 3: A typical region of Lake Burragorang represent by the triangular mesh used in the model.

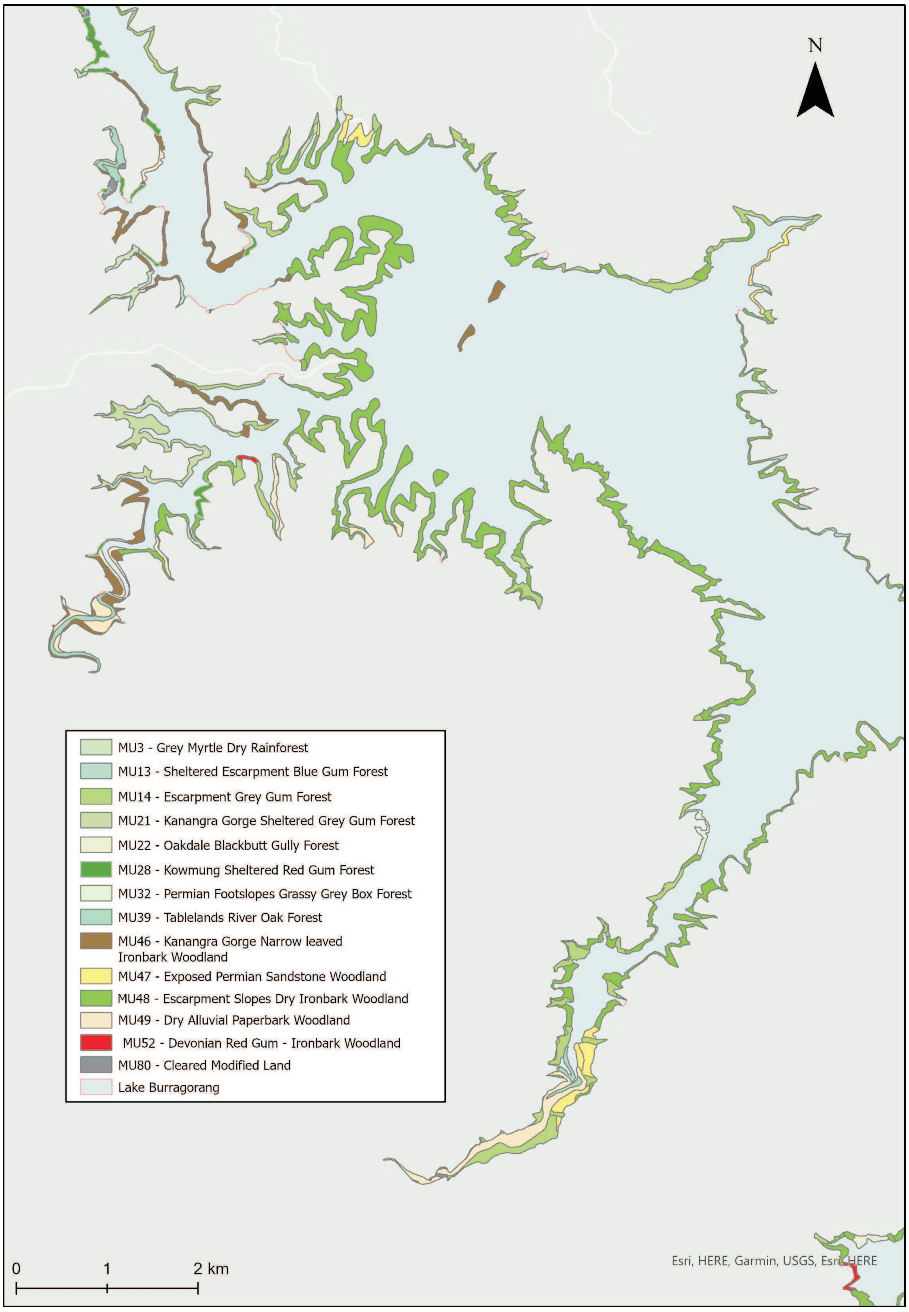


Figure 4: Vegetation types surrounding a small portion of Lake Burragorang, adapted from [17].

Table 2: Peak discharges at several inflows into Lake Burragorang and downstream of Warragamba Dam and their corresponding approximate AEP[14] for the August, 1990 and March, 2020 floods.

MU Identifier	Vegetation Description	Manning's n
1	Sandstone Warm Temperate Rainforest	0.035
3	Grey Myrtle Dry Rainforest	0.030
4	Kowmung Dry Rainforest	0.030
6	Sandstone Riparian Shrub	0.050
8	Sandstone Moist Blue Gum Forest	0.040
9	Shletered Sandstone Intermediate Blue Gum Forest	0.045
10	Sheltered Sandstone Smooth barked Apple Forest	0.040
13	Sheltered Escarpment Blue Gum Forest	0.050
14	Escarpment Grey Gum Forest	0.030
21	Kanangra Gorge Sheltered Grey Gum Forest	0.025
22	Oakdale Blackbutt Gully Forest	0.045
25	Blue Mountains Sandstone Dry Shrub Forest	0.040
26	Nattai Sandstone Dry Shrub Forest	0.045
28	Kowmung Sheltered Red Gum Forest	0.040
32	Permian Footslopes Grassy Grey Box Forest	0.040
39	Tablelands River Oak Forest	0.050
41	Exposed Burragorang Sandstone Shrub Woodland	0.035
42	Rocky Sandstone Heath Woodland	0.045
46	Kanangra Gorge Narrow leaved Ironbark Woodland	0.030
47	Exposed Permian Sandstone Woodland	0.030
48	Escarpment Slopes Dry Ironbark Woodland	0.030
49	Dry Alluvial Paperbark Woodland	0.035
50	Douglas Scarp Woodland	0.025
52	Devonian Red Gum-Grey Box Woodland	0.030
53	Devonian Red Gum-Ironbark Woodland	0.030
78	Regenerating Vegetation	0.030
79	Exposed Rock	0.025
80	Cleared and Modified Land	0.025
	Lake Bed	0.020

4.4 Boundary Conditions

Obvious boundary conditions for the two-dimensional hydrodynamic model requires is the inflows into Lake Burragorang at at Coxs River at Kelpie Point, Kowmung River at Cedar Ford, Woolondilly River at Jooriland and Nattai River at Causeway. These are provided from historical records. The remaining boundary condition required by the model is the outflow from Warragamba Dam. We do not have access to detailed information on the weir structure, its shape or any other outlet structures at Warragamba Dam or the operating rules used during a flood. Therefore, the flows recorded at Warragamba Weir, which is immediately downstream of Warragamba Dam could be used or a weir formula that is dependent on the reservoir level could be used. The difficulty in using a weir equation to define the outflow from the reservoir is that they ignore operating rules and the equation needs to be calibrated.

Assuming a rectangular weir, the discharge is given by

$$q = \frac{2}{3} C_d B \sqrt{2gh^3} \tag{7}$$

where, q is the discharge over the weir in m^3/s, $B = 94.5m$ is the length of the Weir on Warragamba Dam, h is the water depth over the weir, C_d is the discharge coefficient. For an assumed that $C_d = 1.0$, the 2021 flood the peak spillway discharge is approximately 1887m^3/s (118.191m AHD) and for the 1990 flood approximately 1609m^3/s (118.687m AHD). This is far less than the recorded peak flows at Warragamba Weir, which are 5774m^3/s and 7259m^3/s respectively. The spillway level corresponds to the FSL at 116.7m AHD. If we assumed that $C_d = 3$ then the peak flow over the spillway is 5661m^3/s for the 2021 flood, which is closer to the recorded peak flow at Warragamba Weir. Therefore, if a weir is used as the boundary condition and the discharge is given by (7), $C_d = 3.0$ will be used.

5 Simulation of Historical Events

We have chosen two recent historical flood events to to simulate using our two-dimensional model of Lake Burragorang. The August 1-6, 1990 and March 19-29, 2021 floods. The 2021 flood resulted in a downstream flow at Warragamba Weir of approximately 1:25 AEP, and the 1990 flood a 1:30 AEP event[14]. For the 1990 flood the initial water level at Warragamba dam was 115.831m AHD reaching a maximum height of 118.191m AHD. For the 2021 flood the initial water level at Warragamba dam was 115.894m AHD reaching a maximum height of 118.687m AHD. The peak flows for each of these events at Coxs River at Kelpie Point (212250), Kowmung River at Cedar Ford (212260), Woolondilly River at Jooriland (212270), Nattai River at Causeway (212280), and Warramanga Wier (212241) gauging stations are given in Table 3 and 4 and along with their estimated Annual Exceedance Probabilities (AEP)[1] for the 1990 and 2021 floods respectively.

These events are small in comparison to the design floods considered in the Environmental Impact Assessment including the Probable Maximum Flood (PMF)[2].

The recorded discharge hydrographs are shown in Figures 5 and 7 for the 1990 and 2021 events respectively. The recorded water level at Warragamba Dam (212243) is illustrated in Figures 6 and 8 for these events.

These are two very distinct events. The 1990 flood is dominated by inflows from Woolondilly River catchment whilst the 2021 flood is dominated by inflows from the Coxs and Kowmung Rivers.

We have attempted to use the Warragamba Weir recorded discharge as the discharge from Warragamba Dam. Unfortunately, a simple water balance performed for both floods reveals some deficiencies in this approach. For the 2021 flood the recorded accumulated inflows at the gauging stations upstream of the Dam and the recorded flows at Warragamba Weir are shown in Figure 11(a). It is obvious that more water flows out of than into Lake Burragorang. This is confirmed in Figure 11(b) where the accumulated flows for the duration of the flood are shown. With the exception of the first three days of the flood the outflows exceed the inflows. This results in a depletion of water from Lake Burragorang, where the water level drops well below the FSL.

Between the 19th and 29th of March, 2021 inflows were 0.970963×10^9m^3 and outflow 1.297295×10^9m^3, a difference of 0.326318×10^9m^3. More than one third of the inflows are not accounted for. This could be caused by the rating table used to convert water depth to charage at Warragamba Dam overestimating the discharge. It is difficult to measure flows during a major flood. Nevertheless, this is not a design flood, it is only an estimated 1:65 flood at Coxs River at Kelpie Point. Alternatively, there are ungaged inflows upstream of the Dam. There is a catchment area of 1821km^2 surrounding Lake Burragorang that is not captured by the stream gauging stations located at Coxs River at Kelpie Point, Kowmung River at Cedar Ford, Woolondilly River at Jooriland and Nattai River at Causeway. This is a significant catchment area rivaling the Coxs River catchment, see Table 1. It seems that runoff from this portion of the catchment makes a considerable contribution to the inflows into Lake Burragorang.

