frontier economics

Estimation of efficient self-insurance costs

A final report prepared for IPART | 5 February 2021

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1 Executive summary

1.1 Background

WaterNSW supplies rural bulk water services to customers in 13 valleys: nine valleys in the Murray-Darling Basin, three coastal valleys and the Fish River. WaterNSW's customers include private irrigators, irrigation companies, environmental water holders and local councils. WaterNSW supplies bulk water from large dams, pipelines and the State's rivers.

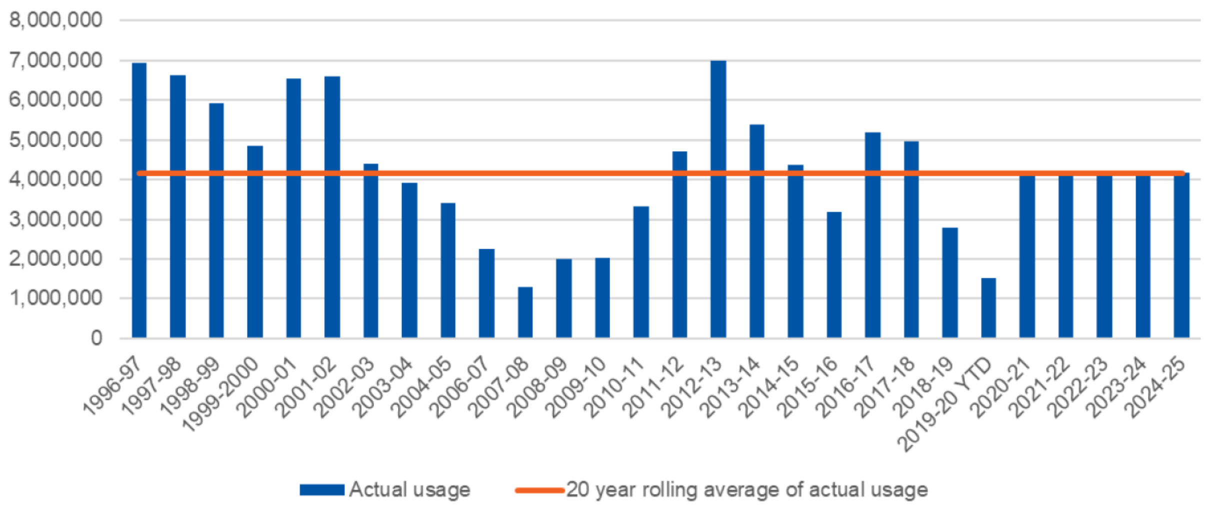
IPART is currently reviewing prices that customers pay for rural bulk water services delivered by WaterNSW. The review will set new prices to apply from 2021-22 to 2025-26. IPART sets regulated prices for WaterNSW by determining the efficient costs of service delivery.

WaterNSW's prices are set in the form of two-part tariffs, where customers pay an annual fixed charge ($ per ML of entitlement) and usage charges ($ per ML of water used).

IPART uses a forecast of WaterNSW's water sales in its process for setting regulated tariffs for WaterNSW. Those forecasts are based on a 20-year rolling average of historical water sales, and are updated every four years at the start of each regulatory period. Underpinning this approach is an assumption that whilst WaterNSW experiences year-to-year revenue volatility, the year-to-year unders-and-overs in revenue recoveries will average out over the long-run.

However, as shown in **Figure 1**, WaterNSW carries significant short-term revenue risk because the volume of water that it sells can vary considerably from one year to the next (e.g., due to drought conditions).

Figure 1: WaterNSW 20-year rolling average of water sales (ML)



Source: WaterNSW, WaterNSW Pricing Proposal to the Independent Pricing and Regulatory Tribunal Regulated prices for NSW Rural Bulk Water Services 1 July 2021 to 30 June 2022, p. 15.

This problem is exacerbated by the fact that, although most of WaterNSW's costs are fixed (i.e., not impacted by the volume of water sold), its tariff structure means that in most valleys 60% of its forecast revenue is expected to come from usage charges and only 40% of its revenue is effectively guaranteed through fixed charges—as shown in **Table 1** below.

Table 1: Current tariff structure associated with WaterNSW's rural valleys

Valley	Tariff structure (fixed % / variable %)
Border Rivers	40/60
Gwydir	40/60
Namoi	40/60
Peel	80/20
Macquarie	40/60
Lachlan	40/60
Murray	40/60
Murrumbidgee	40/60
Lowbidgee	100/0
Fish River	80/20
North Coast	90/10
Hunter	60/40
South Coast	80/20

Source: IPART.

IPART provides WaterNSW with an allowance to purchase a Risk Transfer Product (RTP) to manage its short-term revenue risk and to allow the business to achieve cash flow outcomes consistent with an 80% fixed, 20% variable tariff structure.[1] The purpose of this study is to advise IPART on the efficient costs of managing revenue risk over the forthcoming regulatory period using a self-insurance approach.

1.2 Our instructions

IPART has asked us to identify, describe and estimate the efficient costs of WaterNSW converting its total revenue streams into given proportions of fixed and variable revenues using self-insurance through a borrowing and lending strategy to smooth its revenue over time.

In undertaking this work, IPART has instructed us to:

[1] That is, to 'convert' the cash flows received under the actual pricing structure to those that would have been received under an 80/20 pricing structure.

- Estimate the efficient self-insurance costs that would likely be incurred by a benchmark efficient business, rather than the actual costs that would be incurred by WaterNSW;
- Consider a symmetric mechanism for managing revenue risk, such that the benchmark business can achieve a specific notional fixed to variable cash flow. Under such an approach, any revenue shortfalls would be funded by the self-insurance scheme, and any revenue surpluses would be paid back into the self-insurance scheme;
- Assume that actual proportion of fixed charges, and the efficient target level of fixed charges, over the forthcoming regulatory period, remain in line with those set out in **Table 2** below;
- In those valleys where the target tariff structure differs from the actual tariff structure, conduct sensitivities to understand how varying the target fixed-to-variable revenue split (i.e., a 70/30 split, and a 90/10 split) would affect efficient self-insurance costs;
- For those valleys subject to Border River Commission (BRC) and Murray Darling Basin Authority (MDBA) charges, vary the fixed proportion of those charges from 80% (per the current tariff structure) to 40% (in line with the tariff structures that apply to infrastructure charges in those valleys); and
- Assume that IPART will continue its approach of updating its forecasts of water sales every four years, at the start of each regulatory period.

Table 2: Proportion of actual and target fixed charges by valley

Valley	Fixed charge proportion (actual)	Fixed charge proportion (target)
Border	40%	80%
Gwydir	40%	80%
Hunter	60%	80%
Lachlan	40%	80%
Lowbidgee	100%	100%
Macquarie	40%	80%
Murray	40%	80%
Murrumbidgee	40%	80%
Namoi	40%	80%
North Coast	90%	90%
Peel	80%	80%
South Coast	80%	80%
Border – BRC	80%	80%
Murray – MDBA	80%	80%

Murrumbidgee – MDBA	80%	80%

Source: Frontier Economics summary of assumptions provided by IPART.

1.3 Key findings

In this report, we have sought to estimate the efficient costs of a symmetric self-insurance mechanism with the following characteristics:

- An account would be kept of any under/over-recovery of allowed total revenues (i.e., across all valleys) arising as consequence of any difference between the actual tariff structure applied and the 'target' tariff structure adopted by IPART.
- The business would borrow to finance any revenue shortfalls, and would use any surplus revenues that have accumulated to repay the debt.
- The debt facility used to finances revenue shortfalls would likely be akin to a revolving line of credit. That is, the business would be able to borrow up to a maximum loan amount, and pay interest on any funds that are drawn down from this facility. In addition to interest on any funds drawn down, the business would also pay a commitment fee (i.e., a fixed rate on the maximum loan amount) to the lender for making the debt facility available. The debt facility may also attract other costs, such as upfront set-up and administration fees.
- The business would be provided with a regulatory allowance that would be sufficient to recoup the efficient cost any such facility over the regulatory period.

We estimate the efficient cost of self-insurance using three steps:

- First, we use Monte Carlo analysis, and historical data on WaterNSW's actual water sales, to simulate distributions of future water sales (over a 20-year horizon) for each valley. Our simulation analysis accounts for correlations in water sales over time and across valleys.
- Next, for each valley, we compute a distribution of future revenue under/over-recoveries arising from differences between the actual tariff structure used in each valley to collect revenues and a target tariff structure for each valley (provided to us by IPART). We aggregate the under/over-recoveries across all valleys to obtain a distribution of future under/over-recoveries for the business as a whole.
- Finally, we convert the distribution of forecast aggregate under/over-recovery of revenue into a distribution of self-insurance costs. These cost estimates are expressed as:
  - A commitment fee payable to a lender for making available a line of credit to the business to finance revenue under/over-recovery; and
  - Net interest charges payable on any funds drawn down from this facility. Any short-fall of revenues are assumed to be financed by drawing down on the debt facility, and any surplus revenues are assumed to be invested at the risk-free rate.

  For the purposes of this report, we have assumed zero upfront and administration costs (although we have incorporated an allowance for debt raising costs into the interest rate that is applied to any drawdowns).

Table 3 summarises our preliminary estimates of efficient self-insurance costs, over the forthcoming regulatory period, under a 'Central' case where IPART's target tariff structure of 80%

fixed charges and 20% variable charges for most valleys. The Table also presents the results of sensitivity analyses that considers a 70:30 tariff structure and 90:10 tariff structure.

Table 3: Estimates of efficient borrowing costs

	Current – 40:60 Target - 80:20	Current – 40:60 Target - 70:30	Current – 40:60 Target - 90:10
Commitment fee ($m)	1.651	1.088	2.237
Drawdown / interest ($m)	0.393	0.259	0.532
Total ($m)	2.044	1.347	2.769

Source: Frontier Economics analysis. Note: The estimates in this Table assume that 80% of the charges that relate the recovery of BRC and MDBA charges are fixed.

Table 4 allocates the estimated efficient cost of the self-insurance mechanism under the Central scenario to each valley, according to the contribution of each valley to the variability of aggregate future under/over-recovery across all valleys.

Table 4: Cost allocation by valley (Central scenario)

Valley	Proportion (%)	Cost ($m NPV)
Border	1.6%	0.033
Gwydir	14.2%	0.290
Hunter	0.3%	0.006
Lachlan	25.5%	0.522
Lowbidgee	0.0%	0.000
Macquarie	19.1%	0.390
Murray	10.7%	0.219
Murrumbidgee	14.7%	0.300
Namoi	13.9%	0.285
North Coast	0.0%	0.000
Peel	0.0%	0.000
South Coast	0.0%	0.000

Source: Frontier Economics analysis

Given the time constraints in preparing this advice to IPART, we have adopted 'placeholder' estimates of the commitment fee rate, the interest rate on any drawdowns on the debt facility, and the interest rate applied to any surplus revenues. We intend to refine these input assumptions once we have had an opportunity to consult directly with TCorp, and will update our estimates accordingly in an Addendum report to IPART.

