NATIONAL WATER REFORM 2026

Submission by Lee Donaldson

EXECUTIVE SUMMARY

This submission addresses inefficiencies in the current provision of resilience in Australian urban water supply systems and proposes a practical pathway for improvement through the application of probabilistic planning methods. Probabilistic methods are preferred in infrastructure planning because they explicitly account for uncertainty, variability, and the likelihood of failure, allowing decisions to be based on defined levels of service and risk rather than fixed assumptions, and specifically to avoid over-servicing.

Australian urban water supply systems are presently planned using a mixture of approaches. At one end, raw water sources are commonly assessed using probabilistic methods. At the other end, building water systems are sized using methods originally derived from probability theory. However, most urban water system infrastructure, including its treatment plants, pipelines and storage tanks, continue to be planned using deterministic methods. This inconsistency is significant because these infrastructure elements represent the dominant share of capital investment in urban water supply systems. The continued reliance on deterministic methods for their planning and design has led to inefficient outcomes, including both over-sizing infrastructure and the poor use of capital.

Probabilistic methods and tools for the investigation of urban water supply systems have been recently developed and experience gained through investigations undertaken in Queensland, New South Wales and Tasmania have shown that substantial cost savings can result from their application. In some cases, this has been achieved through the deletion or deferral of capital works proposals, or through showing how to more effectively use existing infrastructure. In other cases, it has included the identification of unnecessary infrastructure. In all cases the savings have been achieved while maintaining desired levels of service relating to the frequency and duration of losses of water supply.

But the key issue in this submission is not the recent development of probabilistic planning methods, nor simply demonstrating their advantages over deterministic approaches. It is that current national water policy frameworks do not require risk and uncertainty to be explicitly quantified in planning decisions. As a result, key components of urban water supply systems, particularly treatment, transfer and storage infrastructure, continue to be designed using deterministic rules that are inflexible and often embed conservative assumptions. This can lead to over-sizing of infrastructure, premature or unnecessary capital works, and inefficient allocation of investment.

A practical and low-risk reform would be to update national water policy frameworks to require that levels of service are defined in probabilistic terms and that planning methods explicitly account for the likelihood and consequences of supply failure. Such reform, through Commonwealth–State agreement, would enable more transparent, comparable, and economically efficient decision-making while allowing flexibility for jurisdictions. Without this reform, comparisons between States are more difficult, funding decisions lack a consistent basis, climate-independent diversification is harder to justify consistently, crisis triggers are less clearly defined, and long-term planning risks becoming ad hoc and politically driven.

SUBMISSION TO PRODUCTIVITY COMMISSION

This submission is made in response to the Productivity Commission's call for submissions on the 2026 review of progress under the National Water Initiative, as required under the Water Act 2007. It focuses on the provision of resilience in urban water supply systems, and how current planning and design practices influence both system performance and cost.

Fundamental to this focus is understanding that urban water supply systems are currently not planned using a single consistent approach. At one end of the system, raw water sources such as rivers and dams are commonly assessed using probabilistic methods which recognise variability in inflows and the likelihood of drought. At the other end, water supply systems within buildings are sized using fixture-based methods that were originally derived from probability concepts. However, between these two ends sits the majority of water supply infrastructure, i.e. treatment plants, pumps, pipelines, and storage. These are generally planned using fixed deterministic rules.

This difference in approach across the same system is not widely recognised, but it has important consequences. The infrastructure that sits between source and customer represents the dominant share of capital investment in urban water supply systems. Planning these elements using fixed rules, rather than approaches that reflect how demand and system performance vary over time, can lead to materially inefficient outcomes.

This submission sets out how that occurs and how it could be addressed.

THE AUTHOR

Lee Donaldson has prepared this submission. Lee is a civil engineer with over fifty years' experience, about half of which has been spent working as a consulting engineer in the water industry. About fifteen years ago he became involved in the investigation of urban water supply resilience in south east Queensland. **Attachment 1** is a short summary of his related experience since then and includes the investigation and consultancy work, published AWA e-Journal papers, and associated research he has undertaken.

Lee's experience is particularly relevant to this submission because of the current gap between policy intent and its practical implementation in relation to the treatment of probabilistic outcomes in infrastructure sizing and resilience assessment. His stake-holding in this inquiry is solely that of a professional engineer with an interest in urban water supply resilience.