The total recorded inflow for this flood at Coxs River at Kelpie Point is 0.361027×10^9m^3 which would suggest that this is a local storm that produced the flood and that the lateral inflows into Lake Burragorang are comparable to the inflows recorded at Coxs River at Kelpie Point.

The situation is much better for the 1990 flood, see Figure 11. In this case the inflows exceed the outflow.

Since we do not have access to data on the catchment surrounding the Lake downstream of the gauging stations, or the results from the rainfall-runoff model RORB, we cannot include this inflow into the Lake in the model. Therefore, we have chosen to simply ignore this runoff and use the weir formula, (7) for the discharge from Warragamba Dam. This will be used as the boundary condition at the Dam in the model for the 1990 flood only. The 2021 flood requires further investigation, in particular the accuracy of the rating curve at Warragamba Weir. The inflows at the gauging stations are also used as boundary conditions in the model.

[1]Annual Exceedance Probability (AEP) is the probability of an event being equalled or exceeded within a year.

[2]the Probable Maximum Flood (PMF) is the largest flood that could probably occur on a catchment. It is established using the Probable Maximum Precipitation (PMP).

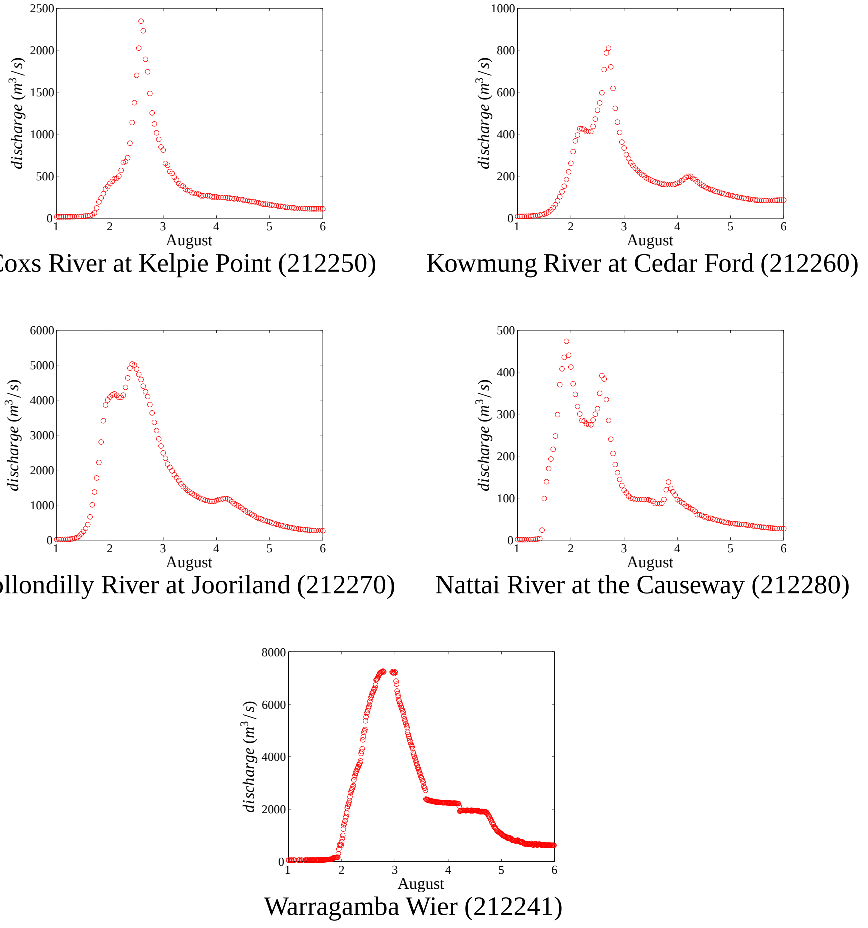


Figure 5: The inflows into Lake Burragorang and the outflow immediately downstream of Warragamba Dam during the August 1-6, 1990 flood .

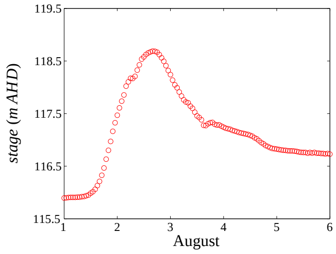
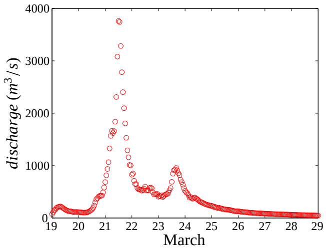
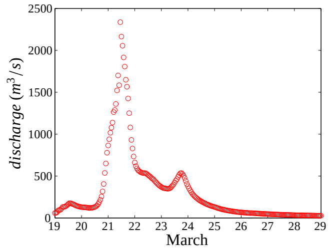


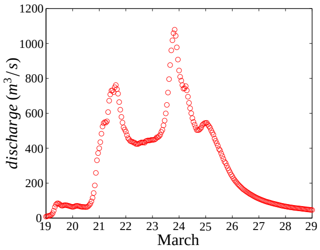
Figure 6: The recorder water level at Warragamba Dam for the August 1-6, 1990 flood .



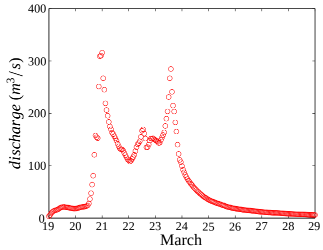
Coxs River at Kelpie Point (212250)



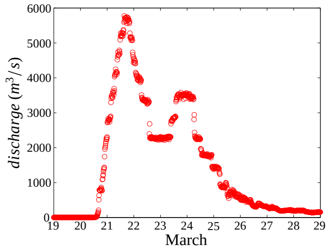
Kowmung River at Cedar Ford (212260)



Wollondilly River at Jooriland (212270)



Nattai River at the Causeway (212280)



Warragamba Wier (212241)

Figure 7: The discharge at various gauging stations upstream and immediately downstream of Warragamba Dam for the March 19-29, 2021 flood .

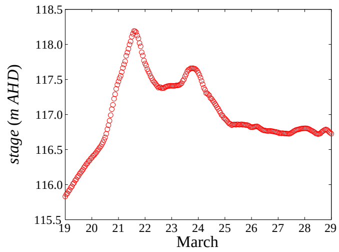


Figure 8: The recorder water level at Warragamba Dam for the March 19-29, 2021 flood .

5.1 Velocity and Water Depth at Selected Points

Results from our two-dimensional model of Lake Burragorang are shown in Figures 12-15 at the locations shown in Figure 9. These are located on the Coxs and Woolondilly River arms of Lake Burragorang.

The depth of inundation and the velocity of flow for the 1990 flood are shown in Figures 12(*a*) and (*b*) respectively for location 3, which is adjacent to Warragamba Dam. No adjustment have been made to any model parameters. The recorded water level at Warragamba Dam gauging station is also plotted in Figure 12(*a*). Although the modelled results lag the observed water levels, there is very good agreement between the the predicted and observed water level. The local depth averaged water velocity at location 3 reflects the proximity of this location to the outlet structure. It is the local velocity because it is restricted to a single triangle at that location. It is not a cross-sectional depth averaged velocity that would be obtained from a one-dimensional model such as MIKE11. In addition, the water level and depth averaged velocity at adjacent triangles may differ. This would not be the case for a one-dimensional model, where the water surface is horizontal across the section.

Point of interest 0 is located on the Coxs River arm. The predicted water level and the local depth averaged water velocity is shown in Figure 13. Although, there is nothing remarkable about the water level at this location, what is interesting is the depth averaged velocities. They are an order of magnitude smaller than the velocities predicted at the Dam. In addition, there is an abrupt change in the velocities. This could reflect the interaction of the the flows in this arm of the Lake by flows from the Wollondilly River arm of the Lake. The flows have almost reversed. This interaction of the flows is not possible with level pool routing.

The dominance of the flows from the Wollondilly River arm of the Lake is obvious from the simulated water surface and velocities shown in Figures 14-15 for location 1 and 2.

Here, the Coxs River arm is acting as a storage and the main path of the flow is from the Wollondilly River arm of the Lake, at location 1 through to location 2 and onwards to the Dam. The depth averaged velocity at these locations is very similar to those predicted for location 3 near Warragamba Dam.

It is straightforward to extract the duration of inundation from these hydrographs for a particular location and water elevation.

The simulation took approximately three hours to perform on a Surface Pro 7 with Quad Core i5 processor and 16Gb of RAM, available from any retailer. This would significantly reduce using a high end Windows PC with more processors.

Although, this is only a preliminary investigation, it does illustrate that a two-dimensional model can provide significantly more information than the use of level pool routing model.

5.2 Comparison with Level Pool Routing

Given adequate time, a comparison between the results from the two-dimensional model and the level pool routing could be easily performed for the 1990 flood. The level pool equation, (1) could be solved using the same triangular mesh that is used in ANUGA to rout the 1990 flood through Lake Burragorang. The storage, $S(t)$ in the Lake is given by summing the surface area of all the inundated elements representing the Lake multiplied by the water depth at each cell, which has a constant elevation throughout the Lake. This simple level routing approach could be used to test whether, level pool routing is justified for routing floods through Lake Burragorang. This comparison was not done by the consultants.

The assumption that level pool routing is acceptable for routing inflows through Lake Burragorang needs further justification using a much larger flood event than those used in this study and using a finer mesh to represent Lake Burragorang. We have demonstrated that it is feasible to use a two-dimensional model to simulate the impacts of floods upstream of Warragamba Dam. This could also include the implications of raising the Dam wall.