We note that our simulated distributions of future water sales were based on a relatively short time series (up 23 years) of historical water sales data for most valleys. WaterNSW has advised that it would be able to provide us with a much longer time series of simulated water volumes for major valleys, that could potentially be used to supplement the historical data we rely on to simulate future water sales. If these data are provided to us, then we would seek to update our simulation analysis to incorporate the additional information.

2 Approach to estimating efficient self-insurance costs

2.1 Overview of approach

2.1.1 Self-insurance mechanism

Our first task is to describe a symmetric, self-insurance mechanism, implemented through a borrowing and lending strategy, that could be used to smooth WaterNSW's revenues over time. Given that IPART sets allowances in line with the efficient costs of a hypothetical benchmark business, we describe how a self-insurance mechanism could work in principle for a benchmark business. The key features of the scheme are the following:

- The benchmark business would maintain a self-insurance account that records any surpluses and shortfalls in total revenues (i.e., across all valleys) arising as consequence of any difference between the actual tariff structure applied and the 'target' tariff structure adopted by IPART. For clarity, we define surpluses and shortfalls as the difference between revenues received under the actual tariff structure and revenues that would have been obtained if the target tariff structure had been applied to the actual volume used.
- The business would borrow to finance any revenue shortfalls, and would use any surplus revenues that have accumulated to repay this debt. The symmetry of the mechanism derives from the fact that the business would use surplus revenues to repay past borrowing, rather than retain those surpluses.
- The debt facility used to finance revenue shortfalls would likely be akin to a revolving line of credit. That is, the business would be able to borrow up to a maximum loan amount, and pay interest on any funds that are drawn down from this facility. In addition to interest on any funds drawn down, the business would also pay a commitment fee (i.e., a fixed rate on the maximum loan amount) to the lender for making the debt facility available. The debt facility may also attract other costs, such as upfront set-up and administration fees.
- The business would be provided with a regulatory allowance that would be sufficient to recoup the efficient cost of any such facility over the regulatory period.

We consider two ways in which IPART could determine the allowance for efficient costs at the start of each regulatory period:

- Under the first approach, IPART would set the regulatory allowance to recoup the expected efficient self-insurance costs over the forthcoming regulatory period, without regard to any under/over-recovery of allowed revenues that may have accumulated in previous regulatory periods.
- Under the second approach, IPART would set the regulatory allowance to:
  - recover the expected efficient self-insurance costs over the forthcoming regulatory period; and
  - recoup (payback to customers) a portion of any accumulated historical under-recovery (surplus) of revenues.

2.1.2 Process for estimating efficient self-insurance costs

At a high level, the process we use to estimate efficient self-insurance costs involves three steps, as summarised in **Figure 2**.

Figure 2: Three steps for estimating efficient self-insurance costs

01

Forecast distribution of future water sales

Simulate future water sales using actual historical data on water sales.

02

Forecast benchmark business's borrowing requirements

Calculate shortfall/surplus in business's revenues arising from difference in actual and target tariff structure.

03

Forecast efficient cost of self-insurance mechanism

Compute cost of self-insuring against revenue shortfalls/ surpluses, given the forecast borrowing requirements of the business.

Source: Frontier Economics

Step 1: First, we develop a distribution of future water sales by the benchmark business over a 20-year forward-looking period. We develop a distribution of future water sales, rather than a single forecast, to reflect the uncertainty over the future volume of sales. We build up a distribution of future water sales using Monte Carlo simulation analysis, calibrated using actual data on historical water sales by WaterNSW by valley.

Step 2: Next, we use the distribution of future water sales to develop a distribution of the benchmark business's future borrowing requirements by:

- Forecasting the revenues that are expected to be collected in each valley, given the business's actual tariff structure (and forecast water sales);
- Forecasting the revenues that would be collected in each valley, given IPART's target tariff structure (and forecast water sales); and
- Subtracting the latter from the former.

If the revenues collected using the business's actual tariff structure are lower than the revenues that would be collected using the target tariff structure, then the business would have suffered a revenue shortfall, which would need to be financed through borrowing. If the revenues collected using the business's actual tariff structure are higher than the revenues would be collected using the target tariff structure, then the business would have enjoyed a revenue surplus, which would be used to repay the debt. We take the 95th percentile of the distribution of revenue under-recovery accumulated over the regulatory period as the business's maximum borrowing requirement.

Step 3: Finally, we convert the business's forecast borrowing requirement into a distribution of possible self-insurance costs for each year of the regulatory period. We do this by calculating (for each possible realisation of forecast revenue under/over-recovery) the sum of:

- Set-up and administration fees;

- An estimated commitment fee, computed as a fixed commitment fee rate multiplied by the business's forecast maximum borrowing requirement; and
- The estimated interest charges on any net draw-downs on the debt facility, offset by the interest received on any surplus balances.

We then take the mean estimate of self-insurance costs in each year as our point estimate (i.e., the expected value) of efficient self-insurance costs for the benchmark business.

Key inputs to this calculation are:

- The maximum loan amount available to the benchmark business;
- An estimate of any efficient set-up and administration fees;
- An estimate of the efficient commitment fee rate to be applied to the maximum loan amount; and
- An estimate of the efficient rates of interest to be applied to any draw-downs on the debt facility or revenue surpluses.

We sought to obtain estimates of these inputs from TCorp. Given that TCorp is responsible for arranging debt facilities for the State Owned Corporations such as WaterNSW, it has unique expertise that would provide insights into the efficient costs that might apply to a self-insurance mechanism of the sort described above.

Unfortunately, due to the tight timeframes available to prepare our advice to IPART, TCorp has not yet been able to provide the final inputs that we require for our analysis. Therefore, we have used placeholder inputs for the purposes of producing the estimates of efficient self-insurance costs presented in this report. As such, the estimates of efficient self-insurance costs presented in this report should be regarded as preliminary estimates only.

We intend to engage more fully with TCorp following the publication of IPART's draft decision, and once we have reviewed the feedback from stakeholders on the preliminary analysis presented in this report. We will then update our modelling inputs, and prepare an Addendum to our report that would inform IPART's final decision—taking onboard TCorp's views as well as feedback from stakeholders on our methodology.

The remainder of this section explains each step in our methodology in greater detail.

2.2 Methodology for simulating the distributions of future water sales

2.2.1 Forecasting approaches

The methodology for simulating the distribution of future water sales consists of two main steps:

- Use historical data on water sales in past years to develop a model that fits the historical data.
- Apply the estimated model to obtain forecasts of future consumption volumes. Since the focus of this project is on the revenue risk associated with volatility of future consumption, we need to forecast not just a most likely scenario for future consumption, but a whole distribution of possible future consumption levels for each year of the forecasting horizon.

There are two basic approaches to modelling and forecasting water sales: the bottom-up approach and the top-down approach.

Bottom-up approach

The bottom-up approach takes into account the factors that influence the consumption decisions of individual customers (e.g., water entitlements, allowances, carry overs, dam levels, etc.) and models how these factors influence water consumption. Using this approach for forecasting would involve developing projections for rainfall, the use of a hydrological models of water flows into and out of dams, and of dam levels, as well as a model of how these would affect regulatory allowances and consumption.

Top-down approach

The top-down approach estimates trends and patterns in aggregated historical consumption levels using statistical models, and then uses the resulting model to forecast consumption into the future. The model can incorporate other drivers of aggregate consumption levels, such as economic conditions and climate change.

The rationale underpinning the top-down approach is that, although the models do not explicitly take account of hydrological models of water flows, dam levels, entitlements, allowances and so forth, they implicitly take these factors into account since the aggregated volumes data represent the outcomes of all these considerations and decisions. Given a large enough sample of historical consumption data, it is possible to estimate a statistical model on the historical data that can be used to forecast future water consumption levels.[2]

The bottom-up approach requires far more data than the top-down approach, and the development of far more complex models. Given the tight timeline for this project, and the limited data available, we have opted for the top-down approach to forecast future water consumption.

2.2.2 Model specification

The data available to develop a model of historical consumption consists of annual consumption volumes for each of the 13 valleys under review. The data goes up to 2020, and for most valleys back to 1997.[3]

The volumes data can be analysed using statistical time series methods. In choosing an appropriate method for the analysis, two important features of the data need to be taken into account:

- correlation of volumes across valleys. For some pairs of valleys the correlation is as high 0.95; and
- correlation of volumes over time within a valley. For some valleys the serial correlation between successive years is over 0.6.

We investigated several different statistical time series methods to model the historical data, in particular, autoregressions, vector autoregressions (VAR) and seemingly unrelated regressions

[2] This assumes that there are no changes in institutional arrangements and other external factors that would materially change future consumption levels from historical patterns.

[3] The data and forecasts all relate to financial years. Accordingly, all references to 'years' in this section relate to financial years.

(SUR). None of these approaches proved satisfactory in capturing the key features of interest mentioned above.

WaterNSW advised us that it uses a 20-year rolling average of historical water sales to forecast consumption levels in each valley, with the rolling average updated every year. Under this approach, consumption in a future year is forecast by using the average of annual water sales in the most recent 20 years of data. IPART also relies on a 20-year rolling average to obtain forecasts of water sales, but only updates the 20-year period over which the average consumption is calculated prior to each four-yearly review of prices.

In view of this, we decided to adopt the approach used by WaterNSW, and to forecast a base level of water sales in any future year by the average annual water sales over the preceding 20 years. However, to capture the uncertainty in the water sales forecast and the correlation in water sales across valleys and across time, we added simulated positive and negative shocks (as explained below) to the base consumption forecasts that incorporated the time series and cross-sectional correlations that we identified in the historical data.

2.2.3 Simulating the distributions of future consumption

Since the focus of this project is on revenue risk, it is crucial that forecasts of future water sales take into account the potential for shortfalls or surpluses in revenue to accumulate through successive years of low water sales or of high water sales, as well as due to correlation in volumes across valleys (e.g., when one valley is experiencing drought, other valleys are likely to have low revenues as well; or, conversely, while some valleys experience drought, other valleys may enjoy a surplus of revenues that help offset shortfalls in the drought-affected valleys). These factors can be captured by taking account of the cross-correlation of volumes across valleys and the serial correlation of volumes over time. The steps for achieving this are described below.

