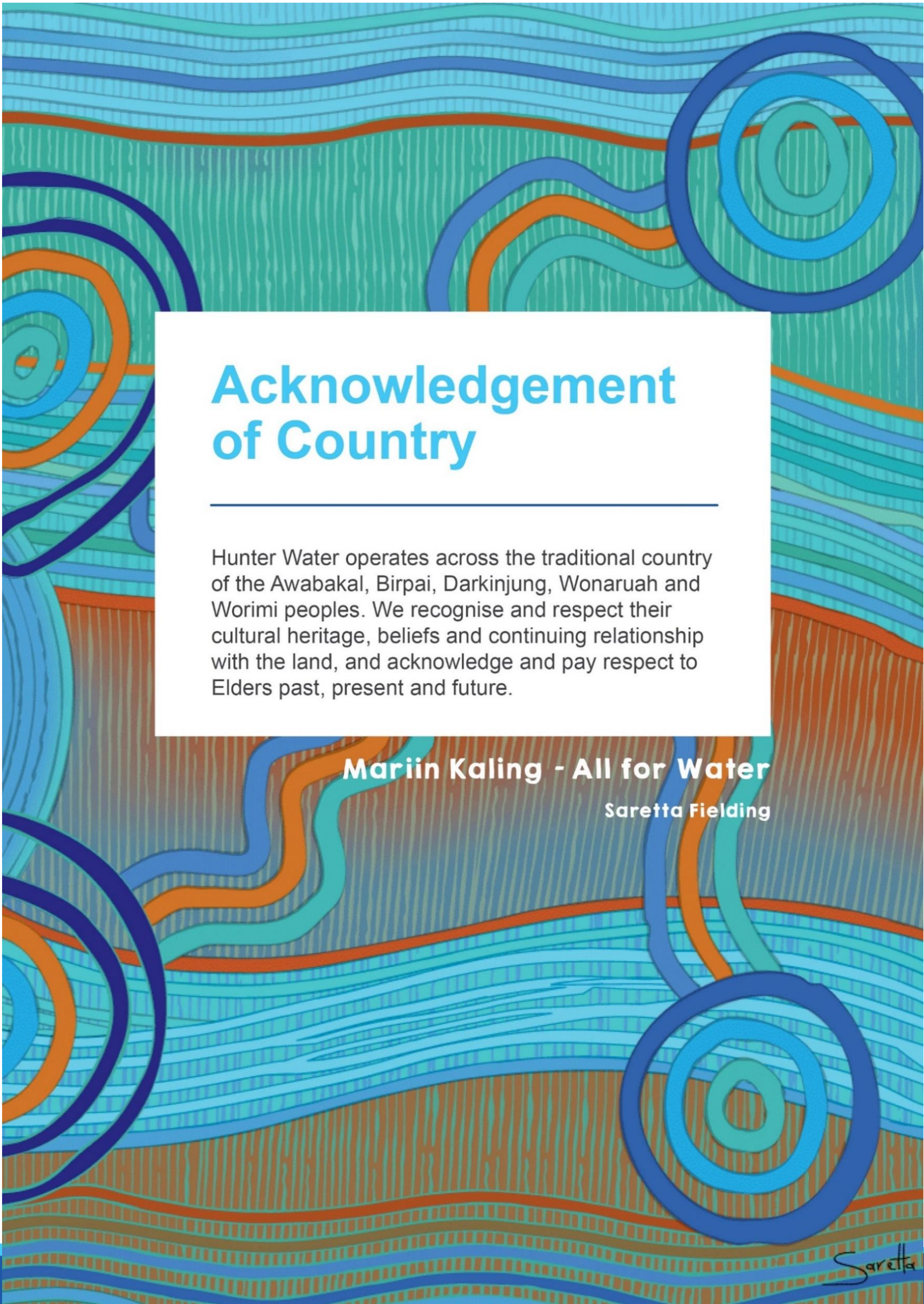
Long Run Marginal Cost of Water Supply

OCTOBER 2022

Response to IPART Secretariat Research Paper
Regulating Water Businesses Special Review

Acknowledgement of Country

Hunter Water operates across the traditional country of the Awabakal, Birpai, Darkinjung, Wonaruah and Worimi peoples. We recognise and respect their cultural heritage, beliefs and continuing relationship with the land, and acknowledge and pay respect to Elders past, present and future.