FORM OF SUBMISSION

The Commission has invited respondents to *address questions related to Part A (NWI Assessment), Part B (secure, resilient and sustainable water services), or both*. This submission follows Part B and, to be conforming, its form is primarily through addressing overall and specific Part B questions.

However, the focus of the submission is on the current inefficient provision of urban water supply resilience and the need for the application of probabilistic methods for the planning and design of urban water supply systems. The Productivity Commission's 2024 inquiry clearly identified the need to modernise the 2004 National Water Initiative considering climate change and growing uncertainty, but these findings have not yet been translated into policy.

Neither the NWI nor the proposed National Water Agreement explicitly require the adoption of probabilistic approaches, nor do they provide the levels of service guidance required for risk-based, i.e. probabilistic, water-security and resilience planning. Therefore, to help the Commission better grasp those issues, an outline is included that explains both the current deterministic and proposed probabilistic approaches used for planning and designing urban water supply systems. That outline is included with this submission as **Attachment 2**.

PART B QUESTIONS

Overall Questions

Are there specific aspects of current water service arrangements, in particular regions or jurisdictions, that create material risks, inefficiencies or misalignments?

Attachment 2 discusses the inefficiencies of two current deterministic methods as compared to those probabilistic. It notes that in Queensland, Tasmania, and the Northern Territory, deterministic methods usually focus on minimising storage tank inflow, while in New South Wales, the common approach is to maximise storage tank inflow. However, the author is not aware of which methods are used in other Australian states. Experience has shown that the minimum inflow method generally results in oversizing storage tanks whereas the alternative results in oversizing of the inflow infrastructure supplying tanks.

Regardless, both methods have been found to be cost inefficient. In that regard it is noted that the thirty Unitywater, Queensland, tanks mentioned in **Attachment 1** which were decommissioned after Lee Donaldson undertook resilience investigations would have a 2025 value in the order of $150 million. And a recent investigation by Lee Donaldson in NSW, where the maximum inflow method had been used, found that cost savings of between $100 and $200 million could be achieved if the probabilistic methods discussed in **Attachment 2** were used.

How do current arrangements affect how trade-offs are made between service reliability, long-term financial sustainability, affordability and any other objectives?

The resilience modelling tools developed for use with probabilistic methods, as outlined in **Attachment 2,** allow a planner to develop a supply system based on all the relationships between a tank's required storage, its inflow, and the desired level of service, i.e. frequency of loss of water supply.

Those tools include optimisation software and can be run to find out how to minimise tank storage volumes and minimise water age and improve system water quality if that is a driving objective; or run to determine how to maximise the system's level of service if that is a driving objective, e.g. if the supply area served an important business area; or run to determine how small a system's water treatment plant and trunk mains could be if capital cost minimisation was the driver.

Trade-offs between system attributes can therefore be made after using probabilistic methods. Such trade-off assessments cannot be undertaken using current deterministic methods.

Are there specific reforms to water service arrangements that would materially improve outcomes?

There is discussion in **Attachment 2** about the provision of alternative supplies to improve resilience, and how it is often much more economically efficient than measures such as reinforcing the resilience of existing systems. It is recommended that all supply authorities prepare future resilience plans which could benefit from the efficiencies of alternative supplies, but within national probabilistic level of service guidelines.

It is noted that in Victoria, urban water planning is undertaken through regionally coordinated processes (such as Urban Water Strategies), involving groups of water authorities preparing long-term plans. It is recommended that similar frameworks be adopted nationally, and with the inclusion of a probabilistic theme.

Theme 4: National consistency and intergovernmental coordination

This theme considers whether, and if so how, greater national alignment and/or intergovernmental coordination would improve efficiency, investment certainty, consumer outcomes, or other key objectives of water service provision arrangements.

The application of probabilistic methods for the planning and design of urban water supply systems will lead to least cost solutions for dealing with risk, uncertainty, and providing long-term service resilience.

Water businesses that use probabilistic methods have been rewarded with reduced costs of service provision. For example, Urban Utilities in south east Queensland have been using probabilistic tools for several years to review their existing storage tank capacities to meet demands in future years. It has been reported by Urban Utilities that if deterministic methods had been used there would have been a much greater call for future tank augmentations.

Current national frameworks, including the National Water Initiative and associated planning principles, refer to the concepts of risk, uncertainty and resilience but do not explicitly require these concepts to be quantified or assessed in probabilistic terms. This has resulted in differing interpretations, and the continued use of deterministic planning approaches across most supply authorities.