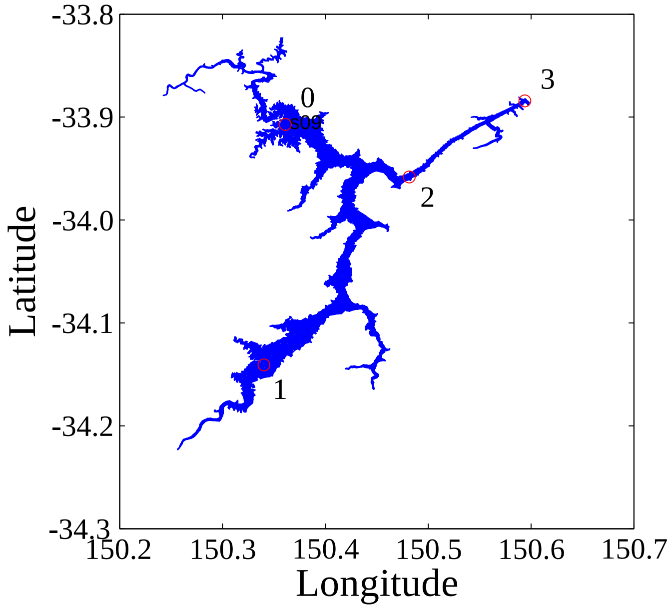


Figure 9: Location of points of interest in Lake Burragorang.

6 Risk Assessment

Risk assessment is also known as *quantifyling uncertainty* or *reliability analysis*. It is the process of establishing *prediction limits*, but incorrectly called *confidence limits*, on a process when the inputs to that process are not known with certainty. This is most processes and activities including mathematical models. There are numerous techniques for performing reliability analysis[25].

Monte Carlo is commonly used in uncertainty quantification to capture a system's or models variability to model parameters that are not known with certainty. It involves running a simulation many times with different random samples from the probability distribution of an input variable that is not known with certainty. The accumulated output from this process is a probability distribution of the model response, With the distribution, it is possible to place prediction limits of the models response. That is the possible range of outcomes given what is not known with certainty about the model and it parameters. Monte carlo simulations will generally involve numerous simulations to establish the prediction limits of the model response. This number is independent of the number of the random variables used in the model and the probability distribution which reflects its variability. what is not known about the variable.

Other approaches include, first-order second moment methods and the point estimate method. First-order second moment methods are suitable for estimating the expected or average model response and its variance. Point estimate methods are able to estimate higher order moments of the model response[11]. Both these techniques provide estimates of the statistical moments of a models response. A probability distribution is fitted to these moments and prediction limits inferred from the probability distribution. Both these methods only require a few model evaluation to estimate these moments compared to Monte Carlo simulation. A discussion of the various techniques for estimating uncertainty in simple hydrologic problems including, first-order second-moment, point estimate method and Monte Carlo simulations can be found in Zoppou and Li (1992)[25].

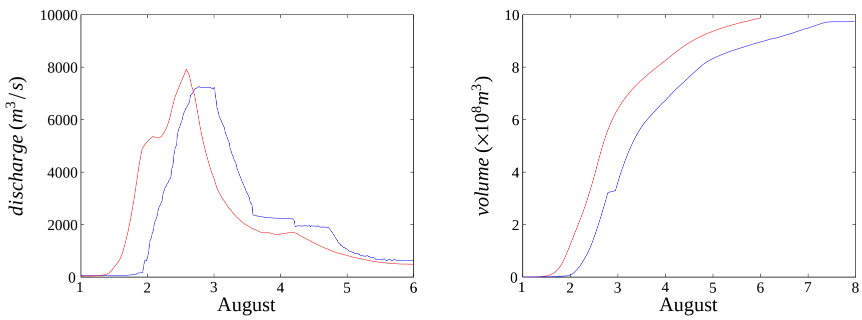
The point estimate method has been known since the 1970′s and is well established technique in geotechnical engineering. It is not well known in hydraulic engineering or Hydrology, although it can be found in the literature applied in this area[8, 25, 26].

Point estimate methods usually refers to methods that require only the knowledge of the model response, $\mathbf{Y}(\mathbf{X})$ at a specific set of values of the random variables, $\mathbf{X} = (x_1, x_2, \ldots, x_n)$ to calculate the statistical moments of the model response.

For example, in the three-point method the expected value, or mean of the model response with one random variable can be expressed in the form

$$E[\mathbf{Y}(\mathbf{x})] = \omega^+ Y(x^+) + \omega^0 Y(x^0) + \omega^- Y(x^-)$$

where ω are weights and x are the quadrature points or specific values of the random variable. The function or model, $\mathbf{Y}(\mathbf{X})$ need only be evaluated three times at the quadrature points, x^+, x^0 and x^- to estimate the expected



(a) (b)

Figure 10: The (a) recorded inflows into Lake Burragorang in red and the recorded discharge at Warragamba Weir immediately downstream of Warragamba Weir, in blue and (b) cumulative recorded inflows, in red and cumulative outflows for the August 1-6, 1990 flood .

model outcome. This is in contrast to many model evaluations that would be required using Monte Carlo simulation. To discount the use of more appropriate modelled for Warragamba Dam on the basis that thousands of simulations would be required, because Monte Carlo simulation was chosen at the reliability technique is short-sighted, since there are other techniques that could be employed. This was the rational for choosing DAMROU rather that TUFLOW to predict the progress of a flood through Lake Burraborang.

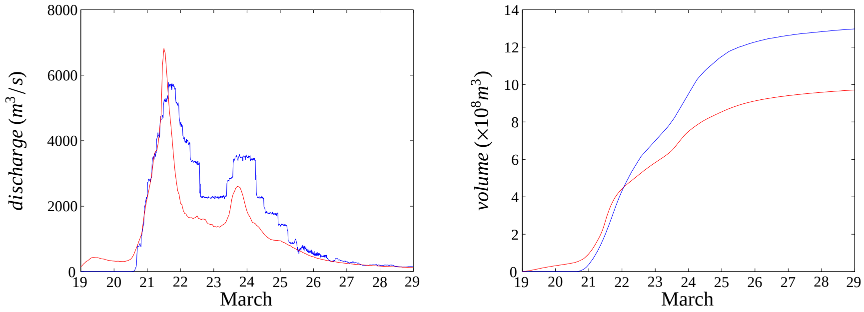
The original point estimate method required of the order of 2^k simulations, where k is the number of random variables considered in the simulations, that is parameters that are not known with certainty that are used in the simulation. ($2^{10} = 1024$). If ten random variables are considered in a problem, typically the point estimate method would require a $1,000$ or so simulations to estimate the statistical moments of the models response. Fortunately, the efficiency of original point estimate method has progressed and it now only required approximately $2k + 1$ evaluations. In the above example this would only involve 21 evaluations for uncorrelated variables.

Although only one random variable was considered by Issermann and Chang[8] in their simulation of flooding in an urban area in Glasgow, UK using ANUGA, reasonable estimates of the prediction limits were obtained with only three model evaluations using their choice of the point estimate method, compares with 500 simulations chosen for the Monte Carlo method.

Monte Carlo framework was established to model flood events based on randomly sampling each variable from within the range of possible inputs:

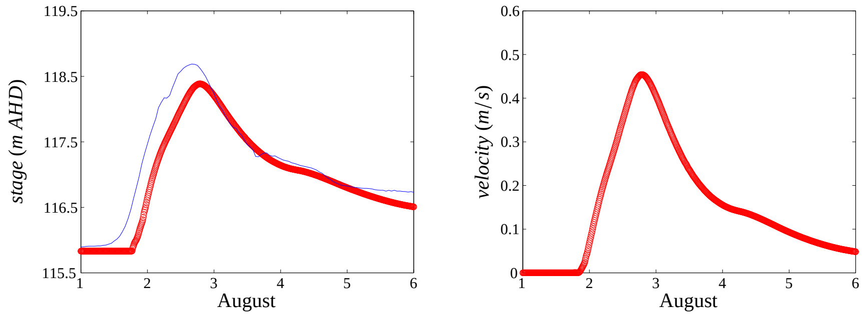
- *rainfall intensity and frequency - catchment average rainfall*
- *spatial pattern of rainfall - where in the catchment rain falls*
- *temporal pattern of rainfall - when in the event rain falls*
- *initial loss - rain 'lost' at the beginning of an event through infiltration into the soil*
- *pre-burst rainfall - rain that occurs before the most intense burst of the storm*
- *dam drawdown - the level of Warragamba Dam before the start of an event*
- *relative timings of tributary inflows*
- *tides.*

This is a reasonable selection of random variables for this problem. There are a max of eight random variables. Therefore $k = 8$ in the point estimate method. A version of the point estimate method would requite approximately 45 simulations significantly less that the *20,000 Monte Carlo runs of the existing dam and the raised dam option.* used by the consultants[2]. The point estimate method, obviously would not include tides as a random variable for simulating floods upstream of the Dam. This makes the use of a two-dimensional unsteady flow model based on the solution of the shallow water wave equations practical.



(a) (b)

Figure 11: The (a) recorded inflows into Lake Burragorang in red and the recorded discharge at Warragamba Weir immediately downstream of Warragamba Weir, in blue and (b) cumulative recorded inflows, in red and cumulative outflows for the March 19-29, 2021 flood .



(a) (b)

Figure 12: The (a) recorded, in blue and predicted water level, in red at point of interest 3, see Figure 9 near Warragamba Dam and (b) the predicted velocity for the April 1-6, 1990 flood .

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including that some sites (generally upstream) do not contain observed hydrographs (e.g. Nattai River at causeway and Kowmung River at Cedar Ford), while the gauge at Jooriland was found to be overestimating flows. However generally a good representation of observed rate of rise is achieved by the Monte Carlo modelling[2].

We had chosen two flows at random. It is difficult to justify any modelling that relies on unreliable data. Issues with the data was pointed out in the environmental impact statement and we have illustrated in Figure 11. NSW Water should rectify this before relying on making any decisions based on inadequate data.