The forecasting horizon for this project covers the 20 financial years from 2021 to 2040. The base level forecast of consumption in each valley for the first year of the forecasting period were determined by taking the average annual consumption in each valley over the previous 20 years. We then added shocks to the base level forecasts. These shocks were random draws from the set of residuals obtained when a 20-year rolling average was fitted to the historical consumption data in each valley for the period 1997 to 2020.[4] To capture the correlation in consumption across valleys, in any draw the same randomly selected year was used to obtain the residuals for all of the valleys. If a residual is positive for one year during the period FY1997 to FY2020 in one valley (i.e., actual consumption was above the 20-year rolling average), it is likely to be positive in that same year in other valleys as well. This approach maintains the same correlation structure for water sales across valleys in the forecasts as was observed in the historical data.

The historical data suggests that there is a significant degree of persistence in water sales. That is, water sales tend to be below average or above average for a number of consecutive years. To introduce serial correlation across time in the forecasts, to reflect this feature of the historical data, we selected random residuals from the historical period in pairs of adjoining years. Thus, to obtain the forecasts for consumption in 2021:

- We set the base forecast in each valley for 2021 equal to the average annual consumption in that valley over the period 2001 to 2020.

[4] For a few small valleys there were gaps in the historical consumption data, and hence the set of historical residuals. We filled these gaps in the set of residuals by replacing the gaps with the residuals for years that did not have missing data.

- We next selected a random year from the 1997 to 2020 period with historical data, say 2002.
- We then selected the residuals for both 2002 and 2003 across all valleys.[5]
- Next we modified the base forecasts for 2021 by applying the residuals from 2002 to the base forecasts to obtain the forecasts for 2021.
- The next step was to recalculate the rolling 20-year averages for each valley to obtain the base forecasts for 2022.
- Finally, we obtained the forecasts for 2022 by applying the historical residuals from 2003.

This process was repeated to obtain the forecasts for 2023 and 2024, and continued in pairs of years up to the end of the forecasting period, which is 2040.

The above steps describe one run of the Monte Carlo simulation process used to build up a distribution of possible future outcomes. It is one realisation of what future consumption volumes might look like for all valleys for the forecasting period. Other realisations of what the future volumes might look like are obtained by repeating the steps described above, but, for each realisation, randomly selecting new historical years for the residuals.

We repeated the process 1,000 times to obtain 1,000 different realisations for what future consumption volumes might be in each. We refer to these 1,000 realisations as an ensemble. The ensemble contains 1,000 different forecasts for each year of the forecasting horizon and for each valley. Thus for each forecasting year and valley we can construct a distribution of consumption. The distribution is centred on the base forecast and also displays the variability of consumption around the base forecast. Using this information, it is possible to calculate a variety of measures relating to the consumption forecasts, such as a 90% confidence interval around the base forecast, or the probability that consumption will fall below some threshold level.

2.2.4 Data used to simulate the distribution of future water sales

As noted above, we were provided with WaterNSW's actual historical water sales data for most valleys for the financial years 1997 to 2020 (inclusive).

This dataset provided us with up to 23 years of historical information for each valley. Ideally, we would want a longer time series of historical data with which to forecast future water sales, to capture the relatively long cycles of water availability. Unfortunately, we were advised by WaterNSW that these data were the most complete historical information on water sales available for each of the valleys.

However, WaterNSW advised us that it could provide us with long times series (e.g., up to 100 years) of simulated water volumes for at least the major valleys. These data would be simulated using the Integrated Quantity and Quality Model (IQQM) that is used within the industry for water resource planning purposes. In principle, such a dataset could supplement the actual historical water sales data, thereby providing a much richer source of information from which to compute the 20-year rolling averages, and to sample the residuals used in our simulation analysis.

[5] Originally, we <u>added</u> the historical residuals to the base forecasts to obtain the actual forecasts. However, this approach sometimes produced negative consumption forecasts, which is clearly implausible. Hence, we changed the approach and, instead of calculating the residuals as the differences between actual consumption and the 20-year rolling average, we calculated the ratio of actual historical consumption to the 20-year rolling average. We then applied these ratios to the base level forecasts to obtain the actual forecasts. While this modification will affect the correlation structure of consumption across valleys and across time, the impact is likely to be fairly small.

However, WaterNSW was unable to supply us with the IQQM data before the completion of this report. In the event that WaterNSW is able to supply us with the IQQM data sought, we would seek to utilise those data to refine the simulation analysis that would be used to prepare our Addendum report.

2.3 Methodology for simulating distribution of future revenue shortfalls and surpluses

Having developed distributions of forecast water sales for each valley, we use those simulated distributions to estimate the distribution of future revenue shortfalls and surpluses—in order to obtain estimates of the benchmark business's future borrowing requirements.

This involves three steps:

1. Define the 'current' and 'target' fixed charge proportion in each valley. That is, the proportion of the revenue allowance collected through fixed charges under current pricing arrangements and under economically efficient target pricing arrangements (which were advised to us by IPART).
2. For each of the 1,000 Monte Carlo consumption simulations, calculate the revenue collected in each valley under the current and target pricing arrangements. The under/over-recovery of allowed revenues is then computed as the difference in total revenue collected (from fixed and variable charges) between the current and target pricing arrangements.
3. For each of the 1,000 simulations, estimate the cumulative total under/over-recovery by aggregating the outcomes across valleys, and adding over subsequent years.

Pricing arrangement scenarios and sensitivities

In most valleys, the current pricing arrangements are that 40% of the revenue allowance is to be collected through fixed charges, and 60% of the revenue allowance is to be collected through variable charges. The revenue collected by variable charges is uncertain however, and depends on annual consumption. Revenue collected equals the revenue allowance if consumption is equal to the forecast, and is higher or lower if consumption is higher or lower than the forecast.

There are some exceptions:

- For some valleys (such as Lowbidgee, Hunter, North Coast, Peel and South Coast), a greater share of revenue than 40% is collected through fixed charges.
- For Border, revenue must be collected to pay Border River Commission (BRC) charges. The pricing arrangements to collect revenue for the BRC are different to pricing arrangements to cover infrastructure costs in Border, with fixed charges collecting 80% of the revenue allowance.
- For Murray and Murrumbidgee, revenue must be collected to pay Murray Darling Basin Authority (MDBA) charges. The pricing arrangements to collect revenue for the MDBA are different to pricing arrangements to cover infrastructure costs in Murray and Murrumbidgee, with fixed charges collecting 80% of the revenue allowance.

We were instructed by IPART to compare the revenue collected under the current pricing arrangements to alternative 'target' pricing arrangements. Under the target pricing arrangements the proportion of revenue collected through fixed charges is higher in most valleys. We modelled a 'Central' scenario and five sensitivities with differing current and target pricing arrangements.

In the 'Central' scenario, the target fixed charge proportion is 80% in most valleys. The current and target fixed charge proportion in each valley, with differences highlighted in bold, is set out in **Table 5**.

Table 5: Overview of Central scenario

Valley	Revenue allowance ($m)	Fixed charge proportion (current)	Fixed charge proportion (target)
Border	1.82	40%	**80%**
Gwydir	7.35	40%	**80%**
Hunter	6.14	60%	**80%**
Lachlan	10.71	40%	**80%**
Lowbidgee	1.37	100%	100%
Macquarie	9.15	40%	**80%**
Murray	6.88	40%	**80%**
Murrumbidgee	12.70	40%	**80%**
Namoi	7.20	40%	**80%**
North Coast	0.11	90%	90%
Peel	1.60	80%	80%
South Coast	0.36	80%	80%
Border – BRC	1.08	80%	80%
Murray – MDBA	19.67	80%	80%
Murrumbidgee – MDBA	4.36	80%	80%

Source: Frontier Economics summary of assumptions provided by IPART

We modelled five sensitivities on the Central scenario:

- **Alternative target:** Varying the target fixed charge proportion from 80% to 70% or 90%
- **Alternative current BRC and MDBA**: Varying the current fixed charge proportion for BRC and MDBA charges from 80% to 40% (in line with other charges in those valleys).

In total, we modelled outcomes under six pricing arrangements (two current pricing arrangements by three target pricing arrangements). The specification of the alternative pricing arrangements is set out in **Table 6**.

Table 6: Overview of fixed charge proportion by sensitivity

Valley	Current 1 Infrastructure: 40:60 MDBA / BRC: 80:20	Current 2 I: 40:60 M/B: 40:60	Target 1 I: 80:20 M/B: 80:20	Target 2 I: 70:30 M/B: 70:30	Target 1 I: 90:10 M/B: 90:10
Border	40%	40%	**80%**	**70%**	**90%**
Gwydir	40%	40%	**80%**	**70%**	**90%**
Hunter	60%	60%	**80%**	**70%**	**90%**
Lachlan	40%	40%	**80%**	**70%**	**90%**
Lowbidgee	100%	100%	100%	100%	100%
Macquarie	40%	40%	**80%**	**70%**	**90%**
Murray	40%	40%	**80%**	**70%**	**90%**
Murrumbidgee	40%	40%	**80%**	**70%**	**90%**
Namoi	40%	40%	**80%**	**70%**	**90%**
North Coast	90%	90%	90%	90%	90%
Peel	80%	80%	**80%**	**70%**	**90%**
South Coast	80%	80%	80%	80%	80%
Border – BRC	80%	**40%**	**80%**	**70%**	**90%**
Murray – MDBA	80%	**40%**	**80%**	**70%**	**90%**
Murrumbidgee – MDBA	80%	**40%**	**80%**	**70%**	**90%**

Source: Frontier Economics summary of assumptions provided by IPART

The results presented in the remainder this report relate to the 'Central' scenario unless otherwise stated.

Modelling revenue and unders/overs

To estimate revenue and under/over-recovery we model a simplified price setting and revenue collection process. It involves the following steps:

1. Take the revenue allowance provided by IPART for each valley, as set out in **Table 5**. Note for Border, Murray and Murrumbidgee there are two components to the total revenue allowance.
2. Split the revenue allowance into two components – one to be collected by fixed charges, and the other to be targeted through variable charges. Estimate a simplified variable charge by

dividing the variable component by IPART's demand forecast (i.e., the average of the previous 20 years of consumption by valley). This process is performed for the 'current' and 'target' pricing arrangements.