It is recommended that future national water policy frameworks, developed through intergovernmental agreement, explicitly incorporate probabilistic (risk-based) planning principles for infrastructure planning. This would support more consistent, transparent, and economically efficient decision-making across authorities, while still allowing flexibility in how individual States implement those principles.

It is appreciated that there might be reluctance among the States to adopt probabilistic planning principles because of fears that such measures will identify areas where they need to provide additional expenditure. However, it is the author's experience (refer **Attachment 1**) when undertaking resilience investigations that outcomes are usually identified which would be significantly less costly than if traditional deterministic approaches had been applied.

As discussed in **Attachment 2**, probabilistic methods are not workable if there are no associated level of service standards. At the same time, levels of service need to be stated in probabilistic terms if they are to drive risk appreciation and in turn resilience levels. At a national level, without level of service standards, States cannot be compared, funding cannot be allocated equitably, climate-independent diversification cannot be justified on a consistent national basis, crisis triggers cannot be defined, and long-term planning risks becomes ad hoc and politically driven.

Level of service standards could include probability of short duration supply failure, probability of entering drought restrictions, and probability of failing to meet essential needs, i.e. minimum per capita supply volumes for life-preserving and community-preserving supply. As a minimum, the last of these should be formalised as nationally agreed planning principles established through Commonwealth–State intergovernmental arrangements, to ensure that the benefits of having level of service standards are applied consistently across jurisdictions.

However, such national guidelines would need to be sufficiently broad to ensure fairness and general acceptability considering the broad range of population sizes, annual supply volumes, alternative water supply accessibilities, abilities to pay, and risk appetites of Australian water supply communities. It is envisaged that the consequences of loss of supply, e.g. loss of life, loss of community, loss of industrial/commercial capability would primarily be used to determine minimum levels of service.

CONCLUDING COMMENTS

The water industry already uses probabilistic thinking in parts of their systems. Extending this approach to the planning and design of major infrastructure would improve consistency, support better decision-making and lead to more cost efficient and resilient outcomes.

The methods to do this are now available and various investigations summarised in **Attachment 1** have shown that they can be applied in a practical and transparent way. The opportunity now is to support their broader adoption. That will only be achieved if probabilistic planning methods and uniform level of service standards are adopted nationally. This is seen as the biggest challenge to the concept moving forward.

Attachment 1

LEE DONALDSON, SUMMARY OF RELEVANT EXPERIENCE

Between 2011 and 2016 probabilistic concepts of relationships between demand, supply and storage for urban water supply systems, including demand data collection and models for solving resilience were developed by Lee Donaldson. This was done whilst initially engaged by the SEQ Water Grid Manager and later by Unitywater in south east Queensland. Those concepts and mathematical relationships did not reach maturity until near the end of 2016 but were nevertheless sufficiently advanced to allow a full review of resilience within the Unitywater distribution system to be undertaken. That review was driven by Unitywater's desire to limit water storage volume, and water age, for water quality reasons and resulted in over thirty storage tanks being decommissioned.

The Unitywater work was initially supported by demand data collection from the Unitywater system, and later supplemented with data from the Urban Utilities, Redland City Council, and Gold Coast City Council and Seqwater data bases. By 2018, the mathematical relationships between water supply demand, system supply capacity and resilience capacity had been sufficiently developed to allow for a series of papers to be printed in the AWA e-Journal: *Sizing Water Distribution Storages for Persistence and Emergency Demands*, *Water Supply Peaking Factor Stochastics and Multiple Levels of Service*, *Water Supply Peaking Factor Stochastics*, and *Water Supply Risk Assessments Using Stochastic Peaking Factors*.

The Excel based models which allowed for the assessment of the probability of a supply outage, and for the assessment of supply systems in association with those probable supply outages, were subsequently developed to maturity in the period through to 2022. Investigations using those models were undertaken for south east Queensland water authorities such as Queensland Urban Utilities and Seqwater. However, the Seqwater investigations were broader than just system resilience, and an initial understanding of levels of service, i.e. acceptable losses of water supply, and how they might respectively relate to relatively frequent events, and infrequent and rare events, each with their own very different consequences was developed. An AWA e-Journal paper, *How Much Water Supply Resilience Is Enough? – A Discussion Paper* was subsequently written in 2023.