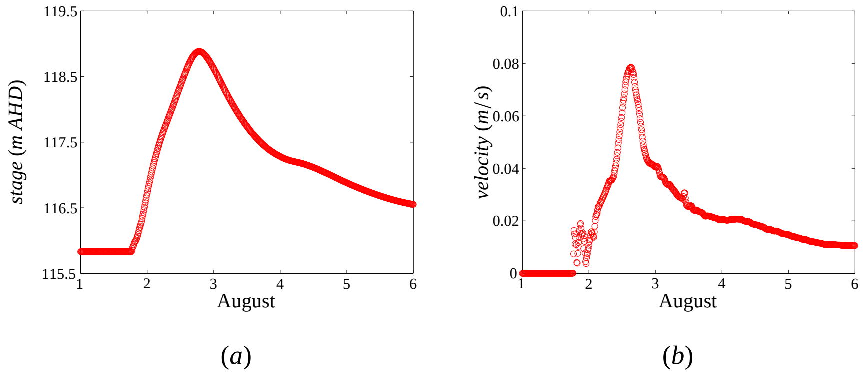


Figure 13: The (*a*) predicted water level and (*b*) the predicted velocity at point of interest 0, see Figure 9 for the April 1-6, 1990 flood .

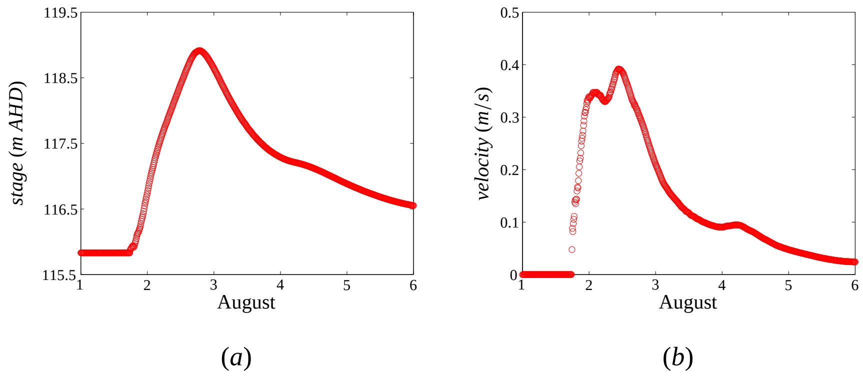


Figure 14: The (*a*) predicted water level and (*b*) the predicted velocity at point of interest 1, see Figure 9 for the April 1-6, 1990 flood .

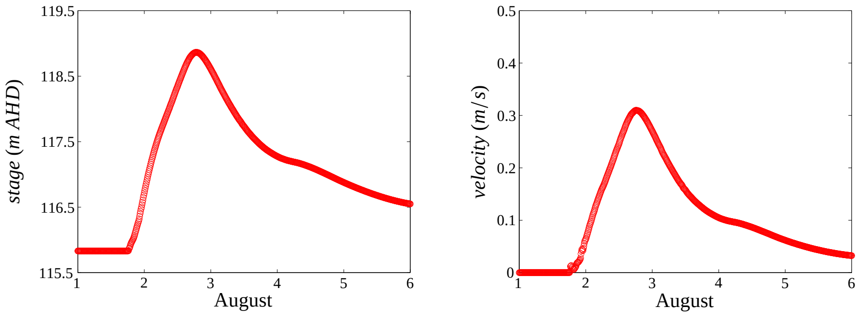
Table 3: Peak inflows into Lake Burragorang and releases from Warragamba Dam and their corresponding approximate AEP[14] for the August, 1990 flood.

Location	Peak discharge (m^3/s)	Approx. AEP
Coxs River at Kelpie Point (212250)	2345	1:30
Kowmung River at Cedar Ford (212260)	809	1:12
Woolondilly River at Jooriland (212270)	5031	1:25
Nattai River at Causeway (212280)	473	1:25
Warramanga Wier (212241)	7259	1:28

7 Conclusions

The urban development in the Hawkesbury-Nepean catchment has changed the primary role of Lake Burragorang from a water supply reservoir to also function as a flood mitigation reservoir. To satisfy this secondary objective, it is proposed that Warragamba Dam be raised to increase the capacity of Lake Burragorang so that it can also attenuate major floods, thereby reducing their impact on the urban environment downstream of the Dam. The raising of Warragamba Dam will have an environmental impact predominately on flora and fauna upstream of the Dam. To asses this impact, extensive hydrological modelling was undertaken.

The modelling of major design floods is constrained by available data, model limitations and the random variability



(*a*) (*b*)

Figure 15: The (*a*) predicted water level and (*b*) the predicted velocity at point of interest 2, see Figure 9 for the April 1-6, 1990 flood .

Table 4: Peak inflows into Lake Burragorang and releases from Warragamba Dam and their corresponding approximate AEP[14] for the March, 2021 flood.

Location	Peak discharge (m^3/s)	Approx. AEP
Coxs River at Kelpie Point (212250)	3761	1:65
Kowmung River at Cedar Ford (212260)	2336	1:65
Woolondilly River at Jooriland (212270)	1079	1:5
Nattai River at Causeway (212280)	316	1:15
Warramanga Wier (212241)	5774	1:22

of flood events. The consultants made a number of modelling choices. To account for the variability of flood events, Monte Carlo simulations were chosen. This choice necessitated the use of simple hydrologic methods instead of more detailed analysis using hydrodynamic modelling. Unfortunately, some of theses decisions were not justified and alternative approaches were not considered.

We have demonstrated that with limited resources and time it is possible to develop a two-dimensional hydrodynamic model of flows in Lake Burragorang. This model provides an opportunity to validate the choices made by the consultants. In particular the use of level pool routing and ignoring flow velocities.

After examining the consultants report and the development of our own two-dimensional hydrodynamic model of Lake Burragorang we have concluded that;

- The application of hydrological model, RORB upstream of Warragamba Dam is appropriate.
- The use of the level pool routing model DAMROU was not justified.
- A two-dimensional hydrodynamic model can provide more detailed information than one-dimensional and hydrologic models.
- Upstream simulations do not include other flood characteristics that are detrimental to the environment, in particular the velocity of the water.
- There are no prediction limits of the model results which are available from the Monte Carlo simulations.
- The rationale for not using the more accurate two-dimensional model for Lake Burragorang is that it is too prohibitive to perform Monte Carlo simulations. This is correct, however, it is more difficult to justify if the point estimate method is used instead of Monte Carlo simulation.

Biographical Notes

Prof. G. Stephen G. Roberts, Emeritus Professor, Mathematical Sciences Institute, College of Science, The Australian National University. Member of the Australian Mathematical Society, Society of Industrial and Applied Mathematics, and the American Mathematical Society. Forty years of experience in the computational solution of fluid flow problems. Lead developer of the ANUGA flood/tsunami modelling package.

Dr Christopher Zoppou, B. Eng., M. Eng. Sc., M. Eng., M. Sc., Ph.D (Civil Engineering), Ph.D (Applied Mathematics), Life Member, ASCE. Visiting Fellow, MSI, College of Science, The Australian National University. Forty years experience in hydrology and hydraulic modelling: quantifying uncertainty, water quality modelling, unsteady flow modelling.

Ms. Claire Rogers, B. Sc. (Physical Geography and Environmental Geosciences) *In progress*, B. PEE (Politics) *In progress*. Research Officer, Colong Foundation for Wilderness,

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Warragamba Dam: Review of Downstream Hydrology

On behalf of the Colong Foundation for Wilderness.

Dr Floris Van Ogtrop

The following is a brief submission on the proposal to raise the Warragamba Dam by 14m and is based on views I have formed over the last 20 years working in and around water.

I will focus firstly on the modelling aspects of the EIS report and secondly the alternatives to raising the dam wall that have been explored in the Warragamba Wall raising EIS.

It is acknowledged that modelling river flow from upstream in the Greater Blue Mountains Heritage Area over Warragamba Dam and then down through Sydney's populous western suburbs and towards the exit into Broken Bay north of Sydney is a complex and costly task. It is also acknowledged that this process is being primarily driven by increased flood risk due to growing population and wealth in potentially flood affected areas and changes in rainfall patterns and temperature due to global warming. A major concern is protecting our iconic Greater Blue Mountains World Heritage Area, which is also under threat from a changing climate and population pressure. The proposal is to raise the Warragamba Dam wall by 14m to decrease flood risk and the EIS focuses on understanding the upstream and downstream impacts of raising the wall using hydrological and hydraulic modelling as the primary tool. The main criticisms I have of the model reporting are:

1) lack of reporting on model accuracy and uncertainty, and
2) lack of reporting on whether the models are properly validated.

While some of the information that is lacking from the EIS can be found in the original Hawkesbury-Nepean Valley Regional Flood Study (Diagrams 1-11), these results should be reported within the EIS, including discussion on how uncertainties will impact the simulations modelling the impacts of raising the dam wall. At best we must trust comments such as "*The modelling reproduces observed events well, reproduces flood frequency analysis at dam, Penrith and Windsor and other key variables like rates of rise and duration of inundation. This provides a high level of certainty in the results*" (page 29, Appendix H1). This lack of reporting makes it difficult for both experts and decision makers to be confident that the model is robust and more importantly understand what the consequences are if the model is not robust. While the modelling limitations are given in different parts of the EIS, it is not clear what the consequences are of these limitations, for example, what is the consequence of paucity of data on in-bank bathymetry on model output (page34. Appendix H1)? In modelling language, how sensitive is the model to changes in bathymetry? As far as I can tell, this is also not discussed in the original Hawkesbury-Nepean Valley Regional Flood Study.

The EIS is focused on raising the dam height by 14m and the exploration of alternatives is minimal. Why is there not more information on other options such as other dam heights (less than 14m) or implementing downstream flood sensitive designs? Importantly, a key issue is that raising the dam wall can in fact decrease the resilience of downstream communities, particularly if further development is allowed to occur in the floodplains as a result of the increase in perceived safety due to the raised dam wall. This is in addition to potential upstream impacts on a world heritage area.

I had the privilege to be able to work in the Netherlands in the early 2000s when the concept of "Room for the Rivers" was first being implemented. This concept saw the shift in policy from building higher and more levees and dams to opening up the floodplains again to allow the rivers to flood. Now 15 -20 years later, we are seeing benefits of this policy shift. For example, one project, the widening of the Waal River in Nijmegen in the East of the Netherlands, has resulted in significant reductions in river height as well as creating benefits for the community in terms of opening up nature reserves. It is important to note that this shift has not resulted in the removal of all existing dams and levees and in some places these have been or will need to be reinforced, but it has resulted in a more holistic view of flood management that is more sensitive to nature and is more resilient. The proposal to raise the dam and the EIS looking at the impacts and alternatives, clearly does not explore a holistic approach to flood management and comments such as "*Generally, these measures do not result in any reduction in flooding extent or frequency, and so cannot be considered substitutes to flood mitigation infrastructure that would reduce significant existing risk exposure*" found in Chapter 4 of the report are counter to the concept of allowing rivers to flood as they should and may lead to the levee paradox. Given that a hydraulic model has been developed, exploration of other scenarios such as maintaining or creating more room for the rivers is plausible and may in the long term be a more cost-effective solution.

