MH Warragamba Dam Wall Raising Submission

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The Hawksbury Nepean catchment can be described as having four general topographic elements

1. Tablelands areas of generally undulating topography
2. Escarpment gorges dividing low site quality sandstone country
3. Floodplains in coastal valleys
4. Gorge reaches draining to the sea.

The Warragamba Dam is located at the lower end of the major escarpment gorge, an ideal location for a large water supply storage. Historically it has had some flood mitigation effect for the settled area of the floodplain, as illustrated in the EIS.

The coastal gorge section provides a choke for drainage of the catchment so that, in the event of local heavy rain over the catchment below the Warragamba Dam, flooding will occur in the settled area of the floodplain irrespective of any raising of the dam wall.

Raising the dam wall is an expensive option that will provide limited flood mitigation for the settled areas of the settled floodplain in the face of a changing climate. Prudent and feasible alternatives should include:

- Encouraging the development of distributed storages throughout the tablelands catchments
- Adapting or modifying buildings on the floodplain to cope with local flooding.

<u>Hydrology of coastal catchments.</u>

In the 1920's, Horton proposed that a typical hydrograph (a plot of flow versus time) could be described as baseflow, which is maintained by the slow percolation of water through soil towards the stream, and stormflow, which he said occurs when rainfall intensity exceeds the surface infiltration capacity of the soil, causing rapid overland flow. (See review article by Bonnel,1993).

In the 1960's, Hewlett and Hibbert (1967) closely observed runoff generation in temperate forests in North America. They found that rainfall intensity <u>almost never</u> exceeds the surface infiltration capacity of forest catchment soils. Rather, they observed that overland flow was generated from a "variable source area", usually in the riparian zone. In this variable source area, exfiltration of water (derived from interflow of water through the soil profile higher up the catchment) out through the soil surface, added to incident rainfall, produces overland flow. This is the "quickflow" runoff that can be counted as stormflow in a catchment hydrograph. .

Subsequently, Emmett O'Loughlin and colleges (O'Loughlin, Cheney and Burns, 1982) developed the "TOPOG" model which describes mathematically the variable source area concept of stormflow generation in temperate catchments.

In brief, TOPOG divides a catchment of a first order stream into pixels bounded by contours and lines at approximate right angles to the contour. The Richards equation is solved for each pixel. (The Richards equation quantifies the movement of water through soil.) TOPOG sums the water flow through adjacent pixels plus incident rainfall to generate a hydrograph for the catchment outlet.

So Horton's description of stormflow generation is limited to bare and compacted areas such as road surfaces, building roofs, log landings and dairy laneways or livestock yards. For most coastal catchments, stormflow is generated from a variable source area, the size of which is determined by antecedent wetness.

Stormflow runoff can also be generated by "subsurface stormflow", sometimes referred to a "throughflow". This is especially significant in geologies with fissures in the regolith and in logged forests, where decaying roots become, in effect, pipes.

Small rainfall events, say less than 15mm, will rarely produce a measurable increase in streamflow because this amount of rain merely makes up the soil moisture deficit accumulated during antecedent dry periods. Only quite large rainfall events will produce stormflow runoff in natural catchments.

A conceptual understanding of how catchments work is useful for understanding how historical changes in land management have affected the hydrological regime. A clear conceptual understanding of how catchments work can also inform strategies to restore catchment values such as persistent flow duration during dry periods.

Historical changes in coastal catchments.

European settlement has resulted in land-clearing for cropping and grazing and the construction of roads. The erratic rainfall distribution of eastern Australia has meant that accelerated erosion along drainage line has resulted from land clearing and road construction, with gullies incising at an increased rate during large rainfall events. This has had the effect of increasing stormflow runoff volumes and decreasing flow duration into dryer periods.

Other impacts of European settlement have been changes in the fire regime and the introduction of exotic pine plantations in some higher rainfall areas. There is evidence from dendrochronology studies the frequency of fires of sufficient intensity to leave fire scars on standing trees has approximately double since European settlement (See Banks, J.C.G. cited in Richards, 1990).   Young regrowth following intensive logging and fire uses up more water than the oldgrowth forest it has replaced. The review by Vertessey (1999) cites a study by Watson et al that shows this effect is particularly severe on flow duration as the regrowth develops. The effect of replacing oldgrowth eucalypt forest with pine plantations is even more severe. There is no "cease to pump" for pine trees or regrowth forests.

Fluvial geomorphology has been used to objectively describe catchment changes resulting from European settlement with the associated land clearing, particularly of fertile soils in swampy areas. (See Brierley and Fryers in the Bega Catchment and Brierley and Fryers, 1998, and Brierley and Murn, 1997, in the Cobargo catchment.) While it is impossible to reconstruct flow-duration curves for the pre-European condition, some idea of the likely impacts can be gleaned from fluvial geomorphology studies. For example, Prof. Martin Thoms (Thoms and Berg, 1994) excavated sediments adjacent to the old Pambula racecourse. He found a dimorphic picture, with uniform topsoil in the lower levels and coarse bedload sediments in the upper, more recent layers. So the catchment had produced very different erosion events from essentially the same climate impacting on a relatively pristine versus a heavily cleared landscape.

Added to these impacts on catchment water yield is the impact of water extraction from streams for irrigation and direct household use. Water demand actually increases as warm, dry weather progresses and streamflow is falling.

Overall, the effect of European settlement has been to increase the proportion of stormflow runoff and decrease the duration of flows into dry periods. The only development countering this is the construction of water storages.

The value and performance of large, on-stream storages, such as Warragamba Dam/Lake Burragorang, could be enhanced by improving the flow-duration in streams feeding the storage. To this end, distributed small storages throughout the catchments could be encouraged. The proposal to increase harvestable rights in coastal catchments from 10 to 30% of average annual runoff may act to increase the uptake of private land dam construction.