Resilience investigations had been until 2023 limited to Queensland and the NT. After then historical demand data was sought from supply areas in NSW and Tasmania to complement data previously collected from south east Queensland, the NT and regional Queensland. It was established, using Bayesian mathematics, that stochastic water supply peaking factors could be reasonably prepared for any Australian supply area, big or small, so long as a short period of representative demand data was available from, say, the local water treatment plant. That ability to probabilistically investigate supply systems almost anywhere with similar urban water use to Australian cities and towns has recently led to resilience studies of NSW and Tasmanian water supply schemes.

Attachment 2

PROBABILISTIC AND DETERMINISTIC PLANNING METHODS

Background

Urban water supply systems are currently planned and developed using a mixture of deterministic and probabilistic approaches. At one end of the system, raw water sources such as rivers and dams are usually assessed using stochastic streamflow analysis to estimate reliability. While these approaches incorporate probabilistic elements, the results are typically reduced to a single design value, resulting in a quasi-deterministic outcome. At the other end, water systems within consumer buildings are sized using fixture unit methods which have been developed using probability concepts to account for likelihood of simultaneous use but are now applied in tabulated form via the Building Code of Australia.

In between the raw water source and the consumer sits most of a water supply system's infrastructure, i.e. its treatment plants, pumps, pipelines, valves, disinfection systems, storage tanks, and control systems. These assets represent by far the dominant share of capital investment in a water supply system. They are mostly planned through deterministic methods.

Advantages of Probabilistic Methods

Probabilistic methods are preferred in infrastructure planning because they explicitly account for uncertainty, variability, and the likelihood of failure, allowing decisions to be based on defined levels of service and risk rather than fixed assumptions, and specifically to avoid over-servicing.

The Productivity Commission's 2013 review of electricity network regulation identified that deterministic reliability standards, which embed fixed levels of redundancy, can lead to over-investment and inefficiencies. The Commission recommended that reliability planning should instead be based on explicit trade-offs between the costs of supply interruptions and the costs of avoiding them, reflecting consumer preferences. This represents a shift from previous prescriptive deterministic approaches toward risk-based (probabilistic) planning frameworks.

However, the Commission did not advocate specific probabilistic techniques. Rather, in critiquing prescriptive reliability standards and promoting economically efficient reliability outcomes, it argued for moving away from rules that ignore probability and toward decision-making frameworks that explicitly account for risk and uncertainty.

These approaches equally apply to water supply systems, although often because of a lack of risk data, especially those relating to very low probability events, and because, as mentioned above, some assessments of water supply systems while incorporating probabilistic elements, provide quasi-deterministic outcomes.

Current Methods

Urban water supplies are, albeit usually unknowingly, planned and sized for just two "resilience event" levels, i.e.:

- *Relatively frequent and short duration resilience events* – These are events which cause some failure in the system be it an infrastructure item failure, e.g. a pipe break, a power outage, or an extended peak in demand, where continuity of supply cannot be maintained for a relatively short period. BOM published Australian data shows that these typically have frequencies of about 10 to 15 years. The associated losses of supply usually last less than about 8 hours and rarely extend for more than two to three days. The impact of these events is generally limited to an inconvenience.

- *Infrequent to rare events with medium to long term durations* – This is essentially all other events. Such events could range from a raw water algae outbreak which greatly reduces the capacity of the water treatment plant, to a flood which washes out a critical infrastructure component, to a drought which empties a water supply dam. Frequencies of occurrence broadly range from 20 to 1,000 plus years, and durations might extend from a few weeks to several years.

Relatively frequent and short duration resilience events - Resilience is the ability to maintain supply during a non-normal event, e.g. a peak day of demand, a pipe failure, a power outage, etc. Resilience against loss of supply is provided by the supply system's storage tank for short duration resilience events.

Storage tanks primarily act to provide a balance between inflow from a water treatment plant, and variations in demand, and commonly have an arbitrarily sized "emergency" storage provision for non-normal events. Around the world storage tanks are sized using deterministic methods. In Australia there are two such methods, one which minimizes storage tank inflow (using a peaking factor called the Mean Day Maximum Month demand as a criteria) and the other which maximises storage tank inflow (using the Maximum Day peaking factor as a criteria).

The former method is generally used in Queensland, Tasmania and the NT, and the latter is generally used in NSW. The author has not been able to determine which methods are used in the other Australian States. Both methods are simplistic, use arbitrary inputs and often produce overly conservative infrastructure assessments, e.g. the storage tank volume and/or its supply infrastructure are oversized. Neither method can be used to reliably investigate options in between minimum and maximum inflows, and neither can assess supply risks in association with demand probabilities, or the associated storage required to maintain supply while meeting a desired level of service, commonly frequency of loss of supply.

