

Submission
No 383

**INQUIRY INTO PROPOSAL TO RAISE THE
WARRAGAMBA DAM WALL**

Name: Associate Professor Barry Croke

Date Received: 22 November 2019

Comments on proposal

Please note that my comments are based on my expertise in hydrology, including both water quantity and quality. I am also a member of the State Emergency Service, and while my experiences there will affect some of my statements, the statements are my personal opinion. While I have extensive experience from my time with the SES (33 years), I do not have specific knowledge on the flood plans for the region. Questions on topics like emergency response and flood planning should be directed to the SES.

While I don't agree with some of the conclusions of the assessment report, in general, the report is comprehensive in terms of the impacts on flows. In my view, the report does not stress enough the impact of raising the dam wall on the area around Lake Burragorang that would be inundated during flood events. It should be noted that with the existing dam wall, in a large enough flood to fill the dam, the water level in the dam will be above the full storage level. The question is given the increase in the dam wall, what is the additional area that would be inundated in a flood event, and what would the increase in inundation depth be. For small events, this is probably going to be small – but I can't say how much without more information (if this is in the report, I missed it). For larger events, the area affected and the inundation depth will increase more significantly, and the ecological and cultural impacts will be consequently increased.

While the extra flood mitigation storage provided by raising the dam wall will impact on the flooding downstream of the dam, this will only be significant for small flood events. For very large flood events, the onset of flooding will be delayed, but the flood peak will not be significantly reduced (see ...). Any further development in the floodplain downstream of the dam will result in an increase in the flood risk. Further, raising the dam wall will result in an increased volume of water retained during flood events. This will lead to an increased impact on people downstream if there is a structural problem. While structural problems with the dam may have a low probability, such problems do occur, and the resulting risk should be considered when evaluating the proposal to increase the height of the dam wall, particularly in the light of further development of the floodplain.

Comments on selected submissions

#019: Penrith City Council

In addition to raising the dam wall, a call for improvement of evacuation routes is requested. I can't comment on this as it is outside my area of expertise. But in general, roads should be designed for a reasonable worst-case scenario. If the roads are struggling to handle peak hour traffic, then they certainly will not handle situations where large scale evacuations are needed. This option is mentioned in Table 2.1 of the assessment report – at the cost of \$58.1M for five key towns.

#43 Andrew Waterhouse

Several points raised

- Raising the dam wall will not impact on the flooding of the Grose River
 - True. Impact of flooding from the Grose River will affect communities downstream of the confluence, as well as in the nearby upstream area due to backwater effects. Reducing flooding coming from Warragamba dam will reduce flooding downstream/near the confluence, but not prevent it. The question is: what is the relative volume of flood coming down the Grose River compared to the water coming from the dam? This will depend on the catchment area (roughly 650 km² compared to the ~9000 km² for the catchment area of Warragamba Dam) and the relative rainfalls.
- Decrease further development in flood-prone areas by regulation
 - Personally, I agree with this suggestion – see comment below about fertile lands
- Manage water levels to best mitigation effect using the existing dam wall height
 - The argument here is that water can be released from the dam prior to the event to increase flood mitigation capacity. This does depend on the rate at which water can be released, and the lead time before the flood starts impacting on the dam storage. This is the problem faced by Wivenhoe Dam operators in 2011. When a dam is used for both storage and flood mitigation, there is conflict. Operators would not release water until sufficiently confident that a significant flood was coming. If they release water and a flood doesn't occur (or is much smaller than expected), then this will impact on the available water resource. This is discussed in section 5.2 of the assessment report.