3. Calculate realised revenue for each of the 1,000 simulations under current and target pricing arrangements. This is calculated by multiplying the variable price by the simulated consumption and adding the fixed charge revenue under each pricing arrangement.
4. The unders/overs by valley is the difference between the total revenue under the current and target pricing arrangements. For each valley, this depends on the difference between the pricing arrangements (i.e., current or target tariff structure) in the particular valley, and the difference between forecast and simulated consumption. The range of outcomes under each combination of factors is set out below:
   - **Simulated consumption above IPART's forecast**: The revenue collected under both current and target pricing arrangements would exceed the revenue allowance.
     - Valleys where the current fixed share is below target (such as Lachlan or Macquarie): Current variable price is higher than target, and revenue collected under current pricing arrangement would be higher than under target pricing arrangements. There is *over-recovery* equal to the difference.
     - Valleys where the current fixed share is equal to target (such as Lowbidgee): The revenue collected under current and target pricing arrangements is the same, so there is *no under or over-recovery.*
     - Valleys where the current fixed share is equal to target (no examples in the 'Central' scenario, but applies to Peel in the 70:30 sensitivities). The revenue collected under current pricing arrangement would be lower than under target pricing arrangements. There is *under-recovery* equal to the difference.
   - **Simulated consumption below IPART's forecast**: The inverse of the above.
     - Valleys where the current fixed share is below target: There is *under-recovery* of revenue in the current pricing arrangement relative to the target.
     - Valleys where the current fixed share is equal to target: There is *no under or over-recovery* of revenue.
     - Valleys where the current fixed share is above target: There is *over-recovery* in the current pricing arrangement relative to the target.
   - **Simulated consumption exactly equal to IPART's forecast**: Revenue recovered under each pricing arrangement is the same, so there is *no under or over-recovery*. This outcome is highly unlikely.
5. The unders/overs across each valley are added together to produce a total WaterNSW unders/overs for each year of each simulation. The unders/overs are carried forward from year to year, with the cumulative unders/overs calculated by adding the value for each preceding year.

Calibrating consumption to IPART's forecast

The revenue modelling is based on the outcome of the consumption modelling, described in Sections 2.2 and 3.1. However, we perform a final step to calibrate the consumption so that it is equal to IPART's forecast on average. This is based on the assumption that IPART's forecast of consumption (derived using the average of the past 20 years at the start of the regulatory period) is unbiased.

The consumption in each iteration is proportionately scaled up or down such that the mean across the 1,000 simulations is equal to the IPART forecast. This maintains the shape of the distribution and maintains the likelihood of material under- or over-recoveries. The scaling factor used to determine the calibration may be different between years and between valleys.

2.4 Methodology for estimating efficient self-insurance costs

Overview

Having determined the total amount of revenue under/over-recovery for WaterNSW for each simulation, we then turn to allocating that figure across each valley. We do this by determining the relative contribution of each valley to the variance (over the *N* simulations) of the total present value revenue requirement. As explained below, this is computed in the same way as one would compute the contribution of one stock to the variance of a portfolio of assets.

For the purposes of this report, we consider two components of borrowing costs:

1. A commitment fee that must be paid on the maximum line of credit that is made available over the four-year regulatory period; and
2. An interest fee that is charged on the amount that is drawn down from time to time.

For simplicity, and until such time as we have been able to seek advice from TCorp, we assume that the upfront and administration fees are zero. However, as explained below, we incorporate into the interest charge applied to any funds drawn down from the debt facility the standard debt issuance cost allowance of 12.5 basis points per annum provided by IPART when setting regulated charges,[6] as a rough proxy for the administration charges associated with this debt facility.

Commitment fee

The maximum size of the line of credit is computed as the 95th percentile of the distribution of total Year 4 revenue shortfalls/surpluses from the previous stage of modelling. That is, the maximum size of the line of credit is computed such that it will be entirely adequate in 19 out of 20 regulatory periods and substantially adequate in all regulatory periods. A total figure encompassing all valleys is computed.

The total commitment fee is then computed by multiplying the maximum line of credit by an estimated cost of commitment fee rate to be paid at the end of each quarter. For the purposes of the analysis presented in this report, we have adopted a placeholder commitment fee rate of 0.25% per quarter. We intend to update this figure in our Addendum report to IPART, once we have sought further advice from TCorp.

These commitment fees are converted to a present value using the relevant quarterly borrowing rate (r, defined below) as follows:[7]

$$PV(Commitment\ fee) = 0.25\% \times \begin{bmatrix} Maximum\ line \\ of\ credit \end{bmatrix} \times \frac{1-(1+r)^{-16}}{r}.$$

[6] IPART, Review of our WACC method, Final report, February 2018.

[7] This formula computes the present value of 16 equal quarterly commitment fee payments. We use the borrowing rate as the relevant discount as the borrowing rate reflects the risk of the cash flows being discounted.

Drawdowns and interest fees

The simulation modelling described in the previous section produces an estimate of the shortfall or deficit for each valley at the end of each year. We begin by converting these figures to quarterly estimates using linear interpolation. For example, if the simulated deficit for a particular valley at the end of Year 1 was $100, we would estimate the deficit to be $25 at 3 months, $50 at 6 six months, $75 at 9 months and then $100 at the end of the year.

For each simulation for each valley, we compute interest charged at the end of each quarter as the balance drawn down at the beginning of that quarter multiplied by an interest rate of 2.4% per annum, or approximately 0.60% per quarter.[8] This interest rate of 2.4% is an estimate of the prevailing cost of 10-year BBB-rated corporate debt (inclusive of an allowance of 12.5 basis points per annum for efficient debt raising costs), computed using a 40-day averaging period to 31 December 2020. This rate represents a placeholder rate of interest until such time as we are able to seek advice from TCorp on the efficient borrowing rate that would apply to a benchmark business with the distribution of simulated revenue shortfalls/surpluses presented in the previous section.

In the event that there is a surplus of revenues, rather than a deficit, interest received is computed at the rate of 0.9% per annum, or approximately 0.22% per quarter.[9] This rate is an estimate of the prevailing risk-free rate of interest, and is derived using the yields on 10-year Australian Government Securities averaged over the 40-day period to 31 December 2020. Once again, this rate is used in this report as a placeholder figure until such time as we are able to consult directly with TCorp.

The computation of interest charges (or receipts, as the case may be) for the above example is illustrated in **Table 7** below. For example, at the six-month point (Time 0.50), there is an interest charge of $25 × 0.6% = $0.15, being interest on the account balance during the course of that quarter. At that time an additional $25 is drawn down, and so on.

Although **Table 7** only shows the net cash flows for one year, this procedure is applied throughout the four-year regulatory period.

Thus, for each simulation path for each valley we have a series of quarterly net cash flows, representing the sum of the amount to be drawn at that point in time and the amount of interest to be paid at that point in time.

[8] $(1 + 2.4\%)^{1/4} - 1 = 0.5947\%$

[9] $(1 + 0.9\%)^{1/4} - 1 = 0.2247\%$

Table 7: Illustrative interest charges

Time (Years)	0.00	0.25	0.50	0.75	1.00
Amount drawn	0	-25	-25	-25	-25
Cumulative total drawn	0	-25	-50	-75	-100
Interest charge	0	0	-0.15	-0.30	-0.45
Net cash flow	0	-25	-25.15	-25.30	-25.45

Source: Frontier Economics calculations.

We then compute the present value of those net cash flows, using the same interest rate that is used to compute interest charges. For example, the present value of the cash flows in **Table 7** is given by:

$$PV = \frac{-25.00}{1.006^1} + \frac{-25.15}{1.006^2} + \frac{-25.30}{1.006^3} + \frac{-25.45}{1.006^4} = -99.40.$$

That is, an up-front payment of $99.40 invested at a rate of 0.60% per quarter would be sufficient to fund the draw downs and interest payments set out in **Table 7** above. Again, in practice this process is applied to all 16 quarters for each regulatory period.

At this stage, for each simulation, we have a present value figure for each valley. We add these to produce a total present value across all valleys. That is:

$$TPV_n = \sum_{i=1}^{K} PV_i,$$

where:

- TPV_n is the total present value of drawdowns and interest fees for simulation *n* of *N*; and
- PV_i is the present value of drawdowns and interest fees for valley *i* of *K* in simulation *n*.

We then repeat this procedure for all remaining simulations, providing a single total present value figure for each simulation. We take the mean of the total present value figures across all simulations as our estimate of the expected total present value requirement:

$$E[TPV] = \frac{1}{N}\sum_{n=1}^{N} TPV_n.$$

Regulatory allowance for forthcoming regulatory period

The total regulatory allowance for the forthcoming regulatory period, computed in present value terms as at the beginning of the regulatory period, is given by the sum of:

1. The present value of the commitment fee; and
2. The expected present value of the total drawdowns and interest fees.

As noted above, for the purposes of this report we have assumed that any upfront and administration fees are zero.

Allocation between valleys

Having determined the total regulatory allowance, we then turn to allocating that figure across each valley. We do this by determining the relative contribution of each valley to the variance (over the *N* simulations) of the total present value revenue requirement. This is computed in the same way as one would compute the contribution of one stock to the variance of a portfolio of assets. Specifically, the contribution of valley *i* to the variance of the total present value revenue requirement is:

$$Allocation_i = \frac{\sum_{j=1}^{K} Cov(PV_i, PV_j)}{\sum_{i=1}^{K}\sum_{j=1}^{K} Cov(PV_i, PV_j)},$$

where $Cov(PV_i, PV_j)$ is the covariance between the present value of drawdown and interest fees of valleys *i* and *j*, computed over the *N* simulations.

Calculating indicative costs for the second regulatory period and beyond

Over the course of any particular regulatory period, the regulatory allowance will be set on the basis of the expected revenue requirement. For the first (i.e., the forthcoming) regulatory period, the allowance is set on the basis that the balance of cumulative under/over recovery at the start of the regulatory period is zero. In practice, this is unlikely to be true for subsequent regulatory periods.

If total revenue collected over the first regulatory period under current pricing arrangements exceeds the revenue under target pricing arrangements, there would be a positive balance and vice versa. The efficient cost in the second regulatory period would include the cost of managing the balance at the start of the period, and managing the risk of additional under/over-recovery of allowed revenues.

We consider two broad methods for setting the regulatory allowance for the second regulatory period and thereafter.

1. **Reset the opening balance of unders/overs each period:** Under this approach, IPART would set the allowance for the second regulatory period ignoring any past under/over-recovery of revenues. That is, the regulatory allowance is set so as to only recover (in expectation) the efficient cost of the self-insurance costs over the forthcoming regulatory period, and no more. Implicit to this approach would be an assumption that:
   a. WaterNSW is best placed to manage the risk between regulatory periods; and
   b. Such deviations are expected to average out to zero in the long-run, so long as expectations about future under/over-recovery of revenue are set in an unbiased manner.
2. **Account for the ongoing efficient cost of managing the opening unders/overs balance**: Set the allowance for the second regulatory period (and every subsequent period) to reflect two things:
   a. The recovery of the efficient self-insurance costs that are expected to arise over the forthcoming regulatory period. This allowance would be the same as the allowance under the first method above.
   b. The recovery (or payback to customers) of a portion of any accumulated under/over-recovery of revenue up to that point in time. Essentially, if the business had historically under-recovered its allowed revenues, then an increment would be added to the allowance

to allow the business to recoup some of its past under-recoveries. Symmetrically, if the business had historically over-recovered its allowed revenues, then the regulatory allowance would be reduced by some amount as a means to repay some of that surplus to customers.