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EXECUTIVE SUMMARY

Hunter Water agrees with IPART's assessment that estimating the long-run marginal cost of water using the established Average Incremental Cost and Turvey methods can produce inaccurate or unreliable results.

We have encountered several methodological questions and challenges in calculating the LRMC of water. The LRMC estimates are strongly influenced by the choice of assumptions, application of the methods, and model specification. It is likely that two practitioners, using the same set of inputs, would produce different LRMC estimates. We describe these challenges in our response.

We welcome IPART's contribution to standardise the methods applied by NSW water businesses, including:

1. Clarifying the way established methods are applied.
2. Developing and testing a new algebraic method for estimating LRMC.

We agree the algebraic estimation method is likely to establish a more standardised approach with fewer errors. IPART's new method has fewer model specifications relative to the established methods. In particular, the algebraic method should resolve inaccuracies generated by using an artificial time horizon that underestimates the value of remaining water demand served by the asset.

IPART's new method requires several simplifying assumptions to enable the closed-form equations to work. Hunter Water observes certain conditions where these assumptions may not hold:

- the assumed source operating rules used to calculate operating costs
- how to include augmentations triggered by storage levels during drought events
- applicability of the method to water treatment and network along with wastewater investments
- whether the method can be applied when a system has an existing yield-demand deficit.

Hunter Water does not have a good understanding of the materiality of each of these conditions. We are eager to work with IPART over the months ahead as we calculate and test the algebraic method using LHWSP augmentations and cost estimates.

Our current thinking is that the algebraic method would not replace the AIC and Turvey estimation methods. We would produce multiple LRMC estimates using the new and established methodologies as part of our next pricing proposal.

We would like to work with IPART and the NSW water businesses to further discuss the methodological and implementation issues with the established methods. This group could co-develop a guideline that sets out the steps in applying the the AIC and Turvey methods, potentially including the development of spreadsheet templates.

TABLE OF CONTENTS

1. INTRODUCTION

In July 2022, the IPART Secretariat released a research note seeking comment on a new methodology for estimating the LRMC for water supply.

We are currently developing LRMC estimates for both water and wastewater to inform price setting and economic appraisal of investments.

This response welcomes and supports IPART's stated intent to promote discussion within the community of practitioners.

1.1. LRMC as a concept

LRMC is the cost of servicing an additional unit of demand when all inputs are considered variable. The LRMC incorporates all actions required to bring supply and demand into balance, including capital expenditure on source augmentations.

Water businesses have typically used LRMC to measure the long-run cost of augmenting bulk water supply, which is the focus of IPART's algebraic methodology.

The LRMC concept can also be applied to water distribution, wastewater networks, and wastewater treatment. There are many Australian examples of LRMC estimates for water supply, but few examples of wastewater LRMC estimates.

1.2. Practical uses of LRMC estimates

LRMC estimates play in important role in investment decision making and signalling the opportunity cost of consumption, including:

- Setting usage charges in a manner that promotes efficient consumption decisions.
- Economic appraisal of recycled water and integrated water cycle management, or other initiatives to reduce the demand for water and/or volumes of wastewater. Examples include the use of the LRMC of water in the Economic Level of Water Conservation method and reducing inflow and infiltration of rainwater into the wastewater network.
- Decisions by privately owned water utilities to invest in wastewater servicing solutions, including recycled water and integrated water cycle management decisions.

IPART's Review of pricing arrangements for recycled water and related services observed, *"…LRMC estimates would therefore ideally underpin everything from usage prices to wholesale and access prices, and to decisions about investment in all aspects of water supply, wastewater, recycled water and stormwater services".*[1]

Hunter Water's 2019 pricing proposal included estimates of the LRMC of water. These estimates were based on bulk water source costs and excluded future investment in water treatment and distribution. Given the work underway at the time on the Lower Hunter Water Security Plan (LHWSP), our estimates relied on costs and sizing of a hypothetical desalination augmentation.