- A warning is given here about the accuracy of flood predictions and the impact on water supply. BoM can predict well the amount of rain that will fall. The challenge is predicting exactly where it will fall.
- The Taskforce focused on 3-day releases before an event – event given the stated challenges in more than a 24-hour prediction. Current BoM can provide a 15-hour target, and the report notes that increasing this to 3 days would be difficult if not impossible.
 - 40 GL/d gives a drop of 1.65 m in three days. 1 day is about 0.5 m. This is the maximum rate if the dam is at 9 m below full storage level – i.e. corresponds to a final level of about 9.5 m below full storage level. This would increase the available flood mitigation storage from 629 GL (~70 mm of excess rainfall) to 669 GL (about 74 mm).
 - 130 GL/d gives a drop of 5.45 m in three days, or about 1.8m/d. Initial storage at this discharge rate is 395 GL (~44 mm excess rainfall), after one day this would be 525 GL (~58 mm excess rainfall).
- Pre-releases will reduce the time for evacuations – so implications for SES
- To be effective, dam operators need to accept the risk of releasing water and not having a flood – at the cost of lost water supply (increased cost of supply if this leads to increase in use of desalinated water).
- Reduces buffering capacity of the dam in regard to water quality of inflows
- Better communication of flood issues
 - Always a good idea
- Minimize cultural and environmental harm
 - The question here is the value of these. To my mind, these sites are valuable and need to be cared for. The question is how long will they be inundated, and what would the impact be? It should also be taken into consideration how much has already been lost – otherwise, the cumulative impacts of decisions over a long period can gradually erode such key resources.
- Fertile lands
 - Definitely true. It is easier to build on the flat areas because they are flat. They are flat because they are flood plains. The flood plains are generally the most fertile parts of the landscape, and we tend to bury them in concrete and bitumen. It is also true that structures like Warragamba dam reduce the flooding, which will have a gradual impact on the fertility of the flood plains.

#184

Key points are

- Likelihood of more urban development on the flood plain
 - True – see the submission by Chas Keys (#0362)
- Impact on ecology and archeological sites
 - See response above for submission #43

#190

- Issue of landfill activities
 - Cannot comment about the particular cases raised here. Land levelling to remove depressions can have an impact on flows – but the magnitude of the impact will depend on the site characteristics.
- Impact on upstream areas
 - See comments above for submission #43

#200

- Issue of development in floodplain areas
 - More attention needs to be given to such development proposals, and be viewed in terms of the total flood risk across the catchment rather than just focusing on a single development. A development by development approach is a recipe for disaster.
- Impact of climate change on the flood exceedance probability
 - Generally, there will be an increase in the probability of extreme events. The question is by how much – I cannot comment on that impact in the Sydney basin.
 - It should be remembered that the probability of an extreme event, e.g. 1% (~1:100 year event) is for a specified site only. The probability of a 1% AEP event occurring somewhere in NSW is considerably higher than 1%. This is why we see so many events at the 0.25% (1:400 year)

probability and higher. Planning for a 1% event across the state is accepting a considerably higher probability of such an event (or higher) affecting a community somewhere in the state.

- Alternative flood storage – proposed decreasing full storage level and using desalinization to provide the necessary water security.
 - Additional water sources would need to be identified to maintain the reliability of supply in extended dry periods. Desalinisation is an option, but this is expensive, and also has implications due to the power requirements as well as possible environmental impacts concerning discharge of the resulting brine. Sahin et al. (2017) discussed the option of using hydropower that could be generated through dam level management to offset the energy needs of desalinization, which would reduce the cost. In terms of the flood mitigation, however, lowering the full storage level would be the cheapest and simplest solution, but only if the consequences for water supply are ignored.
- Water quality
 - See comments on submission #349 below
- Environmental impacts of raising the dam wall
 - See comments on submission #43.
- The question of housing data needs to be looked into. How much development (number of house, increase in population in flood-affected areas) from 2016 should be evaluated to see how significant this is.

Oz Sahin, Rodney A. Stewart, Damien Giurco, Michael G. Porter (2017) Renewable and Sustainable Energy Reviews, 68, 1076-1087. <http://dx.doi.org/10.1016/j.rser.2016.01.126>

#249

The core of this submission is a call to consider the risk to lives, ecosystems and our heritage. All important concerns. The assessment report talks about the probability of lives lost (section 10.1). The issue not just the loss of life, but also impact that has on the family concerned, their community, and emergency personal involved.

#250

- False sense of security
- Details on the factors affecting flooding
 - Rain is the primary cause of flooding. The other factors mentioned affect the impact of flooding (depth, extent, duration).
- In favour of reducing flooding – just doesn't believe raising the dam wall will do this.
 - Raising the dam wall will reduce flooding resulting from water spilling over the dam wall, particularly for smaller events. This depends on how the dam is operated (see recent court case against the operators of Wivenhoe Dam in 2011). For larger floods, increasing the dam wall will delay the onset of flooding, but not have a significant impact on the peak height. Raising the dam wall will not prevent flooding due to water spilling over the dam wall.