To briefly summarise, there needs to be more transparency in and around the uncertainty of flood estimates under the different dam scenarios and a more thorough exploration of alternative flood mitigation and flood adaptation scenarios.

Dr. Floris van Ogtrop
Senior Lecturer, The University of Sydney

13. Project rationale, alternatives and economic justification

More sustainable and economically rational alternatives to mitigate flood risk in the Hawkesbury-Nepean Valley exist but were discounted by the Project's proponent before the SEARs were ever issued through the Hawkesbury-Nepean Valley Flood Management Strategy.[48] Despite representations about alternative flood mitigation infrastructure made by numerous parties, including the Australian insurance industry,[49] the proponent has continued to pursue the raising of Warragamba Dam as their sole flood mitigation option.

Continued secrecy and lack of transparency

It is impossible to validate or quantify the purported downstream benefits and impacts on the basis of the information provided in the EIS. No cost benefit analysis or business case has been provided for public review; neither are the inputs that informed the costing of the Project or its possible alternatives available. For example, there is no way to verify the secondary benefits of alternative options, such as non-emergency use of evacuation routes.

How such precise conclusions can be drawn in the EIS about the downstream benefits, as seen in the EIS Executive Summary and Appendix H1, without the operational protocols or the underlying economic modelling for the Project being provided is unknown.

Project cost

Chapter 4 of the EIS states that the capital cost of the Project is $1.6 billion. However, no breakdown of capital cost is provided in the exhibited EIS. On the other hand, it has been suggested in calculations leaked to the media that biodiversity offset costs are several orders of magnitude larger than the $1.6 billion in themselves. It is absurd that the proponent has not provided a detailed breakdown of capital costs.

Extended downstream flood peaks

Flood peaks will undoubtedly be extended downstream in a raised dam scenario as water is released from the flood mitigation zone of the raised dam wall. However, without any operation protocols or spillway designs being included in the EIS, the changed magnitude and duration of downstream flood peaks remains unknown. As such, the downstream economic, social and

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environmental impacts of the changed downstream flood regime cannot be ascertained from the EIS. This is a fundamental flaw in the EIS, which is not compliant with the SEARs requirements as discussed in Section 2 of this submission.

Liability issues for downstream communities and the insurance industry

It is a clear requirement of SEARs requirement 2.1(o) that the statutory environment of the Project must be provided in the EIS. The SEARs state:

"*statutory context of the Project as a whole, including: − how the Project meets the provisions of the EP&A Act and EP&A Regulation; − a list of any approvals that must be obtained under any other Act or law before the Project may lawfully be carried out*".

However, from leaked information obtained by the media (Appendix F) and evidence given by the Hon. Stuart Ayres to the NSW Legislative Councils, it has become evident that further legislative changes must be made before the raised dam wall can be operated as described in the EIS. Details of these statutory changes, however, are not provided in the EIS.

Titled Managing a Flood Mitigation Zone at Warragamba Dam, the NSW Government report highlights the plethora of risks facing the proponent if legislation is not amended, including breach of statutory duty and vicarious liability:

"The current statutory protections have been adequate given the dam's operating environment. However, this level of protection is inadequate in an operating environment which includes a flood mitigation function for Warragamba Dam.

"At a high level, WaterNSW would require: amendment to its enabling legislation to provide complete statutory limitation of liability to the operator, its directors, officers and employees for actions performed in the undertaking of its statutory functions".

If WaterNSW were not to indemnify themselves through the successful passage of such legislation, they would be placing the risk of improper operation of the raised dam back onto residents and insurers in downstream communities. Indeed, the failure to provide details of this significant cost risk to downstream communities and the Australian insurance sector is again contrary to the SEARs requirements, notably requirement 8.2(h) that states that the EIS must assess and model *"any impacts the development may have on the social and economic costs to the community".*

The Hon. Stuart Ayres gave evidence to the NSW Legislative Council on 27 October 2021 regarding the legislation, stating:

"The legislation will need to be drafted to reflect the fact that you are now operating the dam in a dual fashion. A dam will need to do two things: It will need to store water and it will need to store water up to a height that is effectively consistent with where the level is now. When you raise the

dam wall, you are raising the dam wall for the purposes of creating airspace. Right now the operation and function of the dam is designed entirely to protect Sydney's drinking water supply, so you have to change the legislation to allow the dam to have a dual purpose...

"If the Government decides to present this legislation to the Parliament, it would be doing so on the basis that we would want to be able to protect Sydney's drinking water assets as well as run flood mitigation capacity. If there were members of the Parliament that wanted to vote against that and allow the dam to fill and utilise all of the airspace that we have just built."

Based on the evidence given by the Hon. Stuart Ayres, it would seem to be the intention of the proponent and the NSW Government is to only pass such legislation after the raised dam has been given planning approval and is constructed. Preempting the passage of such critical legislation through the NSW Parliament after approval, funding and construction of the Project has taken place is extremely problematic.

It is abundantly clear the economic costs, alternatives, downstream impacts and statutory environment for the Project have not been adequately considered in the EIS as is required under the SEARs and EPBC Act.

The attached paper by Professor Jamie Pittock of the Australian National University details alternative flood management practises for the Hawkesbury-Nepean Valley . Further information on these matters can also be found in submissions made to the EIS exhibition by Professor Jamie Pittock and Dr Neil Perry of Western Sydney University.

Managing flood risk in the Hawkesbury – Nepean Valley

A report on the alternative flood management measures to raising Warragamba Dam wall.

September 2018

Associate Professor Jamie Pittock

Fenner School of Environment & Society

The Australian National University.

Dr Jamie Pittock (BSc, Monash; PhD, ANU) is an Associate Professor in the Fenner School of Environment and Society at The Australian National University. He is also Director of International Programs for the UNESCO Chair in Water at ANU. Jamie worked for environmental organisations in Australia and internationally from 1989-2007, including as Director of WWF's Global Freshwater Programme from 2001-2007. His research from 2007 has focussed on better governance of the interlinked issues of water management, energy and food supply, responding to climate change and conserving biological diversity. Jamie directs research programs on irrigation in Africa, hydropower and food production in the Mekong region, and sustainable water management in the Murray-Darling Basin. He is a member of the Wentworth Group of Concerned Scientists, the board of Water Stewardship Asia-Pacific, and is a scientific adviser to WWF Australia. Dr Pittock teaches courses on environment and society as well as on climate change adaptation.

This report was prepared for the Colong Foundation for Wilderness.

Flood risk in the Hawkesbury-Nepean floodplain

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 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.

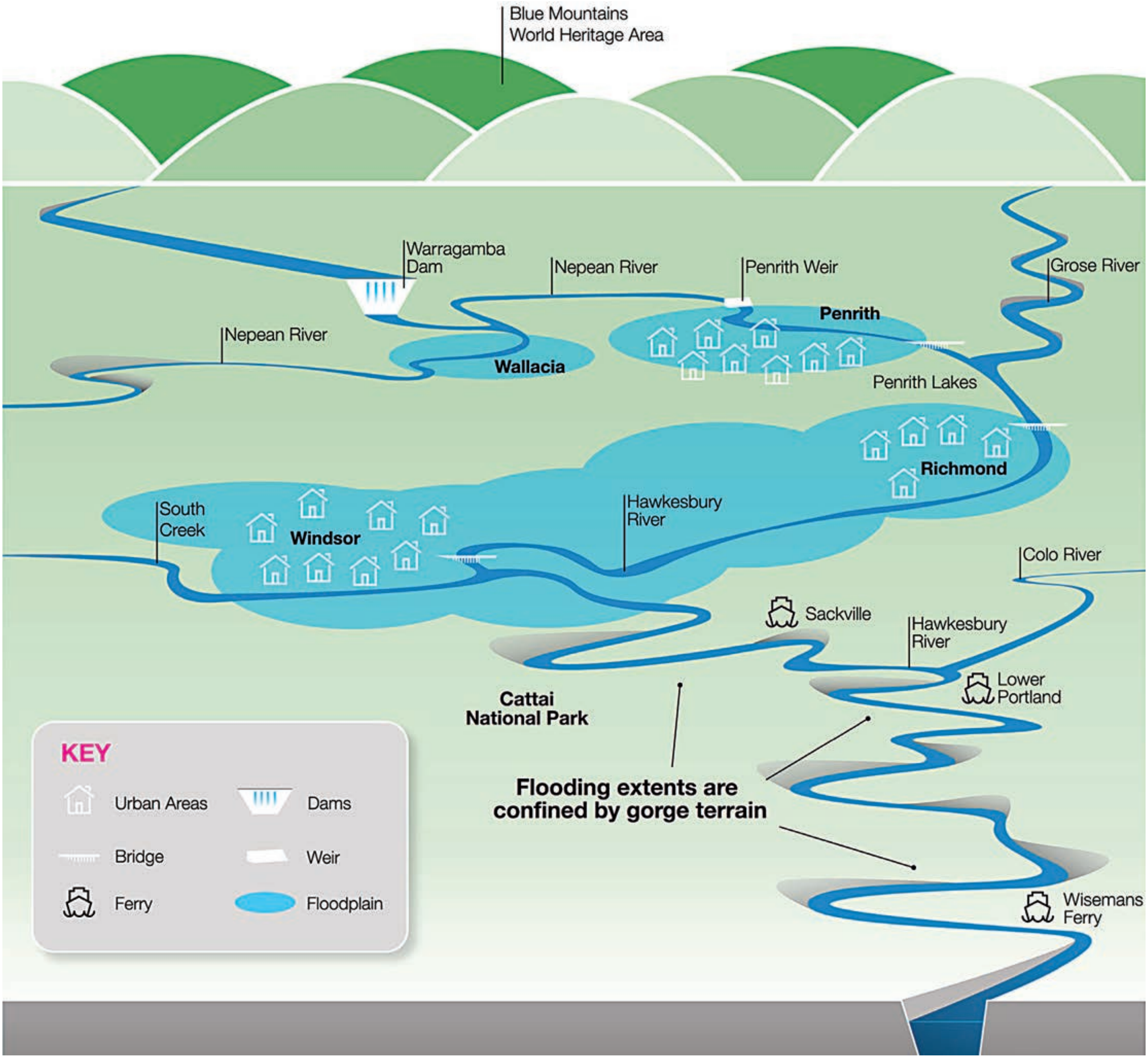

Figure 1. The Hawkesbury-Nepean floodplain (Infrastructure NSW Flood Factsheet, February 2018).