The NSW Government approved the LHWSP in April 2022. We are currently updating our LRMC estimates of water using the LHWSP portfolio of actions timing and costs. We hope to include bulk water source, treatment, and network infrastructure.

IPART has flagged its intent to move towards LRMC-based usage pricing for wastewater.[2] Hunter Water is developing estimates of the LRMC of wastewater using the established LRMC methods.

[1] IPART (2019), *Review of pricing arrangements for recycled water and related services*, p.*42.*
[2] IPART, June 2020, Review of prices for Hunter Water Corporation from 1 July 2020, Final Report, page 108,109 and 112.

1.3. LRMC is inherently uncertain

Modelling of LRMC estimates is subject to various uncertainties:

- LRMC is forward-looking and relies on forecasts of investment sequences, costs, supply volumes and demand.
- LRMC can be estimated at any point in time, and the estimates generated will vary over time.
- Using the established LRMC estimation methods – Average Incremental Cost (AIC) and perturbation (Turvey) – requires a variety of assumptions, model specifications, and decisions about how to apply the methods. This creates variability in results, undermining the reliability of the estimates and making it difficult to compare between different LRMC estimates.

As noted by IPART, there is no single estimate of LMRC, *"… we continue to see merit in presenting estimates based on both methods"*.[3]

We consider it good regulatory practice to address these uncertainties by using alternative methodologies as well as including scenario and sensitivity analysis. The various inherent uncertainties will always influence LRMC estimates, irrespective of the methods used – including algebraic estimation. We think it will always be difficult to pick the 'most-correct' estimate.

1.4. Proposed next steps

We agree with IPART's general assessment about the shortcomings of the established methods. We speculate that two practitioners, using the same set of inputs, would come up with materially different LRMC estimates given the inherent discretion in how they apply the estimation techniques.

IPART proposes a new algebraic estimation method to address shortcomings with the established methods. We comment on the relative strengths and weaknesses of this method in Section 2. IPART's method involves a number of simplifying assumptions. There is likely to be some trade-off between gains made via eliminating potential sources of inaccuracy or variability and losses from using assumptions that may be rigid or less reflective of reality.

We suggest the next step in the process should be for IPART and interested NSW water businesses to road-test the application of the algebraic estimation method. This could include case studies with real-world numbers in order to determine how various assumptions affect the LRMC estimates. We are currently refreshing our LRMC estimates and have most of the required model inputs ready to test the different methods.

At this time, we suggest IPART's algebraic estimation method should complement the established methods.

IPART's Information Paper highlights four common sources of inaccuracy with the AIC and Turvey methods. We comment on these examples and raise our own challenges and potential issues in Section 3.

We would welcome the opportunity to discuss the methodological and calculation issues with IPART and interested NSW water businesses. One idea is to establish a working group that would co-develop a guideline that explicitly steps out how to apply each method, supported by example spreadsheet templates.

[3] IPART (2019), *Prices for Sydney Water from 1 July 2020 – Issues Paper*, p.90

2. IPART'S ALGEBRAIC ESTIMATION METHOD

IPART's algebraic estimation method consists of:

- a closed form formula to estimate LRMC for supply augmentations
- a set of associated modelling assumptions to enable a closed form LRMC formula to exist.

IPART's approach essentially allows LRMC to be estimated by inputting assumptions into a calculator, thereby eliminating common errors introduced by undertaking complicated spreadsheet modelling. This would improve transparency and consistency of modelling assumptions and the application of the method.

We agree with IPART's observations about the weaknesses and causes of variation or inaccuracies in estimates using the existing methods.

IPART's approach addresses a number of shortcomings:

- Influence of artificial time horizon and truncation of water volumes
- Measurement of the demand increment under the AIC method – either measuring the increment against existing capacity or against existing demand.
- Magnitude of demand shock assumed under the Turvey method
- Spreadsheet calculation errors and lack of transparency in poorly-designed or presented models

We observe that IPART's standardisation using closed-form equations introduces a range of assumptions. In some instances, these assumptions are more rigid than the established methods for estimating LRMC, making it more difficult to reflect realities of water supply planning and operation.