For the purposes of our analysis, we have assumed that any accumulated under-recoveries at the start of the regulatory period would be financed through standard corporate debt over a 20-year period. As the business's borrowing requirements would be known at the start of the regulatory period, there would be no need for debt facility from which funds would need to be drawn down and, therefore, no commitment fee to be paid. The business would simply pay interest on a fixed term loan. For the purposes of the analysis in this report, we assume that rate of interest is 2.4% per annum (consistent with the prevailing cost of BBB-rated corporate debt, and inclusive of an allowance of 12.5 basis points per annum for debt raising costs).

We also assume that any surplus revenues at the start of the regulatory period are invested at the risk-free rate, which we have estimated to be 0.9% per annum.

The key benefit of the second method is that a regulatory mechanism is provided to recoup/repay to consumers over time any past under/over-recoveries of revenue. Intuitively, this would result in a narrowing in the range of accumulated under/over-recovery of revenue. This would have two advantages over the first price-setting approach described above:

- Firstly, because the second method provides a formal mechanism for the business to recoup past under-recoveries (rather than leaving it to chance that under/over-recoveries will simply average out over time), the business would presumably be a more creditworthy borrower than would otherwise be the case. In turn, we expect that the rate of interest that a lender would demand in order to provide an ongoing line of credit to the benchmark business would be lower under the second method than under the first. We have no means of quantifying how much lower the borrowing rate would be under the second method. However, this is an issue that we intend to seek TCorp's views on, before we prepare our Addendum report.
- Secondly, this method would be more cost reflective because it would ensure that over time customers would make payments that are equivalent to an 80/20 tariff structure (or whatever is considered to be efficient and cost reflective for a particular valley).

For the first method, the methodology to calculate the efficient self-insurance cost in the second period and onwards would closely align with the methodology outlined above for the first period.

For the second method, the efficient self-insurance cost would have two components:

- Firstly, the expected cost of the self-insurance mechanism for the period under method 1; and
- Secondly, the expected cost of managing the past unders/overs with the following components:
    - Interest fee: If the balance is in deficit it would attract interest charge equal to the quarterly cost of debt on the balance at the beginning of each quarter. If the balance is in surplus, it attracts a quarterly return on the balance at the beginning of each quarter.
    - Repayment allowance: Allowance to repay the balance over time. We have computed the repayment allowance on the basis of a 20 year repayment period, so that 20% of the opening balance would be collected over the next period and 80% recovered in subsequent periods. If the business has historically over-recovered revenue, this repayment allowance would be a negative amount.

3 Modelling results

3.1 Simulated distribution of future water sales

In this section we present results on simulated future water sales generated using the methodology described in section 2.2.3. As explained above, a distribution of future water sales (based on 1,000 simulations/realisations) is generated for each valley from 2021 to the end of the forecasting period, 2040.

Below, we present visual summaries of the simulated future water sales by valley, and also at the aggregate level (i.e., total sales across valleys). Namely:

- **Figure 3** presents three possible realisations of future water sales (for the first, fifth and tenth simulations—as illustrative examples). **Figure 4** presents total simulated water sales across all valleys for the same three realisations.
- **Figure 5** and **Figure 6** present 20-year rolling averages of consumption at the individual valley level and at the aggregate level (respectively), again for the first, fifth and tenth simulations only.
- **Figure 7** and **Figure 8** present the distribution of future water sales (using all simulations) for individual valleys and in aggregate across all valleys, respectively.

We note that our analysis excludes Fish River for two reasons:

- The historical water sales that relate to Fish River are very small (only approximately 0.21% of the total volume of rural bulk water supplied by WaterNSW between 2014 and 2020). This means that any under/over-recovery of allowed revenues for Fish River would have a negligible impact on WaterNSW's total under/over-recovery and, therefore, efficient self-insurance costs;[10] and
- Fish River has an actual tariff structure of 80% fixed charges and 20% variable charges. Given that the actual tariff structure for Fish River matches IPART's target tariff structure, as a practical matter, there are no associated under/over-recoveries related to that valley.

Hence, the Figures below present forecasts of water sales for WaterNSW's remaining 12 valleys.

3.1.1 Consumption paths – three realisations

The simulated paths for future water sales for three realisations (i.e., the first, fifth and tenth simulations) are presented below:

- **Figure 3** presents the paths of water sales by valley based on three simulations. The Figure suggests that:
  - For the most part, the simulated consumptions 'move together'. This reflects the expected persistence in water sales over the short term, and is induced by pairwise sampling of historical residuals as described in section 2.2.3;

[10] Based on historical volume data supplied to us by IPART.

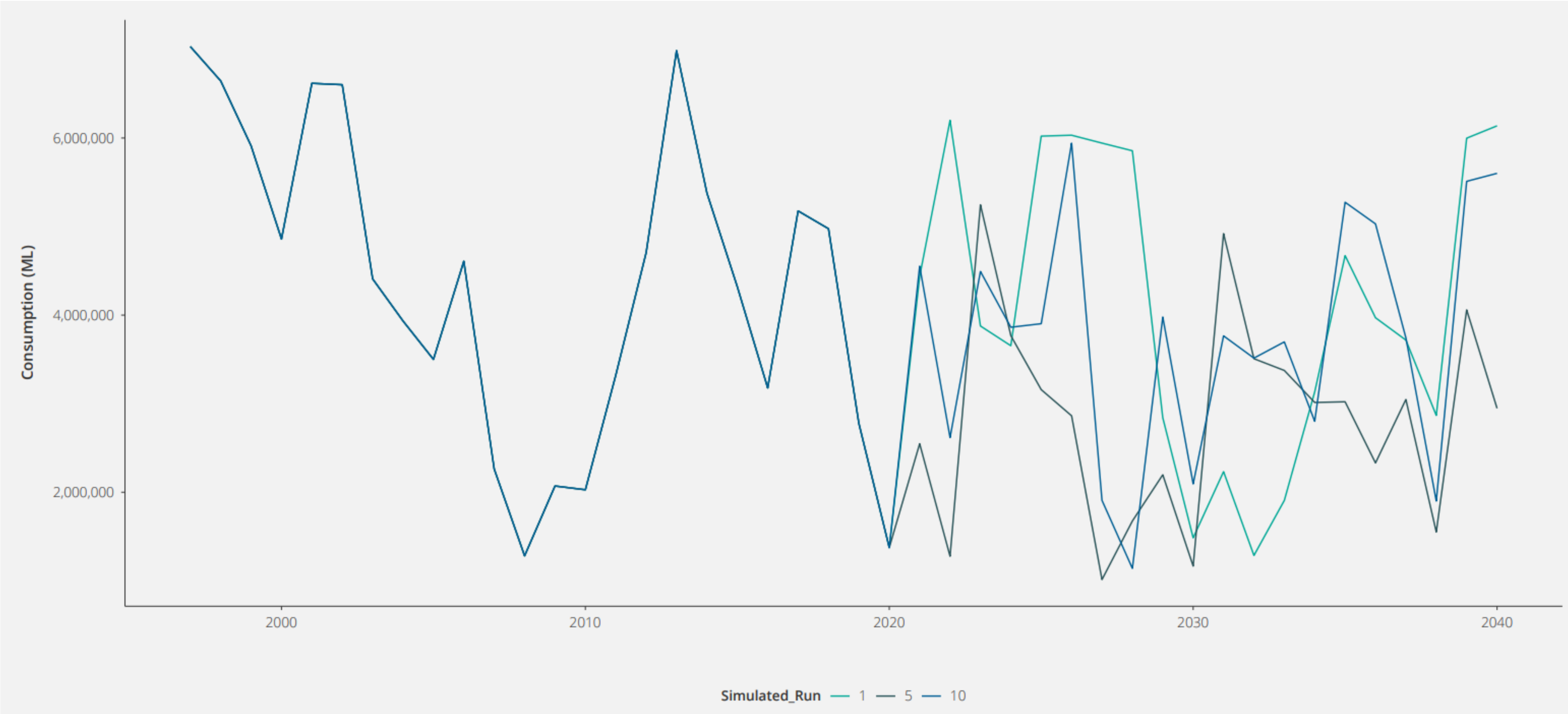
- Each simulation appears to capture the historical variability in the level of consumption in each valley; and
- Valley-specific anomalies are captured. For example, forecast water sales are zero in several forecast years for Lowbidgee, which reflects historical outcomes that particular valley.

- **Figure 4** presents the same information as **Figure 3** but aggregates simulated consumption across all valleys, showing total consumption results for the three simulations. It is clear that even after aggregation, simulated consumptions are correlated over time and tend to move together. As with the individual valley results, historical volatility appears to be captured.

Figure 3: Consumption path by valley – three simulations

Source: Frontier Economics analysis of WaterNSW and IPART historical water consumption data

Figure 4: Total consumption path – three simulations



Source: Frontier Economics analysis of WaterNSW and IPART historical water consumption data

3.1.2 20-year rolling averages – three realisations

20-year rolling average results are presented below:

- **Figure 5** presents the 20-year rolling averages of forecast water sales by valley based on three simulations. Analysis of these results highlights the following observations:
  - As expected, rolling averages are far 'smoother' over time than simulated water sales in individual years; and
  - While they tend to move in the same direction, there is expected 'fanning out' over time. That is, the range of possible outcomes for water sales widens the further forward in time volumes are forecast.
- **Figure 6** presents the same information as **Figure 5** but for aggregated consumption across valleys, showing rolling average results for total consumption for the three simulations. It is clear that fanning out is exhibited in aggregate too.