NSW Government response

The NSW Government has prepared a Hawkesbury – Nepean Valley Flood Risk Management Strategy (Infrastructure NSW 2017). 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 (Colong Foundation for Wilderness 2018).

The Hawkesbury – Nepean Valley Flood Risk Management Strategy concludes that raising the dam is the most cost-effective method of managing flood risk by applying a very narrow economic assessment to the project. For each flood risk reduction option, the Infrastructure NSW assessment converts lack of vehicles evacuated into projected deaths of people, turning these deaths into a monetary value, then adding property losses to estimate the cost of flood damage. This is then compared to the cost of each intervention, such as raising Warragamba Dam wall. Their calculations exclude any additional benefits of alternative risk management measures. For example, in considering the $950 million costs of upgrading roads to allow residents to evacuate at higher flood levels, none of the other benefits of an improved road system appear to have been considered, such as increased road safety and faster travel times. The cost benefit analysis also excludes any estimate on the economic benefits of conserving the Blue Mountains National Park and World Heritage Area upstream of the proposed raised dam.

The NSW Government's strategy is constrained by two overriding policy decisions, namely that (i) it will not reduce the 5,000 houses on the most flood-prone lands, and that (ii) it will allow an additional 134,000 people to settle in harm's way on the floodplain over the next 30 years (Infrastructure NSW 2017). The flaws in such a policy were seen during the 2011 Brisbane floods. One of the reason for the severe flood damages during the Brisbane floods were previous state and local government decisions to allow housing development on high-risk areas of the Brisbane River floodplain, falsely believing Wivenhoe Dam had 'flood-proofed' the valley (Cook 2017).

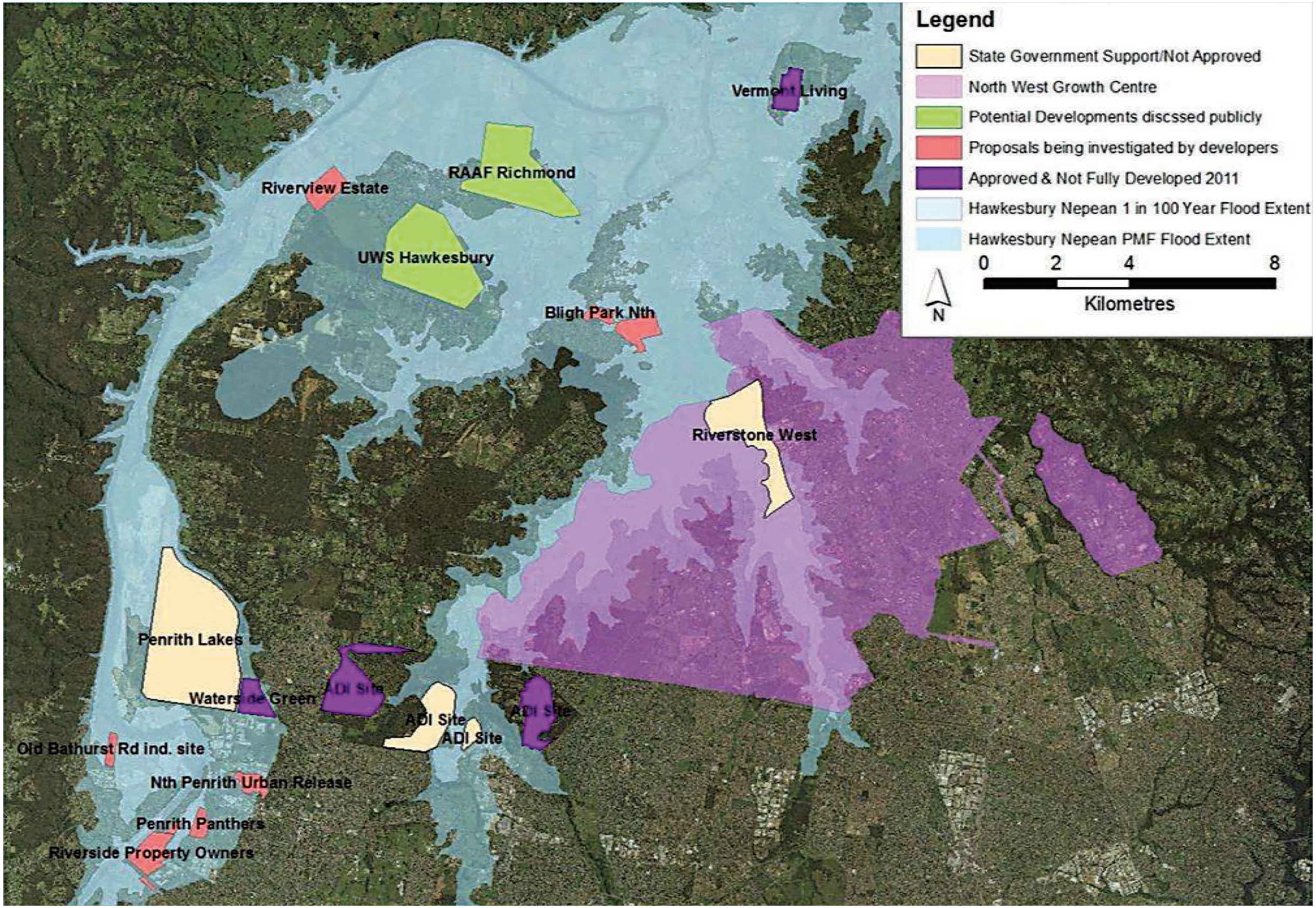

Figure 2. Future development areas overlaid with flood extend on western Sydney floodplains (Infrastructure NSW, Molino Stewart 2012a)

Importantly, no configuration of Warragamba Dam will prevent flooding in the Hawkesbury-Nepean Valley. Since the dam's construction in 1960, contribution of the Warragamba catchment to major flooding events has ranged from 73% to 42%. An average of 45% of floodwaters originate from catchment areas that are not upstream of Warragamba Dam (NSW SES 2015). This means that even if a raised Warragamba Dam was to hold back some flood waters, other catchments could still cause significant flooding in the valley. In fact, flood waters from the Grose River alone can cause moderate to major flooding of Richmond in the lower Hawkesbury (AWACS 1997).

Further, flood mitigation dams tend to 'control' only small and medium sized floods from upstream catchments. In large flood events, once a dam is full, operators have no choice but to spill the water from the dam. This was seen in the case of Queensland's Wivenhoe Dam which was kept half full to provide 1,450 billion litres of flood mitigation airspace. The airspace was not enough to prevent extensive damage to Brisbane when the dam waters were released in the January 2011 floods. Water released from the dam was ruled as the "principal immediate cause" of the floods by the Insurance Council of Australia (2011), which affected over 200,000 people and cost insurers $2.55 billion (van den Honert & McAneney 2011).

While a bigger flood control airspace in a dam may delay a flood peak, the captured water takes longer to release from the dam, and so prolonging flood durations in downstream areas. It would appear that prolonged downstream flooding resulting from the raised dam has not been considered in the Infrastructure NSW flood strategy.

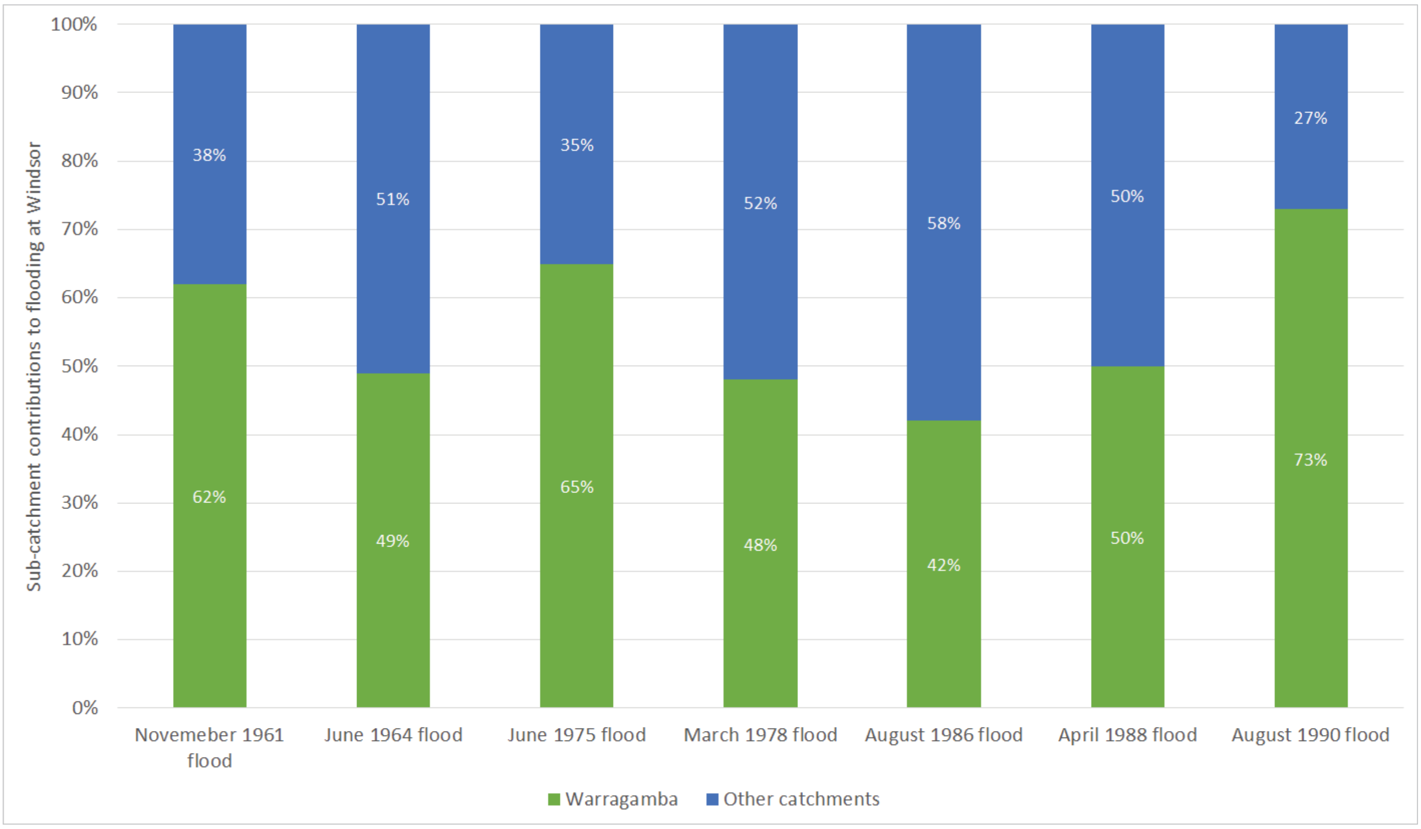

Figure 3. Sub-catchment contributions to flooding at Windsor from recent floods (NSW Office of Water 2014).