2.1. Assumptions in the closed-form equations

We provide comment on the key assumptions in the algebraic estimation approach in the below table.

KEY ASSUMPTIONS IN IPART'S ALGEBRAIC ESTIMATION MODEL	HUNTER WATER COMMENT
The same set of demand augmentations are considered in each period of the evaluation (i.e. the decision set is fixed)	The ability to augment our system in response to drought is a crucial part of the LHWSP. A drought-response augmentation is triggered by storage levels rather than the long-term supply-demand balance (intersection of demand and yield). It has a probability of being triggered, which changes each period. Importantly, we can trigger drought-response augmentations when yield is above demand during a drought event. We would like to explore whether the algebraic estimation method can accommodate drought-response investment, especially where this investment then becomes a permanent supply source. This would need to allow adjustments or deferrals of any other planned investments. In practice, the decision set is not fixed. As a first step, we should look to understand the materiality of drought-triggered investments on the LRMC estimates.
Calculation of variable operating costs of new sources, and assumed operating model for desalination plants	IPART's method appears to assume new water sources are operated proportionally to the incremental demand growth that needs to be met. That is, the variable operating costs reflect the theoretical supply contribution, rather than actual production of

	the source based on operating rules. We ask IPART to correct us if we have misinterpreted the equation in this regard. In practice, decisions about source operating rules are driven by hydrology and relative cost. The incremental yield provided by a new source should be viewed as the contribution or 'benefit' provided by the scheme and is not necessarily the same as annual supply. Desalination plants, and other sources, provide a yield contribution without necessarily producing drinking water. When storage levels are high, we are unlikely to run a desalination plant at capacity. We would likely preference sources with lower short-run costs. This is true even when we reach the theoretical long-term demand-yield intersection point, triggering the need for further augmentation. The incremental yield improvement from operating the desal more frequently (e.g. at higher storage levels or all the time) diminishes, and must be compared against other options of building new, or expanding existing, supplies.
If the new capacity is another desalination plant, then the current desalination plant will keep operating at its capacity	As outlined above, a new augmentation may be triggered by the long-term yield-demand balance (intersection point) prior to the desalination plant operating at capacity. In addition, the decision to continue operating the desalination plant as opposed to mothballing could depend on relative cost, economies of scale, and technological improvements.
If the new capacity is a dam, then the current desalination plant will be switched off once the new dam is in service. We assume, in this case, that the desalination plant will not be used again	It is possible that the dam might be so big we would mothball any existing desalination plant, however, it may be that the desalination provides other benefits by continuing to operate. For example, addressing nodal risks within the system, managing resilience risks through source substitution, and providing drought-protection.
Assets supply water in perpetuity	Electrical and mechanical assets may not supply water in perpetuity.
Annual maintenance costs represent all major periodic maintenance and asset renewal costs to enable assets to supply water in perpetuity	This approach appears reasonable but should be tested with some example replacement cost profiles in order to confirm the impact on estimates. Maintenance and operating costs will need to include all costs to allow for infinite asset lives – which requires potential lumpy maintenance and asset renewal costs to be estimated and annualised. As different approaches to this may generate different results, there is a need for guidance about how this should be done.
Demand increases by a fixed increment each period (linearly) until the capacity of all know augmentations are exhausted, and is then held constant at that level	If demand growth is exponential or non-linear, this assumption has potential to distort the estimates. Because demand growth forecasts are inherently uncertain and growth is relatively close to linear, we believe the distortions may not be material. Again, it warrants further testing.

A constant service standard is used to trigger investments; for bulk water supply. The service standard is that "yield is greater than or equal to demand".	This assumption does not currently hold for the Lower Hunter. Our current demand is greater than system yield and there is a lead time for commissioning new infrastructure. One of the main costs of this supply deficit is a heightened risk of triggering drought-response investment and increased likelihood of water restrictions. We would like to talk with IPART about how an existing supply deficit can be incorporated into the proposed formulation.
Water network, water treatment, and wastewater costs.	Applying the established methods for LRMC to the water network, water treatment and wastewater costs poses additional complexities, particularly relating to the cost drivers for these investments. We are keen to work with IPART to consider how, or if, the proposed approach would or could be extended to include investments beyond bulk water source augmentations with drivers other than average annual demand.