The embargo construction of dams on third or higher order streams is important for the protection of fish habitat, and may not necessarily be much of a disincentive to dam construction if feeder drains are used to intercept interflow and conduct water to the dam. Such a design would entail:

- The construction of a side-cut track at a moderate slope (say around 3 to6 degrees) to intercept interflow and direct it to the storage
- The location of the storage on a relatively gently sloping site, to optimise storage size for a given volume of earthworks
- The location of the storage where there is a sufficient clay content in the subsoil to create an impervious dam wall
- The use of “smart culverts” at regular intervals along the feeder drain. These are simply culvert wells with a through-pipe of limited diameter (say, 90mm PVC) allowing water to progress along the feeder drain and a conventional culvert pipe under the track, whose inlet is higher than that of the through-pipe. Fouling of these pipes by debris can be averted by protection with a cage of 25mm weldmesh or similar.

The use of smart culverts on feeder drains greatly increases the effective catchment area of a storage without the need for concrete armour on the spillway, because very large flows in very large rainfall events are effectively dispersed throughout the catchment.

It is instructive to consider the proportion of runoff which occurs as baseflow and the proportion that occurs as stormflow runoff. By calculating the area under a flow-duration curve at different percentiles of daily flow, it is apparent that, for most coastal catchments, a very high proportion of daily flows are likely to be out to sea within a week or two of a significant rainfall event. Capturing, storing and subsequently using a proportion of this water during dryer periods will have major beneficial effects. These include some reduction in flood peaks and some improvement in flow-duration into dryer periods.

Rather than raising the Warragamba wall, tax-payers funds might be better spent on facilitating the construction of distributed storages throughout the Warragamba and other downstream catchments. This might include such actions as developing designs and extension programs for the construction of fish ladders on licensed dams on third order streams.

Flood Mitigation on the Floodplain.

As the climate warms and the atmosphere becomes more energised, the likelihood of intense localised rainfall events increases. Since the catastrophic 2019/2020 fires, there have been some highly erosive rainfall events in coastal catchments.

An increase of 1 degree C means that 7% more water vapour can be held in the air.

Following the March 2011 floods on the far south coast, a bureau of meteorology spokesperson said that they expected about 100mm of rainfall from the weather pattern but actually recorded more than 500 mm along the escarpment for the event. This was attributed to the ocean being unusually warm. Subsequently, Dr. Matthew Griffiths (A.N.U.) addressed the Sapphire Coast Marine Discovery Centre seminar. He made the following points about the relationship between oceans and atmosphere:

- The oceans represent 99.9% of the heat capacity of the earth's climate system. This is because they cover 71% of the earth surface, they are an average of 5.8 km deep and liquid water has an enormous capacity to exchange heat compared to land or air
- Worldwide, ocean currents are intensifying as the earth heats up
- The east coast Australian current is intensifying by a factor of 3 to 4 times the world average.

So, we can expect the water off the east coast of Australian to continue to warm and feed more water vapour into rainfall events in coastal catchments.

An example of a localised extreme intensity rainfall event occurred in January 2016. We received 177mm of rain in about 3 hours. This caused the failure of stormwater drainage in Eden and necessitated the evacuation of the BUPA aged care facility during the night.

It seems prudent to encourage the re-development of more sustainable housing in flood prone areas of the coastal plains. Such a strategy has been adopted on the Brisbane River flood plain. Examples include such as "High Water Haven" in Sanctuary issue 56, page 60, Spring 2021.

This is a "Queenslander" style elevated home with the ground level spaces modified by adopting such features as:

- No cavity walls
- Timber louvres at ground level to allow the egress of floodwaters
- Door sills flush with a concrete floor to allow easy hosing out
- Elevated services

Not all existing homes could be feasibly elevated, for example masonry buildings. However, new builds and rebuilds could be constructed under a suitable code. Reticulated sewerage systems could be made flood-resilient with the use of wells/silos of impermeable concrete to house pumping stations.

Intense localised rainfall events are likely to become more common as the climate warms. Raising the Warragamba Dam wall may have no effect on local flooding due to intense local storms over the suburbs on the floodplain. Irrespective of any decision on the dam wall, development controls on the floodplain should be tightened to provide greater flood-resilience.

Effects of Temporary inundation on water quality.

Raising the Warragamba Dam wall as a flood mitigation measure will result in the temporary inundation of riparian areas around the dam perimeter and along considerable lengths of tributary streams and gullies. This is likely to kill vegetation that is not used to being under water for several days or even weeks. As the water recedes, decomposing terrestrial vegetation and surface litter will enter the dam and continue to use up oxygen as it rots. This is likely to result in a "black water" fish kill event as seen along the northern rivers from time to time. Black water fish-kill events have also occurred in the Murray River associated with "environmental water" releases to flood areas of Red Gum forest that have gone without periodic inundation for decades, as a result of dam construction and irrigation extraction.

The main EIS summary report contains some information on the effects of temporary inundation of one Eucalypt species. This is an inadequate assessment of the likely risk to water quality of the proposal.

Conclusions.

Raising the Warragamba Dam wall will temporarily inundate and perhaps irreversibly damage some riparian areas of the streams flowing into Lake Burragorang. It will provide limited flood mitigation for areas of the floodplain below the dam from large rainfall events in the catchment above the dam, but none from local heavy rain events or from rain events in other catchments such as the Nepean and Grosse Rivers or South Creek.

Taxpayers funds would be better spent on restoring, so far as possible, the flow regimes in these coastal streams that have been adversely impacted by European settlement. Funds could also go towards raising the essential infrastructure on the floodplain.

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