Alternative options – a different vision

There are several alternative options that the NSW Strategy either does not adequately consider or does not consider at all. Four key alternative options are discussed below.

1. Provide alternative flood storage in Warragamba Dam.

Lowering the full storage level of Warragamba Dam by 12 metres would free 795 billion litres of airspace for flood control. Further, lowering the full storage level would have no upstream environmental impacts and can be implemented immediately. This option was briefly mentioned as part of the Hawkesbury – Nepean Valley Flood Risk Management Strategy but dismissed on the grounds that it would compromise Sydney's water security (Infrastructure NSW 2017). Independent, peer reviewed research by the University of Technology Sydney has examined this option and shown that coupled with use of current and new desalination plants, lowering the FSL could be more cost effective than raising the Warragamba Dam wall (Turner et al. 2016). The University of Technology modelling found that this approach not only provides some level of flood mitigation, but also enhances Sydney's water security. Feasibly and cost benefit analysis research has also been undertaken by the University of Sydney on this option (Paton 2014), as well as receiving support from UNSW water specialist Assoc. Prof Stuart Khan (2012).

2. Stop putting people in harm's way.

The state government is proposing to allow a further 134,000 residents to join the 70,000 existing residents on the floodplain over the next 30 years (Infrastructure NSW 2017; Molino Stewart 2012a). As discussed above, no dam can stop the largest of floods, so this proposal will put more people in harm's way regardless of whether the dam wall is raised. Infrastructure NSW consultants have stated that over 16,000 residential lots are currently unable to be developed "due to flooding constraints" (Molino Stewart 2012b). These lots are located on flood-islands that are unable to be properly evacuated during flood events (Molino Stewart 2012b). The NSW Government's strategy states that it will permit development on land immediately above the 1:100 flood level. In the United States, a minimum 1:500 year threshold is now widely used (Wenger et al. 2012), whereas in the Netherlands they have adopted a 1:1,250 year flood return threshold (Wenger et al. 2013). The NSW Government should impose a safer planning standard on local governments that is in line with the rest of the western world. Doing so would save billions of dollars in future flood damages and dramatically reduce the risk to life that floods pose.

Changes to flood planning limits have already been put forward in the Land Use Guidelines prepared for the Hawkesbury-Nepean Floodplain Management Steering Committee. These guidelines highlighted that more comprehensive floodplain risk management measures are required, rather than a single 1:100 flood planning limit that is currently applies (HNFMSC 2006). This is not to say that the Hawkesbury-Nepean floodplains should be undeveloped. These guidelines describe the need to develop 'graduated planning controls', which allow for maximum use of the floodplain, while ensuring that risk to property and life is minimised (HNFMSC, 2006).

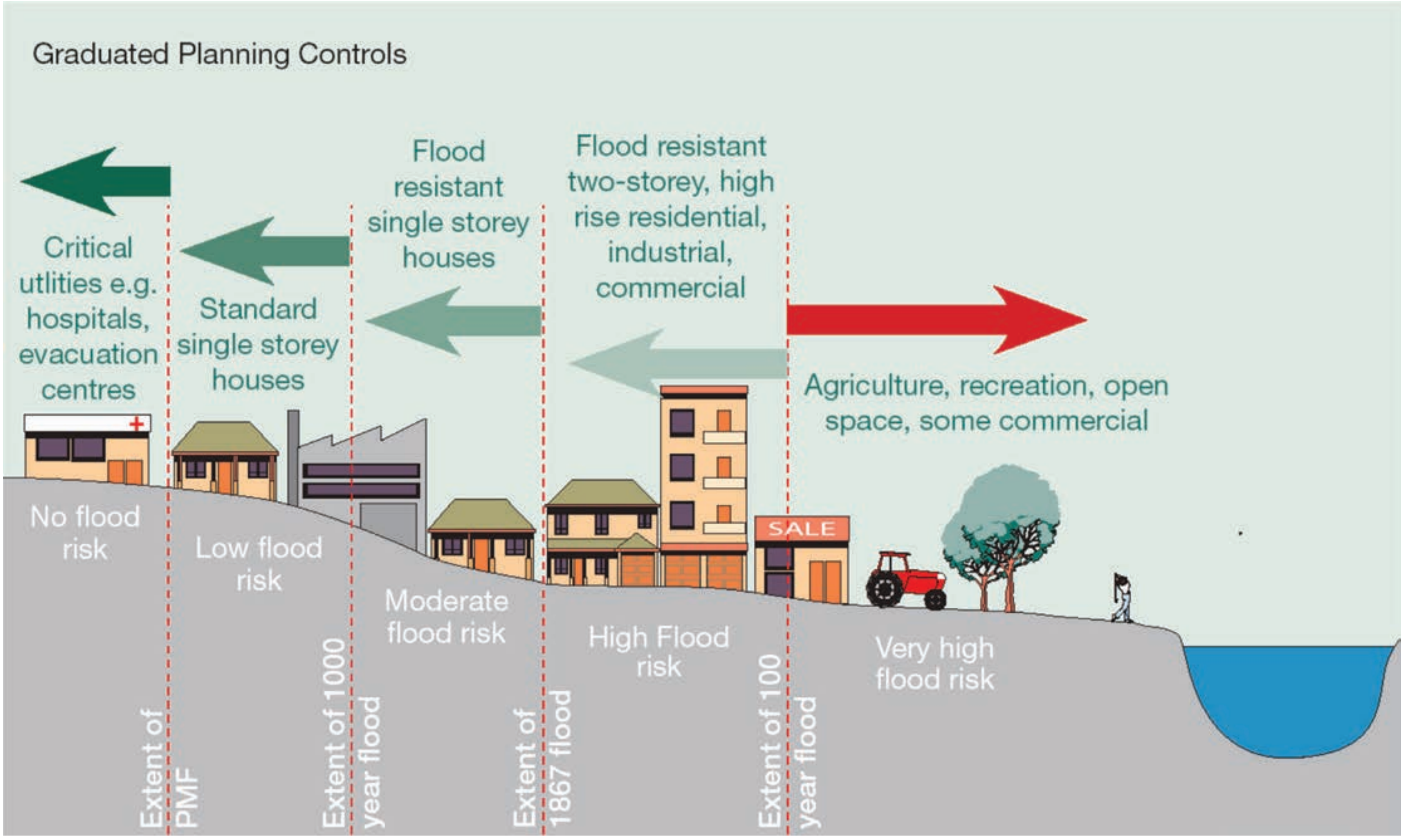

Figure 4. An example of distribution of Land Uses on the Floodplain to reduce risk (HNFMSC 2006)

3. Improve evacuation routes.

Previous government investigations into flood mitigation strategies have found that effective evacuation is the only measure that guarantees a reduced risk to life in the Hawkesbury-Nepean Valley (Infrastructure NSW 2017). Given the multitude of catchments from which floodwaters are sourced, a $950 million program of upgrading roads to allow evacuation at higher flood levels, as was consider before being dismissed due to cost in the Government's 2017 strategy, would dramatically increase the safety of residents in the Hawkesbury-Nepean Valley. The Windsor Viaduct, completed in 2005, is an example of such infrastructure.

An evacuation infrastructure analysis that was completed for Infrastructure NSW (Molino Stewart 2012c) found that significant flood evacuation upgrades were needed in the Hawkesbury-Nepean Valley. Without evacuation infrastructure upgrades, the analysis found there was a significant risk that people would not be able to evacuate their homes before roads became inundated by flood waters. The report recommended that evacuation routes surrounding Windsor, Bligh Park, Richmond and Penrith be significantly improved. The report also noted that new floodplain development proposals in the north-west corridor of Sydney, including at Penrith Lakes, would put significant pressure on evacuation routes into the future.