3. ESTABLISHED LRMC METHODS

In this section we comment on the challenges with the AIC and Turvey methods, including the causes of variation in estimates. We are of the view that developing an 'LRMC guideline' could help standardise the application of both methods, and improve the reliability and usefulness of the LRMC estimates.

3.1. Influence of model time horizon

We have observed that the chosen time horizon over which to estimate LRMC has a material effect on the range of estimates, particularly under the AIC method. As IPART describes, ending the model at a pre-determined timepoint usually truncates the remaining water volumes provided by the last augmentation. The larger the quantum of water volumes truncated, the greater the bias in results.

We support IPART's work to resolve the issues created by an artificial model time horizon. We are open to testing IPART's algebraic estimation method which assumes the infrastructure operates in perpetuity, and to standardising how NSW water businesses apply the AIC and Turvey methods.

When using the established methods, there are two common ways to ensure costs included in the LRMC calculations take account of the un-utilised asset life:

1. Apply the capital costs as an annuitized stream of payments over the useful life of the asset.
2. Apply a terminal or residual value in the final model period, effectively 'refunding' the cost of the remaining useful life of the asset.

Hunter Water questions whether either of these techniques adequately resolve the issue. Both approaches apply a linear, or straight-line depreciation, adjustment to capital costs. In practice, the incremental demand served by the source over its useful life is often non-linear.

Typically, incremental demand met from a newly built water source is small, grows over time, and then approaches capacity. Straight-line depreciation often does a poor job of estimating the future water volumes that are left outside the model horizon. Underestimating volumes will lead to overestimates of LRMC.

We welcome further discussion by IPART and NSW water businesses on two alternative approaches, described below. Both approaches aim to estimate the future stream of water volumes (net of costs) that would otherwise sit outside the appraisal period.

3.1.1. Flexible appraisal time horizon

Rather than rely on the common but arbitrarily set 30-, 40- or 50-year period, the appraisal time horizon could be set and adjusted to always contain the full useful life of the final source augmentation. This approach would capture the future water volumes (and costs) that would have otherwise fallen outside the truncated horizon. For example, if an augmentation with a useful life of 40 years is commissioned in year 25, the appraisal horizon would run for 65 years. We assume that demand stops growing and remains constant once the theoretical capacity of the final investment is exhausted.

A similar approach without changing the appraisal horizon is to estimate the sum of the water volumes (net of costs) that sit beyond the appraisal period until the end of the useful life of the asset. We convert this into a terminal value that is added to the appraisal horizon. These two approaches should generate the same LRMC estimates, but with different presentation.

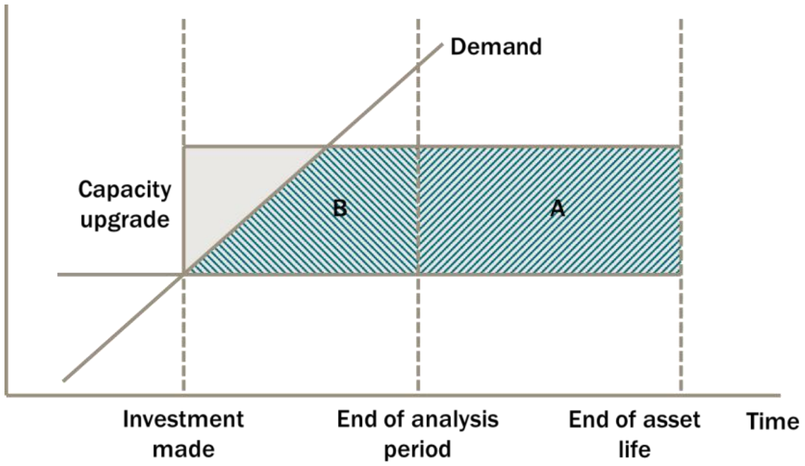
For these approaches to work under Turvey, the shocked portfolio may need a different time horizon than the baseline portfolio. We acknowledge that this may bias the results, and the proposed approaches may only be suitable for the AIC method.