3.1.3 Consumption- all realisations

Distributions of future water sales (based on all 1,000 simulations) are presented below. The 1,000 realisations for each year are presented in boxplots which depict the 75^{th}, 50^{th} and 25^{th} percentile of consumption outcomes (given by the top, mid-line and bottom of each 'box') for each year in the forecast period up to 2040. Forecast 'outlier' values are plotted as dots:[11]

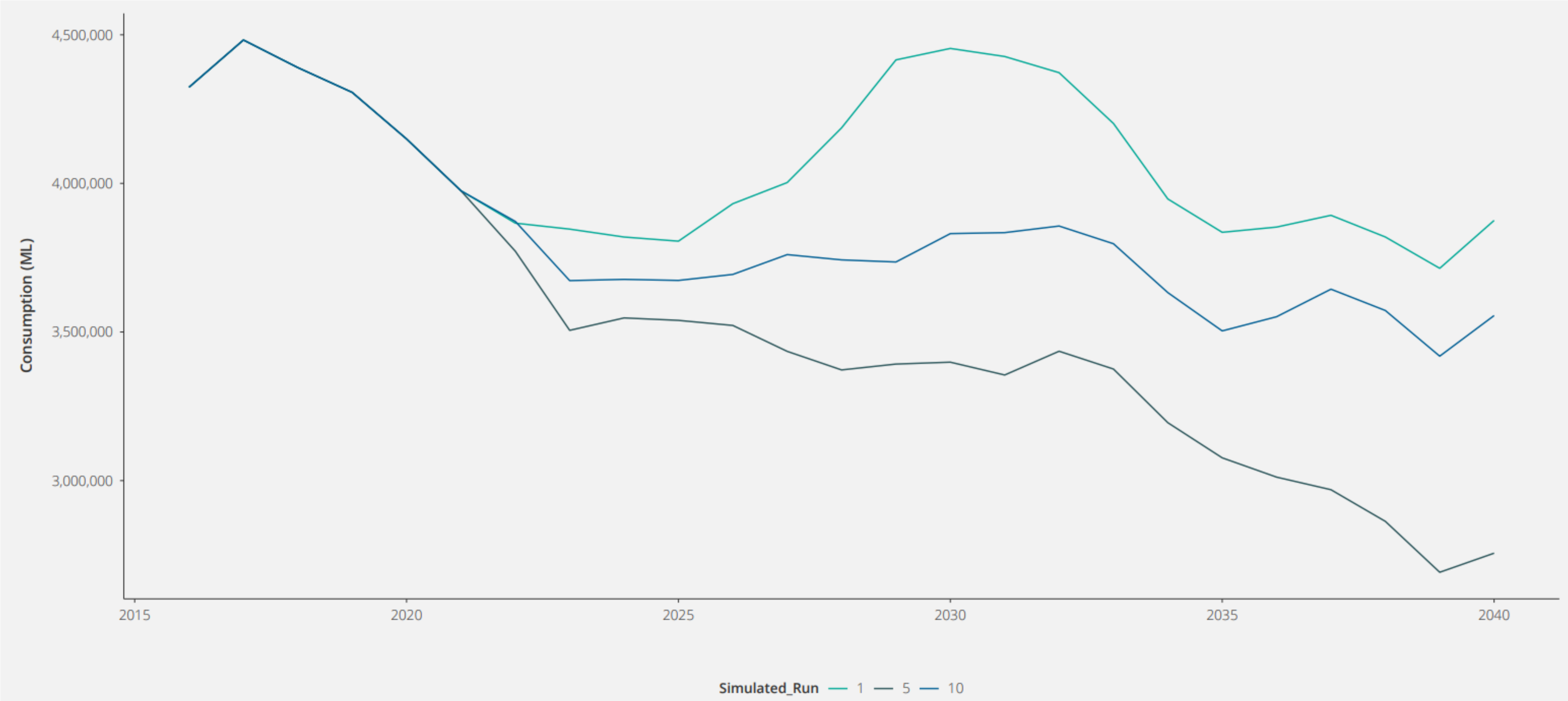
- **Figure 7** presents all simulated results in each year by valley. Analysis of these results highlights a number of observations:
  - Typically, the upper and lower bounds of all simulated consumptions 'fan out' over time, staying within the bounds of historical data initially then expanding into the future as uncertainty associated with the consumption forecast increases;
  - While uncertainty tends to increase over time, the median outcome remains relatively stable; and
  - The spread between the 25^{th} and 75^{th} percentile outcomes generally lies within the historical range of consumption.
- **Figure 8** presents the same information as **Figure 5** but for aggregated consumption across valleys, showing simulated results for total consumption for the three simulations. Though far more stable, the aggregate series still exhibits some fanning out, as expected.

[11] Outliers are defined as any consumption realisations that are more than 1.5 * **Interquartile Range**, which is the difference in consumption between the 25^{th} and 75^{th} percentiles.

Figure 5: 20-year rolling average by valley – 3 realisations

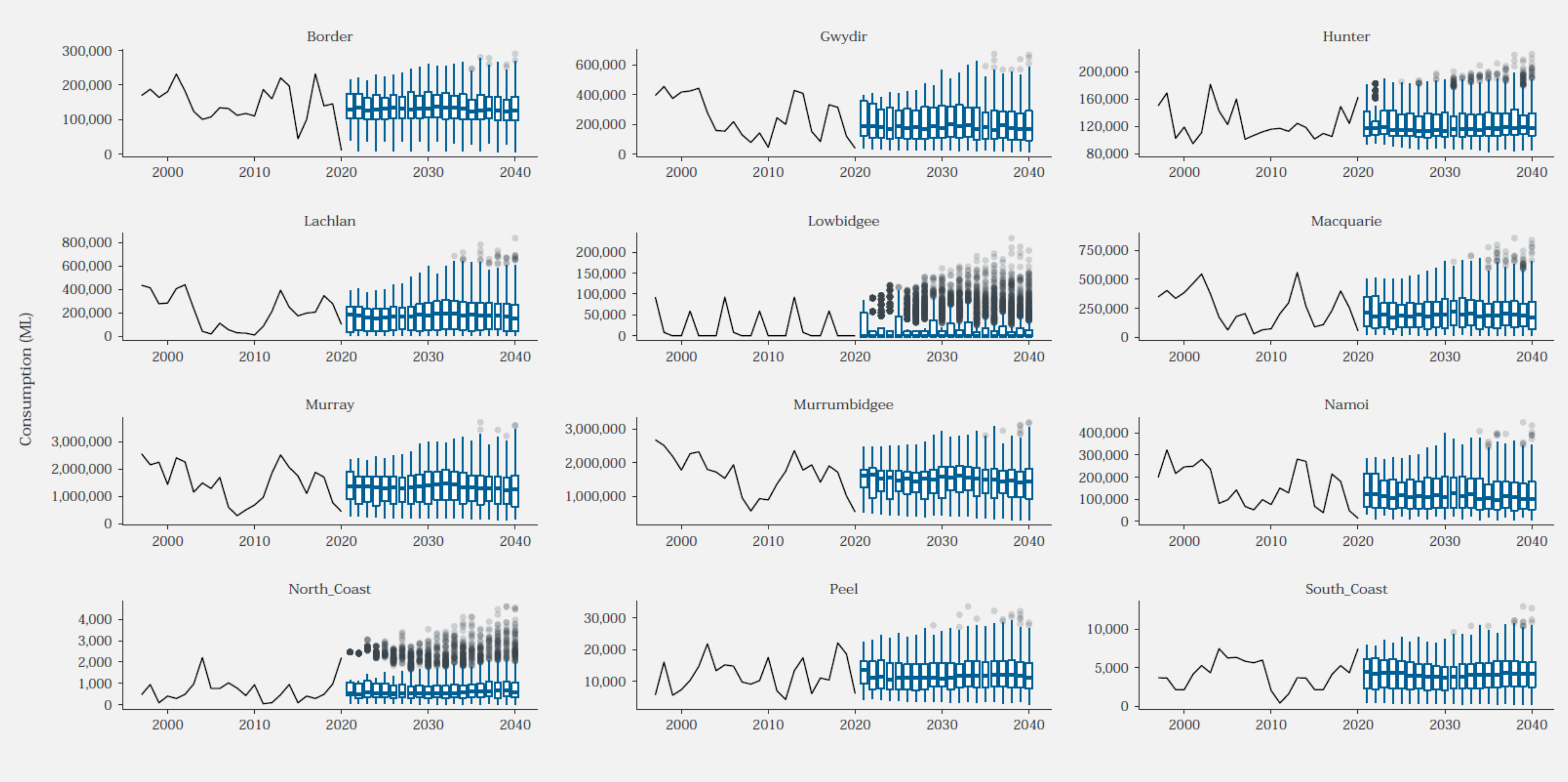
Source: Frontier Economics analysis of WaterNSW and IPART historical water consumption data

Figure 6: Total 20-year rolling average – 3 realisations



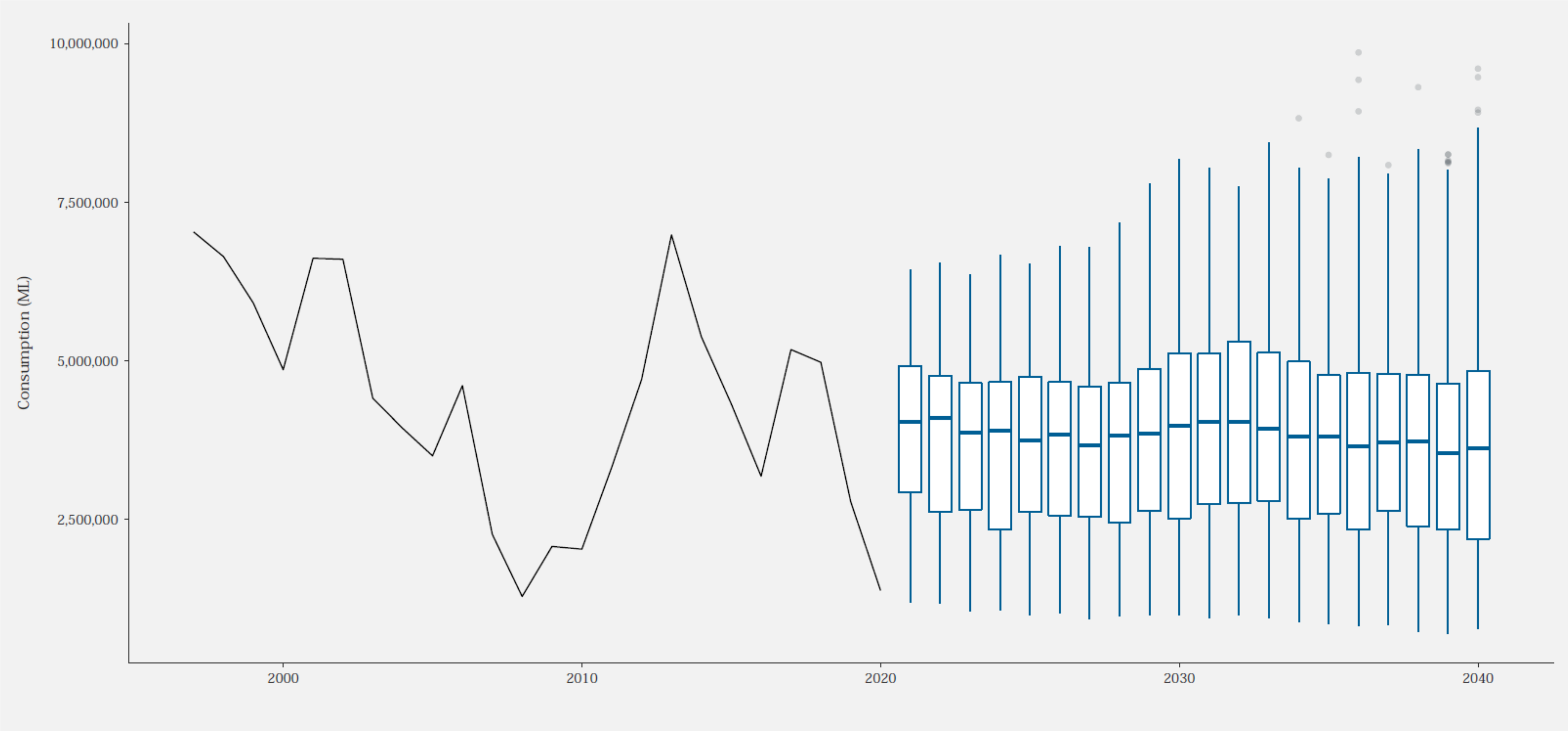
Source: Frontier Economics analysis of WaterNSW and IPART historical water consumption data