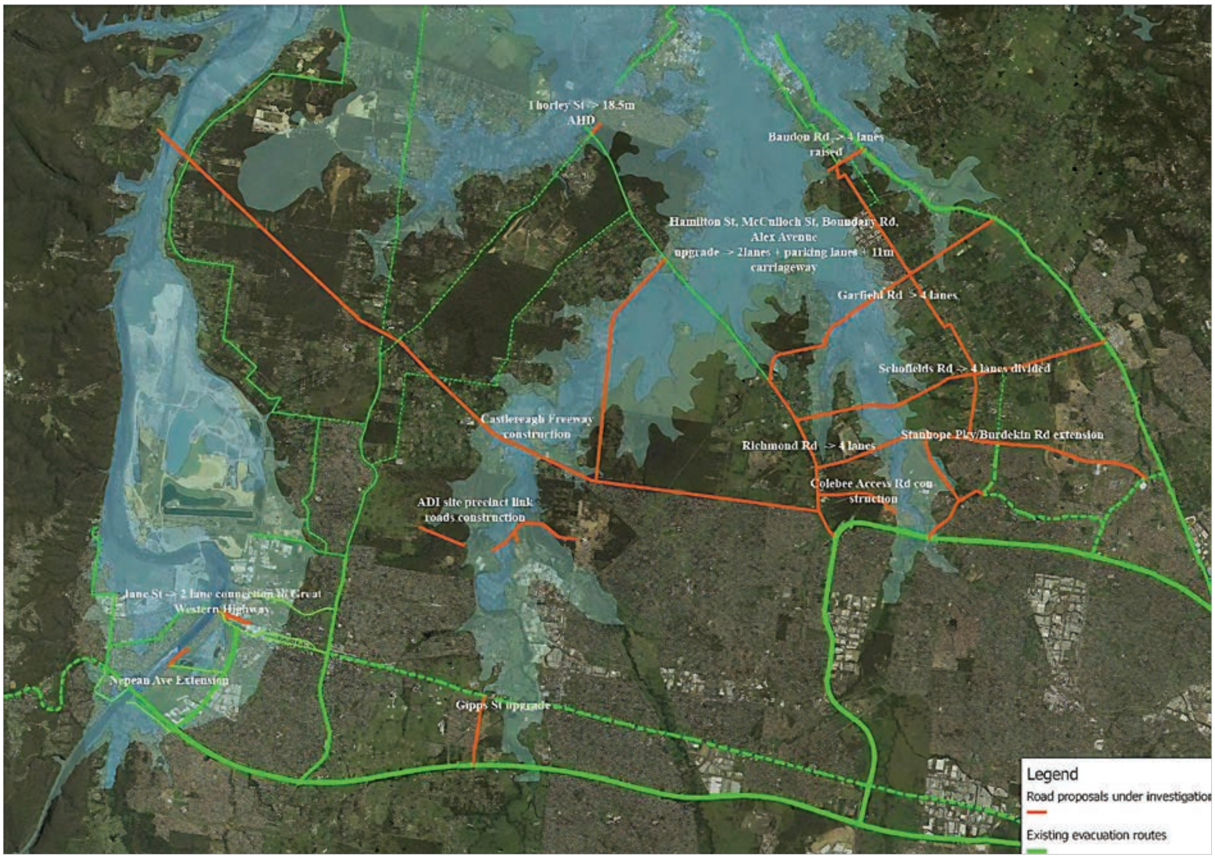

Figure. 5 Proposed and existing flood evacuation infrastructure in North-West Sydney (Infrastructure NSW, Molino Stewart 2012c).

4. Relocate the most flood prone residents.

A large number of people on the Hawkesbury-Nepean floodplain live in houses that are flooded regularly: 5,000 houses lie under the 1:100 year flood level, and a further 7,000 lie under the 1:500 year flood level (Infrastructure NSW 2017). Importantly, many of these residences can potentially be flooded by lower catchment tributary rivers that are not regulated by Warragamba Dam. Around the world, in Europe, the United States and China, governments are increasingly relocating people living in harm's way. Such relocations have also happened in Australia: most recently, the town of Grantham was relocated after the 2011 Queensland floods (Wenger et al. 2013). More than 100 residences were moved to higher ground, and the shift is believed to have reduced the damage bill from the latest floods by "tens of millions of dollars". Relocation also has recent precedents in NSW. For example, 147 residences were acquired under the high noise portion of the Sydney airport flight path (Sydney Airport 2018).

While the NSW Government puts the cost of relocation at $3.3 billion (Infrastructure NSW 2017), the cost recovery of such a scheme should be properly considered in terms of the alternative economic benefits of floodplains. Relocation could occur in a staged manner over several decades, and by removing the most frequently flooded properties, the total flood damage bill will be significantly reduced. In other countries, floodplains have been restored for agriculture, forestry, fisheries, recreation and nature conservation (Ebert et al. 2009, Pittock and Xu 2011). The Dutch Government program of giving "room for the river" is an example of how regional communities like Arnhem and Nijmegen on the Rhine River can thrive with targeted relocation for better flood management (Bekhuis et al. 2005).

Conclusion

The NSW Government's strategy for managing flood risk in the Hawkesbury-Nepean Valley is predicated on allowing more people to move into harm's way. The assessment of flood control favours raising the Warragamba Dam wall by ignoring its environmental and social impact, and any the non-flood control benefits of alternative options. Alternative flood management options have additional benefits for western Sydney, including greater safety for the most flood prone residents, better transport, a more vibrant agricultural sector, a healthier environment and improved water security. It is therefore crucial that other flood management measures are considered in a transparent process that is tested through an independent review process to avoid the serious economic and social impacts of major flood events.

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14. Community and social licence

There is no community-based movement in support of the raising of the Warragamba Dam wall. While support for the proposal by sections of the property industry is unsurprising, the reversal of support from the Australian insurance industry, which has a self-evident and long term commercial interest in flood mitigation in western Sydney, is of fundamental significance.

The Australian insurance industry

The Insurance Council of Australia (ICA), a previously influential advocate for the dam Project before 2021, dramatically reversed its support in early 2021. It has called on the government instead to find alternative methods to reduce flood risks in the Hawkesbury-Nepean Valley.

Andrew Hall, the Chief Executive Officer of the ICA has said, “[T]he position of the general insurance industry is now that without satisfactory environmental and cultural heritage impact assessments being completed and made public to allow for [a] full and open assessment, the industry is unable to support the proposal as it currently stands.

“We would advocate for the exploration of alternative mitigation options to reduce flood risks for downstream communities in consultation with the industry and traditional owners.”[50]

Australia’s largest insurance company the Insurance Australia Group (IAG) also announced its withdrawal of support for the raising of the Dam wall as a solution to flood management at its Annual general Meeting in October 2020.[51]

IAG Chair, Elizabeth Bryan said, “In the past we have expressed support for the raising of the wall,however we now have additional information concerning the probable loss of significant cultural heritage sites and important natural habitats.”[52]

QBE, Australia’s third largest insurer, has also reversed its previous support for the raising of the dam wall in the face of more sustainable and valley-wide solutions to flooding.[53]

Local Government

The Local Government Councils covering both upstream and downstream catchments have expressed their opposition to the dam Project, as indicated through their submissions to the EIS currently on exhibition. These councils include Blue Mountains City Council, Wollondilly Shire Council, Hawkesbury City Council and Penrith City Council.

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[50] Sydney Morning Herald (2021). Retrieved from: http://bitly.ws/g26R
[51] Australian Financial Review (2020). Retrieved from: http://bitly.ws/g26P
[52] The Guardian (2020). Retrieved from: http://bitly.ws/krpZ.
[53] Sydney Morning Herald (2021). Retrieved from: http://bitly.ws/krqg.

Blue Mountains and Wollondilly Councils have jointly hosted a “mayor's event” at Springwood in November 2019 to demonstrate vigorous and fundamental opposition to the dam Project, as well as significant rallies and public meetings.[54] Both councils have continued to advocate against the Project, as evidenced by numerous actions and media releases over the past three years.[55]

Penrith Council has voted to support a staff recommendation asserting that a host of matters raised in the EIS are not then adequately addressed. Hawkesbury Council staff have made fundamental criticisms of the EIS.

Select Committee on the Proposal to Raise the Warragamba Dam Wall

In November of 2021, the Select Committee on the Proposal to Raise the Warragamba Dam Wall handed down a bipartisan interim report (Appendix D) recommending that the dam wall raising should not proceed. Many of its recommendations relate to the inadequacy of assessments in the EIS.

The Colong Foundation for Wilderness supports all the recommendations in the Select Committee’s interim report given the breadth of evidence it has heard and considered over its six hearings.

International and National World Heritage bodies

The International Union for the Conservation of Nature (IUCN) and the International Commission on Monuments and Sites (ICOMOS) provide expert advice to the UNESCO World Heritage Committee on natural and cultural matters respectively, including all recommendations for endangered and delisting decisions for World Heritage properties.

It is of critical importance that both advisory bodies have objected to the Warragamba Project in the strongest possible terms due to the natural and cultural impacts it would have in the Greater Blue Mountains World Heritage Area.

The Greater Blue Mountains World Heritage Advisory Committee, a statutory committee which advises NSW and Commonwealth Environment Ministers on protecting the Outstanding Universal Values of the Greater Blue Mountains World Heritage Area, has objected to the Project (Appendix C).

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[54] Blue Mountains City Council Media Release (2021). Retrieved from: http://bitly.ws/krxT.
[55] The Blue Mountains Gazette (2019). Retrieved from: http://bitly.ws/krya.

Western Sydney community and business groups

Numerous western Sydney community groups have objected to the Project. These groups include Mulgoa Landcare, Blue Mountains Conservation Society, Sydney Bushwalkers, Western Sydney Community Unions, the Hawkesbury Environment Network and the NSW Nature Conservation Council.

The Western Leadership Dialogue as an important representative of business interest in Western Sydney and has objected to the Project.[56]

Patagonia and Paddy Pallin, both major Australian outdoor equipment manufacturers and retailers, have objected to the dam Project

15. Conclusion

The EIS prepared for the Project is unsatisfactory and does not meet the requirements set out by the *Environmental Planning and Assessment Act 1979*, the Secretary's Environmental Assessment Requirements (SEARs) nor the *Environment Protection and Biodiversity Conservation Act 1999*. If the proponent is to proceed with the Project it must be required to undertake a new EIS that meets all legislative and regulatory requirements.

16. Appendices

We attach below appendices that have (a) been referred to in the above submission or (b) we see as relevant to the EIS and Project and therefore should be considered by the decision maker.

(a) Warragamba Dam Non-Aboriginal Heritage Impact Assessment DRAFT
(b) Adequacy advice provided to the Department of Planning, Industry and Environment by NSW and Commonwealth Agencies in 2020
(c) Greater Blue Mountains World Heritage Advisory Committee submission to the Select Committee on the Proposal to Raise the Warragamba Dam Wall
(d) Interim Report No 1 - Select Committee on the Proposal to Raise the Warragamba Dam Wall
(e) World Heritage Values and the Warragamba Dam by Professor Jamie Kirkpatrick
(f) Managing a Flood Mitigation Zone at Warragamba Dam: Liability issues
(g) Joint letter: No free, prior and informed consent to raise Warragamba Dam wall from Traditional Owners

[56] Sydney Morning Herald (2021). Retrieved from: http://bitly.ws/kryg.