3.1.2. Terminal value proportional to the remaining economic value

Under the typical straight-line depreciation approach to terminal value, if a source augmentation asset has a useful life of 40 years, and the appraisal period ends 20 years after it is commissioned, a terminal value would ‘refund’ half of the cost. In this case, half of the useful life years remain unutilised and outside the appraisal period.[4] However, if demand is growing, the remaining water volumes would typically be more than half of the total water volumes provided by the asset over its useful life.

The aim of a terminal value is to capture the remaining *economic* life of the asset after the appraisal period. This should reflect the remaining value of all subsequent net benefits, not necessarily the accounting value approximated by the straight-line depreciation method.

An alternative is to base this on the proportion of water volumes remaining rather than calculate a terminal value based on the remaining years of an asset’s life at the end of the model horizon. For example, if after 20 years there is 75% of the total water volumes yet to be utilised, then 75% of the asset’s cost would be ‘refunded’ using a terminal value. The LRMC would be estimated by including the proportion of the asset’s cost that matches the proportion of water volumes utilised – shown as B/(A+B) below.



This approach is conceptually similar to the ‘units of production’ depreciation method in accounting, where depreciation occurs based on the number of units produced (demand served so far) as a proportion of the total units that are estimated to be produced (total demand served) over its useful life.[5]

3.2. Defining the AIC demand increment

IPART describes how water businesses have used different increments when applying the AIC method, either measuring the increment against existing capacity or against existing demand. Hunter Water agrees with IPART that NSW water businesses should adopt a common approach given the material impact on estimates of the different assumptions.

3.3. Demand shock using Turvey

The choice of demand shock in the Turvey method is a crucial input. We understand that the shock should be sized such that it changes the timing of the future planned source augmentation(s) by one period. Different decisions on the size of the shock will see material variability in the results.

Applying the demand shock to water network augmentations introduces additional choices and complexity. For the water network, the ‘nature’ of the assumed shock matters in defining how the timing and costs of investment changes in the ‘shocked portfolio’. We discuss this issue further in section 3.6.

[4] Similarly, the capital cost annuity payment stream method would lead to only half of the asset cost being incurred.

[5] Australian Accounting Standards Board (2021) – AASB 116: Property, Plant and Equipment (https://www.aasb.gov.au/admin/file/content105/c9/AASB116_08-15_COMPdec21_01-22.pdf)

3.4. Probabilistic drought-response plan and dynamic LRMC

Hunter Water's LHWSP includes investment in climate-independent supply in the case of a severe and prolonged drought – responding to drought and ensuring continuity of supply by constructing a desalination plant as climate-dependent water storages deplete. Hunter Water's definition of system yield now includes a level of service that defines the probability of getting to a storage level that allows 36 months to construct a drought-response desalination plant.

We consider that the method for estimating the LRMC of water should reflect these probability-weighted drought-response costs. The likelihood of constructing a costly drought-response changes over time as growth occurs, and as water storage levels change – with the likelihood increasing markedly as storages deplete. In practice, the LRMC is dynamic and ever-changing as storage levels fluctuate, implying a dynamic or variable 'scarcity price'.

We observe different ways of incorporating drought-response costs in the LRMC estimate with different degrees of complexity. This creates yet another source of potential variability.

3.5. Estimating LRMC when yield is insufficient to meet demand

IPART suggests that: *"In some years of the forecast, the combined yield of the activated augmentation options is not sufficient to meet demand. This will cause an underestimate of the LRMC but it is often not obvious it has occurred."*

Given the timing of augmentations is triggered by the intersection of yield and demand, we think this error should be obvious to detect in a transparent and well-built spreadsheet model.