Figure 7: Consumption by valley – all realisations



Source: Frontier Economics analysis of WaterNSW and IPART historical water consumption data

Figure 8: Total consumption – all realisations



Source: Frontier Economics analysis of WaterNSW and IPART historical water consumption data

3.2 Simulated distribution of future revenue shortfalls and surpluses

In this section we present the simulated revenue and under / overs outcomes based on the methodology presented in Section 2.3 and consumption outcomes presented in Section 3.1. As outlined in Section 2.3 the consumption outcomes are calibrated such that the mean outcome across the 1,000 simulations is that the IPART forecast is correct, but there is a distribution of outcomes around the mean.

Unless otherwise stated, all results presented in this section are based on the 'Central' scenario.

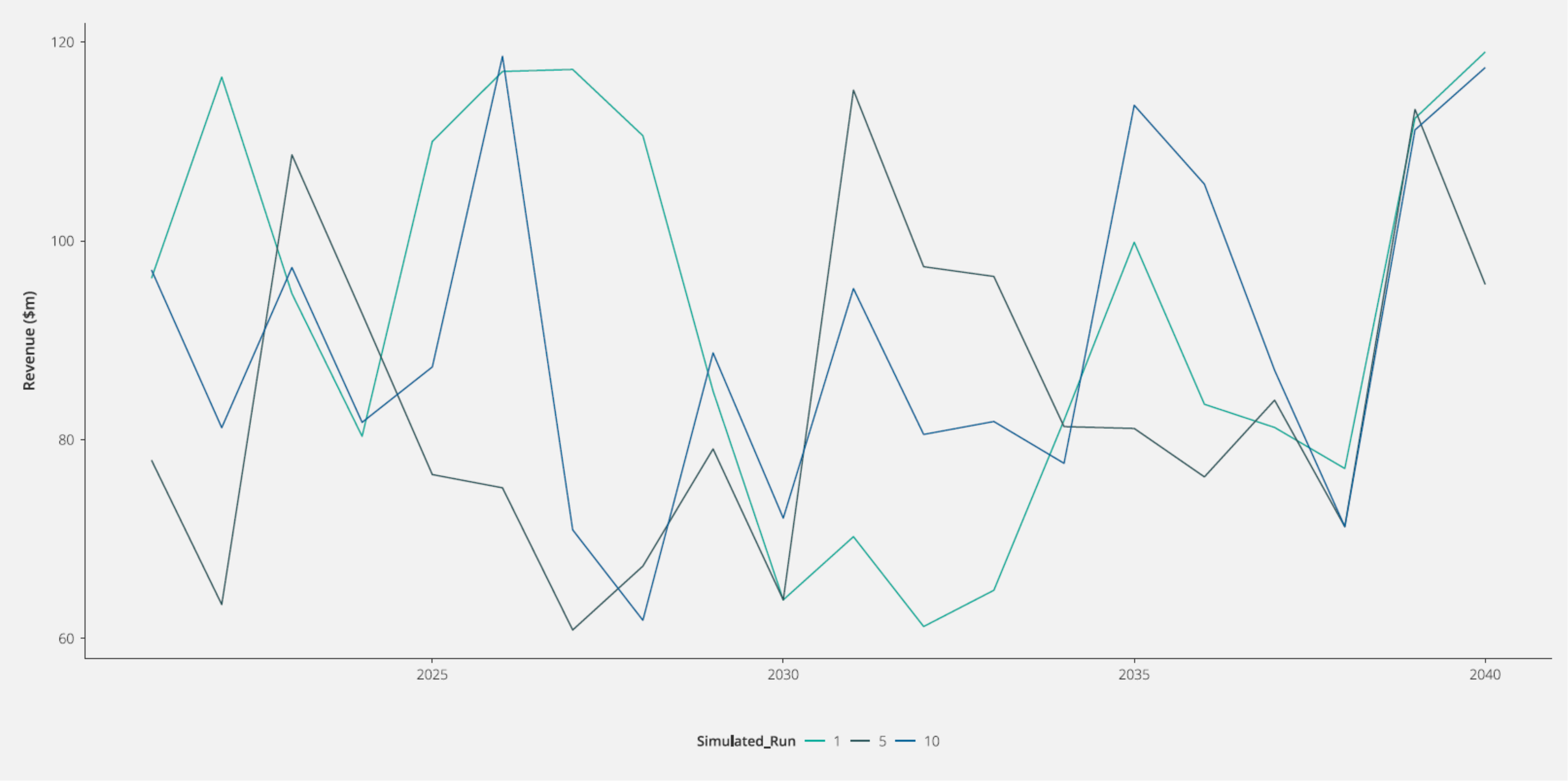
3.2.1 Revenue outcomes – three realisations

Figure 9 presents simulated revenue outcomes for each valley under the current pricing arrangements across three realisations. **Figure 10** presents the simulated revenue outcomes, aggregated across each of the valleys. The three simulations presented here are the same for which consumption is presented in Section 3.1.

Figure 9: Revenue by valley – three simulations

Source: Frontier Economics analysis

Figure 10: Total revenue – three simulations



Source: Frontier Economics analysis

Overall, similar patterns are observable in the revenue forecasts as in the consumption forecasts. The total revenue is highly variable from year to year, and between simulations. There is a positive correlation between consumption and revenue, but the correlation is not one-to-one. Additional consumption in some valleys impacts revenue more than others. For example, additional consumption in Lowbidgee (with all revenue collected through fixed charges) does not impact total revenue. Overall, revenue tends to be higher in simulation '1' and lower in simulation '5', although this varies from year to year. Similar to consumption, there is a positive correlation in revenue between most of the larger valleys.

As outlined in Section 2.3, the simulated revenues in each simulation are an input to calculating the under / over recovery. The under/over-recovery in each valley is calculated as the difference between revenue recovered under the current pricing arrangements and target pricing arrangements. In some valleys (North Coast, Peel, and South Coast), the revenue collected in each simulation varies depending on consumption. However, as the current pricing arrangements align with target pricing arrangements, there is no under/over-recovery despite the movements in revenue.

Figure 11 presents the cumulative under/over-recovery of revenue by valley for the same three simulations. **Figure 12** presents the aggregated under/over-recovery across valleys.

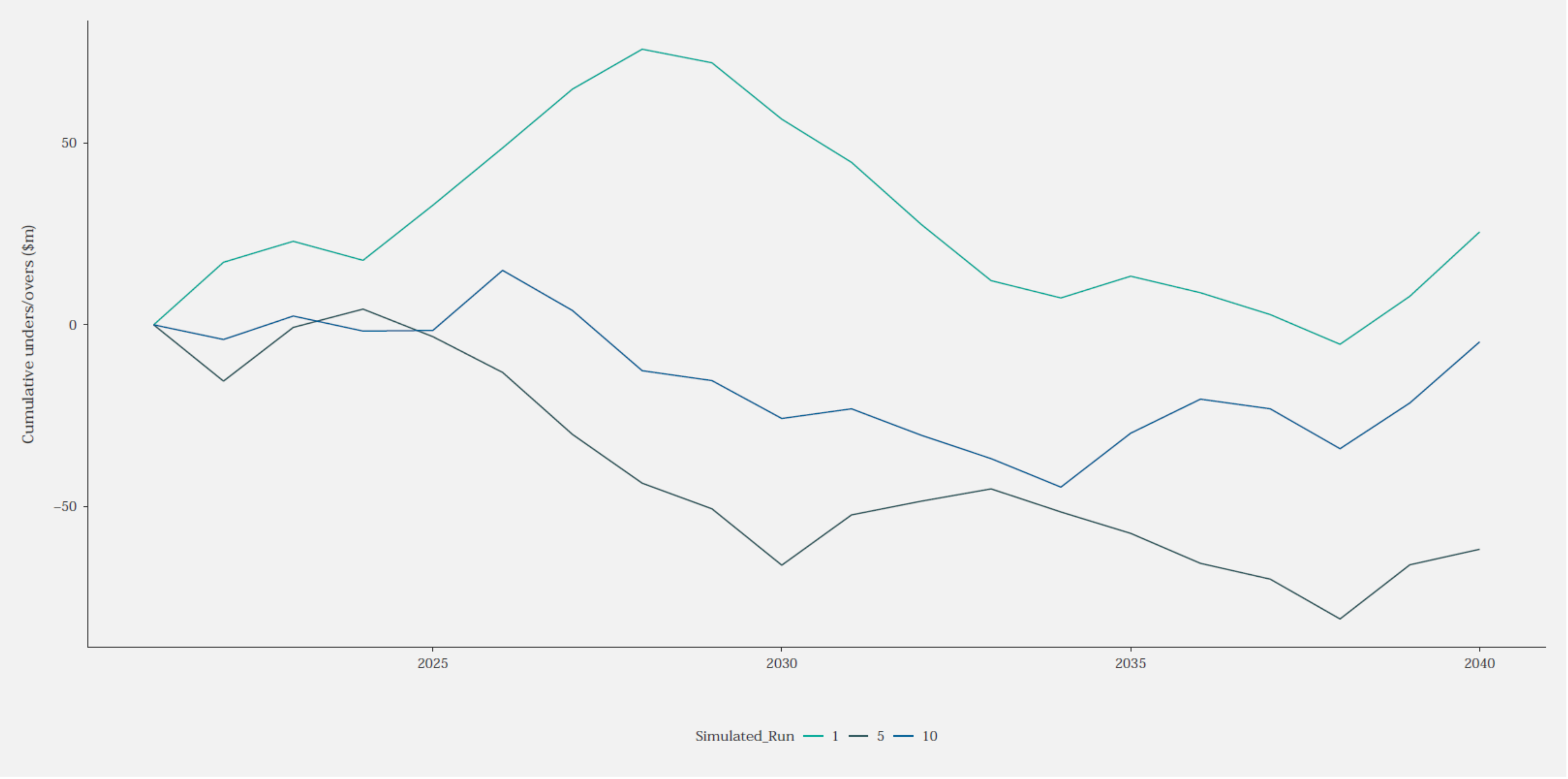
In simulation 1, which has the highest average consumption and revenue, the cumulative under/over-recovery tends to be positive in most years. This means that the revenue collected under the current pricing arrangements exceeds revenue collected under the target arrangements. In simulations 5 and 10, there tends to be under recovery of revenue. The account balance varies from year-to-year, but with less volatility than consumption or revenue, as the values accumulate over time.