Infrequent to rare events with medium to long term durations - Resilience for all events, including those which occur infrequently, or have long durations, can be affected by improving the reliability of the existing system. This can take many forms such as raising or building more supply dams, repairing, and replacing infrastructure to minimise leakage losses, educating consumers to reduce water usage, etc.

But the most effective way of improving a system's resilience is through providing an alternative supply. (Storage tanks, as discussed above for the first level of resilience, are in fact an alternative supply, albeit with limited capacity). Resilience for many small communities is provided by trucked in water, i.e. by alternative supply during droughts and other emergencies. However, trucked in water supplies are expensive and usually need to be provided in conjunction with some regime of demand restrictions. As a "rule of thumb" communities of up to 10,000 persons can be serviced using trucked in water supplies.

Resilience improvements for larger communities which cannot be reliably or economically done by upgrading existing supplies is often achieved by making a connection to an adjacent supply scheme to share the risks of both schemes being simultaneously without supply. While this is usually planned with deterministic principles, probabilistic methods are needed to assess the effectiveness and benefits of such schemes.

Probabilistic Methods

Relatively frequent and short duration resilience events - Probabilistic tools have been developed by the author over the last decade which allow the preparation of probabilities of loss of supply versus outage times.

Probabilistic models have also been developed by the author which, in conjunction with optimisation software, can be used to analyse supply systems for, say, the least required volume for a single storage tank, or group of tanks, or the least capacity that a particular storage tank requires, or the least capacity that a single or group of water treatment plants needs all while ensuring that system provides a desired level of service for resilience, e.g. loss of supply would not occur any more frequently than, say, once in 20 years.

These tools and models are supported by real probability of demand profiles for Australian urban supply areas. Studies using these tools have shown that greater insights into how a system probabilistically works can be obtained along with allowing better expenditure decisions and optimisation of associated capital cost savings.

Infrequent to rare events with medium to long term durations – While deterministic and probabilistic methods are both already in use for infrequent events with long durations, it is recommended that a stronger probabilistic focus should be adopted which also embodies greater economic efficiencies. Discussion about possible arrangements to achieve that objective follow:

Probabilistic methods need to have associated levels of service to be meaningful – Level of service guidelines need to be prepared which set out acceptable probabilities of loss of supply for urban supply areas.

Level of service standards should include probability of short duration supply failure, probability of entering drought restrictions, and probability of failing to meet essential needs, i.e. minimum per capita supply volumes for life-preserving and community-preserving supply. If applied at a national level, and to be fair and generally acceptable, level of service standards would need to allow for Australian water supply communities having a broad range of sizes, abilities to pay, and risk appetites.

The provision of alternative supplies to improve resilience is often much more economically efficient than other measures such as raising an existing dam - Improving existing resilience, be it to a raw water supply or the system's infrastructure, will provide some resilience improvements but providing an alternative supply will be more economically efficient. For example, raising a supply area's local dam might improve its resilience, measured by its probability of failure, from, say, 100 years to 500 years. But providing an alternative independent supply with the same 100 year probability of failure would provide an overall resilience equal to 100 x 100, i.e. 10,000 years.

This ability to disproportionately increase the resilience of a supply area by including an alternative supply is significant at a time when there is concern about the reliability of hydrological assessment methods even those which consider the non-stationary nature of climate patterns. The effectiveness of including alternative supplies is limited by the independence of the existing and alternative supplies. Greatest independence would be achieved for an existing climate dependent supply, such as a river or dam, if the alternative supply was from desalinated seawater or potable treated recycled water. Perhaps, equally importantly, by providing an alternative supply resilience is provided against not just climate related failure, but also against other low probability risks such as unforeseen infrastructure failures, earthquakes, and even terrorist attacks and wars, and all at no additional cost.

Alternative supplies have, of course, long been recognized to improve resilience but have traditionally been seen as a more costly option. Funding alternative supplies is best realised if planned to happen when the extent of existing resilience provisions become unacceptable. Typically, this occurs when a drought has forced severe and lengthy water restrictions to be applied.

It is proposed that all supply authorities prepare future resilience plans which could benefit from the efficiencies of alternative supplies, but still within the probabilistic level of service guidelines discussed above.