#284

- The SES doesn't do studies on dam failures. This is done by the dam operators.
- Decreasing the dam level by 30 m would have a significant impact on the water resources. The question is whether 10 desalinisation plants would be enough to offset this.
- Flood levels for planning are an unresolved question. The current 1:100 yr + 0.5m is inadequate in my view. A higher level would be better, but I am not sure where the numbers in this submission come from. Note that the exceedance probabilities discussed here do not cover a dam failure.
- Localized flooding and runoff do need to be considered when considering the flood impact on downstream communities. However, the time for these to increase to a peak height will be much shorter than the flows coming from the existing dam, and increasing the height of the dam wall will delay this even further. The effects of bushfire on runoff is not likely to be significant for very large events (will only impact on the first part of the event). The impact would be much more on smaller events. The main impact of bushfires on large floods would be in terms of water quality.

#349

- Water quality risks from heavy rainfall and catchment flooding
 - While it is true that there are many water quality issues related to floodwaters (including mobilization of fecal matter and pathogens), this is not necessarily related to the issue of raising the dam wall. This is an issue that will exist whether or not the dam wall is raised. Raising the dam wall will impact on the downstream water quality in small events (where the input to the dam is contained by the free storage space available). In such situations, there will

be increased deposition of material into the lake, which may have longer-term implications. For large events, raising the dam wall will not have much impact on the water quality flowing downstream of the dam compared with the situation with the current wall. As I said, this is not saying there isn't an issue with the water quality in floods – just that raising the dam wall will have little impact on this in my view.

- Water quality risks from inundation of the area around the existing lake
 - Mobilization from inundation is different than mobilization from intense rainfall. Water entering the lake will be quickly slowed (except for a plume running down the centre of the lake), so erosion is less of a concern.
 - Mobilization of pathogens from the inundated area into the lake will be a factor, but this needs to consider the animal densities and the fecal load that exists on that land prior to the flood. This will be somewhat variable due to topography and vegetation, but my view is that the load coming from the catchment area would likely be higher. It is something that may need consideration, however. Studies of pathogen risk would need to be carried out. A preliminary study of pathogen transport in the Sydney drinking water catchment was carried out by Ferguson, Croke and others was carried out about 15 years ago.
- Tropical cyclone Marcia
 - Yes, such water quality issues are a problem in floods that does need looking into. However, this is not directly relevant to the question of raising the dam wall in my view.
- Bushfires
 - Yes, bushfires in the inundated area will result in ash being added to the lake. As I mentioned before, the question is the relative strength of this compared with the load coming through the rivers. My view is that if the fire is more general than just around the lake, that the input from the catchment area will dominate over the inundated area.
- Hydrodynamics
 - Yes, the residence time of water (and contaminants) is determined by the hydrodynamics, and there is also the potential for short-circuiting to occur. This is where a plume of incoming water makes its way relatively quickly towards the dam wall, rather than mixing with the existing water in the lake. With high inflow rates in flood events, this is more likely to occur. How far the plume gets depends on a number of factors including the flow length, and the temperatures at different layers in the dam.

Overall, I agree with the statements here and agree that more work needs to be done on managing water quality issues. While important, they are mostly not relevant to this particular inquiry.

[#355](#)

I agree with the overall message, but question the wisdom of building houses on any floodplain. See above comments for submission #43

[#362 Chas Keys](#)

Personally I agree with the statements made here. Reducing the flood risk to the current community will almost inevitably result in an increase in the population living in the flood plain. This increases the complexity of the problem in future floods. The only way this can be prevented is by legislating no further development in the area, and not revising this later.

There is also the issue of changes in policy in dam management leading to the additional flood mitigation storage being used for water storage as Sydney's population increases (even without consideration of possible climate change impacts).

Comments on the resulting implications for emergency response should be directed to the SES directly.

[#364 Jamie Pittock](#)

I agree with the concerns regarding the impact on the upstream area that would be inundated in flood events. Reducing the full storage level by 12 metres would help in flood mitigation (not as much as a 14m increase though). However, the impact on the reliability of the water supply for Sydney is a factor. See comments for submission #200.

I also agree in regard to the issue of putting people in harm's way.

The issues of evacuation routes and flood forecasting are discussed above

Relocation of the most flood-prone residents is worthy exploring, though may not be accepted by the community. Improved education about flood risks may help here.