However, there is one specific case to consider. We note that yield can be re-estimated periodically, including changing the level of service definitions underpinning the yield calculation. A change in theoretical yield can lead to a current or future projected supply deficit. In this case, we cannot cover the shortfall immediately due to the lead time required to deliver a source augmentation. We currently face this circumstance. There is a risk in the Lower Hunter of triggering an emergency drought-response, which presents as a supply deficit where sustainable yield is less than current demand.

This can effectively make some future planned augmentations 'sunk'. The investment timing is both constrained by lead time – can't be brought-forward – and is still required to address the supply-demand shortfall. The investment cannot be deferred even if there is a minor or moderate reduction (shock) to demand. This implies that water use in the short term by consumers does not create a change in the long-run costs of water supply. However, there is a heightened risk of triggering a drought-response, or being unable to meet restricted demand. When there is a supply deficit, including the costs of drought-response augmentation in the LRMC estimate becomes even more important.

3.6. The LRMC of water network and water treatment investment

For the bulk water system, we use average annual demand to determine augmentation timing. The measure of demand used to determine the timing of growth-driven water distribution network augmentations (reservoirs, pump stations and watermains) is typically peak day demand. The water network is sized to provide sufficient water capacity, covering water pressure and continuity, under peak day (hot and dry) conditions. The measure of demand used to determine the timing of growth-driven water treatment augmentations (i.e. water treatment plants) is typically peak or extreme week demand.

Given the different measures or drivers of demand there is a need to estimate separate additive LRMCs across the various parts of the value chain.

Applying a demand shock using the Turvey method requires consistent assumptions to be applied across the drivers in order to translate the assumed demand. We question how to apply an increase or shock in average annual demand to changes in peak-day demand across different areas of the water network?

We assume this requires assumptions about the composition, location and nature of the demand in order to evaluate the timing of water network investments. The relationship between these drivers and the effect on investment in different parts of the value chain is often non-linear.

We provide two examples to demonstrate this point:

- An increase in average annual demand driven by a large non-residential customer with a uniform seasonal demand profile may have a different (lower) impact on peak day demand than an increase in residential connections with higher peak day demand.
- An increase in average annual demand driven by residential connection growth will influence the timing of water network investments differently depending on where, spatially, the connections are assumed to occur.

For the LRMC estimates to be valid, the assumptions need only be consistent and realistic. However, the introduction of additional assumptions introduces yet another source of variability into the estimates.

3.7. Applying LRMC concepts to wastewater

Hunter Water highlights the added complexity of estimating the LRMC of wastewater services:

- Investment decisions are driven by a range of factors. Wastewater hydraulic capacity upgrades tend to be driven by peak instantaneous flow (L/s) and wastewater process capacity upgrades by equivalent population (EP) or specific treatable loads (kg/day).
- Hunter Water has 19 wastewater catchments that function largely as discrete systems. Each catchment has multiple investment drivers. We will need to disentangle these relationships and future investment costs.
- Our work on developer charges provides reasonable good estimates of forecast costs over the next decade. We will need to make assumptions about the likely timing and scale of investments for a longer time horizon.

There are few examples of Australian water businesses publishing LRMC estimates of wastewater services. SA Water and Melbourne Water's estimates for wastewater treatment plants being notable exceptions.[6,7]

We are keen to work with IPART to consider whether, and how, IPART's algebraic method may be extended to wastewater.

3.8. Well-designed spreadsheets should be error-free

IPART points out that they have reviewed LRMC spreadsheet models that lack transparency.

> *"The spreadsheets are still fairly complex and often rely on macros to perform the calculation. Overall, they tend to lack transparency."*[8]

There are many spreadsheet models, more complex than an LRMC model, that are able to maintain transparency, auditability, and user/reviewer confidence. A well-designed spreadsheet is more readily understandable and less complex for most users and reviewers than algebraic estimation. However, we acknowledge the variability in quality and potential for hidden calculation error.

[6] Sapere Research Group, 2014, *LRMC of SA Water's Trade Waste services*. Report for the Essential Services Commission of South Australia.

[7] Melbourne Water, 2021, *Price Submission 2021: 1 July 2021 to 30 June 2026*, page 31 and 7-7.

[8] IPART (2022), *A more accurate way to estimate LRMC* – Information Paper, p.2-3

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