Most valleys display similar outcomes, with the most material over-recovery in simulation 1 and most material under recovery in simulation 5, however Hunter appears to have different trends to the other valleys.

Figure 11: Cumulative unders/overs by valley – three simulations

Source: Frontier Economics analysis

Figure 12: Cumulative total unders/overs – three simulations



Source: Frontier Economics analysis

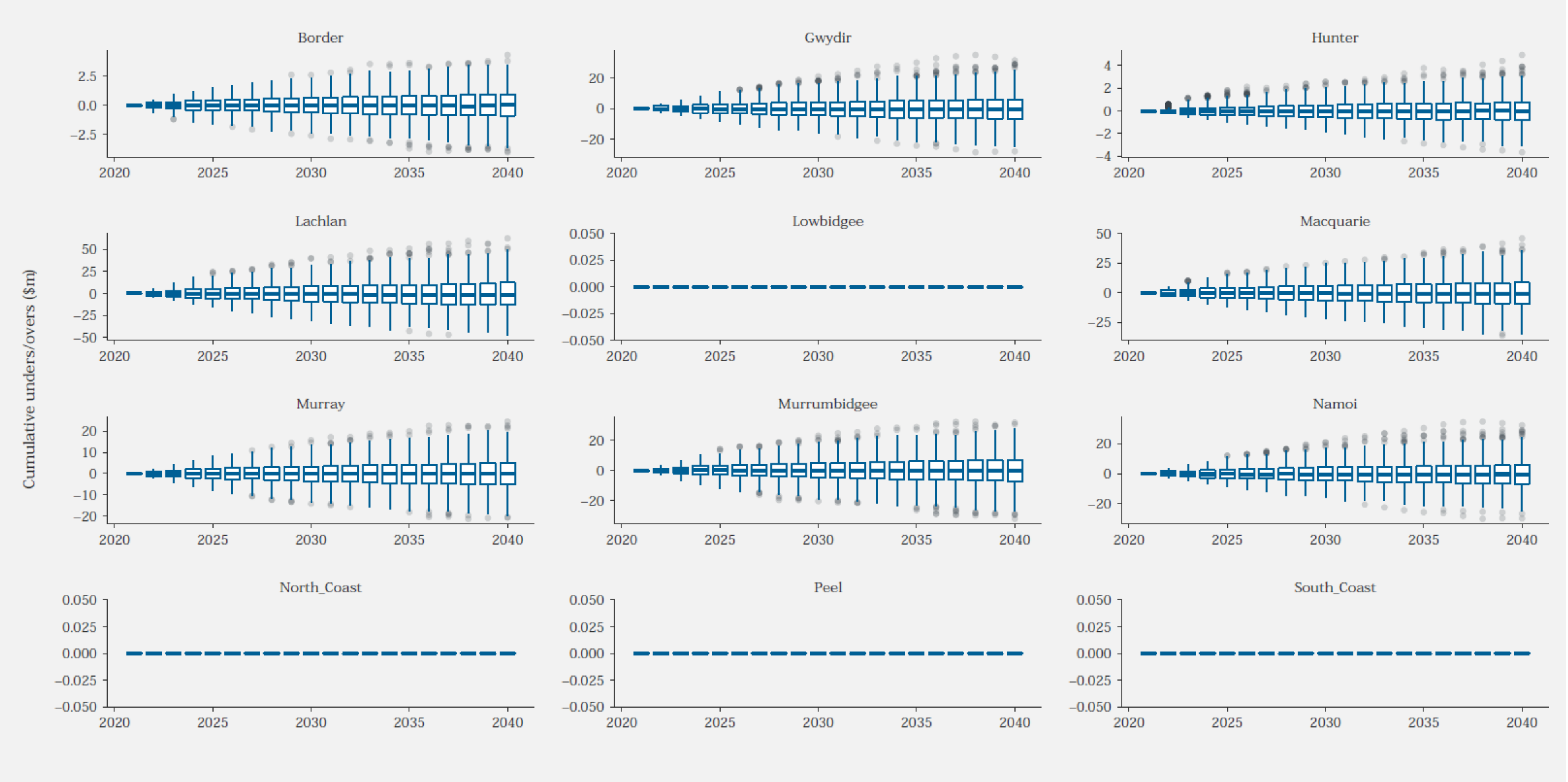
The distributions of cumulative under/over-recovery across the 1,000 simulations are presented below. The boxplots are formatted consistently with those presented in section 3.1. The box contains the 75th, 50th and 25th percentiles of the distributions of outcomes, the lines reach 1.5* the inter-quartile range (or the max / min values), and the dots represent outliers beyond the range of the lines.

Figure 13 presents all simulated results by valley, and **Figure 14** presents aggregate results across valleys.

Across the simulations, the range of outcomes tends to fan out over time. This is particularly true for the outliers in each valley, which increase in number and magnitude in all relevant valleys over the forecast period. The median result tends to be slightly below zero, with more extreme high outcomes (over-recovery) than extreme low outcomes. By the end of the first regulatory period in 2025, the highest simulated over-recovery is approximately $81m, and highest simulated under recovery is approximately $61m.

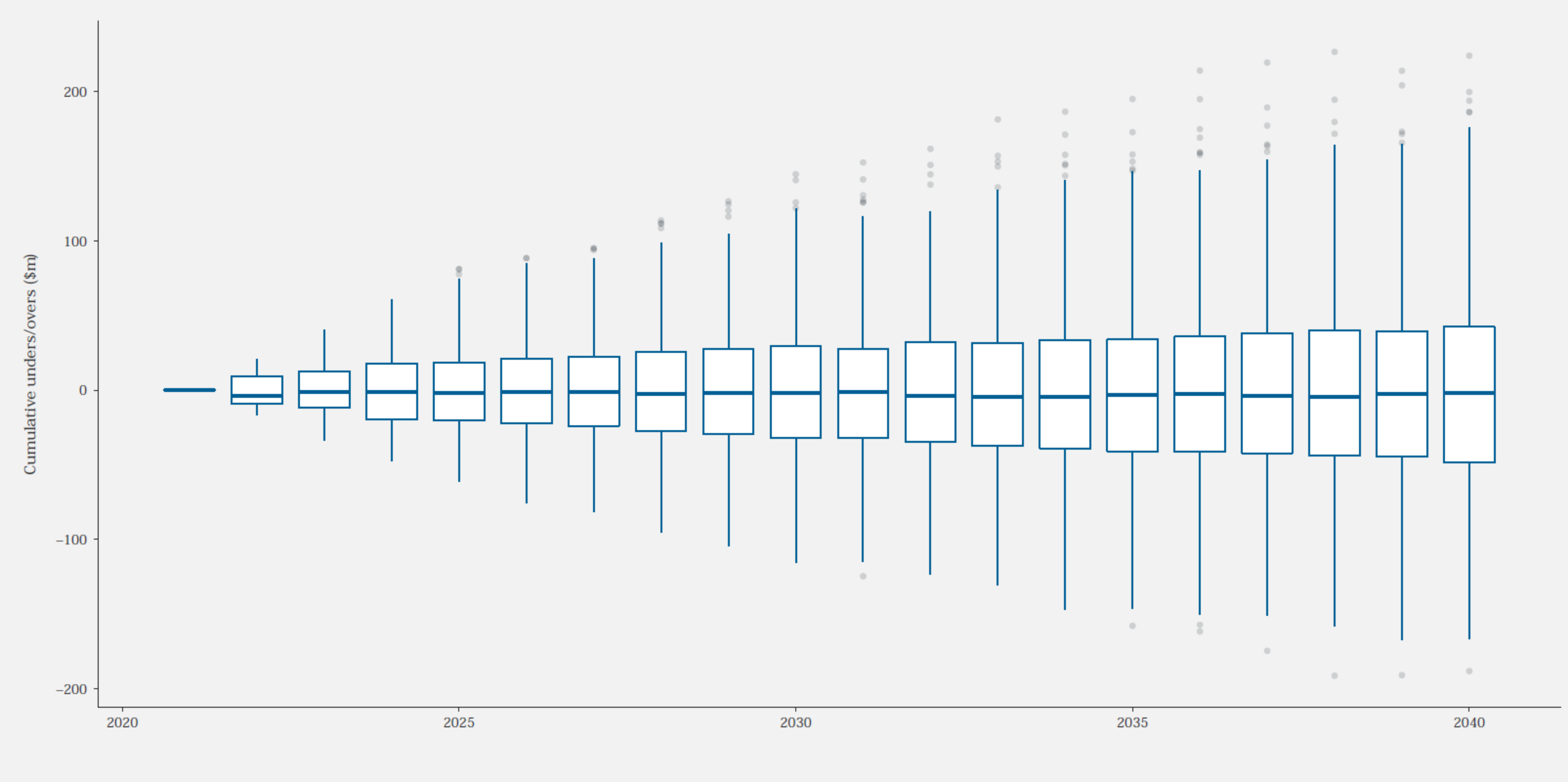
Further detail on the range of simulated under/over-recovery is presented in **Figure 15**. This contains the deciles, ranging from the highest over recovery (100th), to lowest under recovery (0th). As discussed above, there is a fanning out in the distribution of outcomes, particularly for the tail ends of the distribution. By 2040, the highest simulated cumulative under-recovery and over-recovery is approximately $200m.

Figure 13: Cumulative unders/overs by valley – all simulations



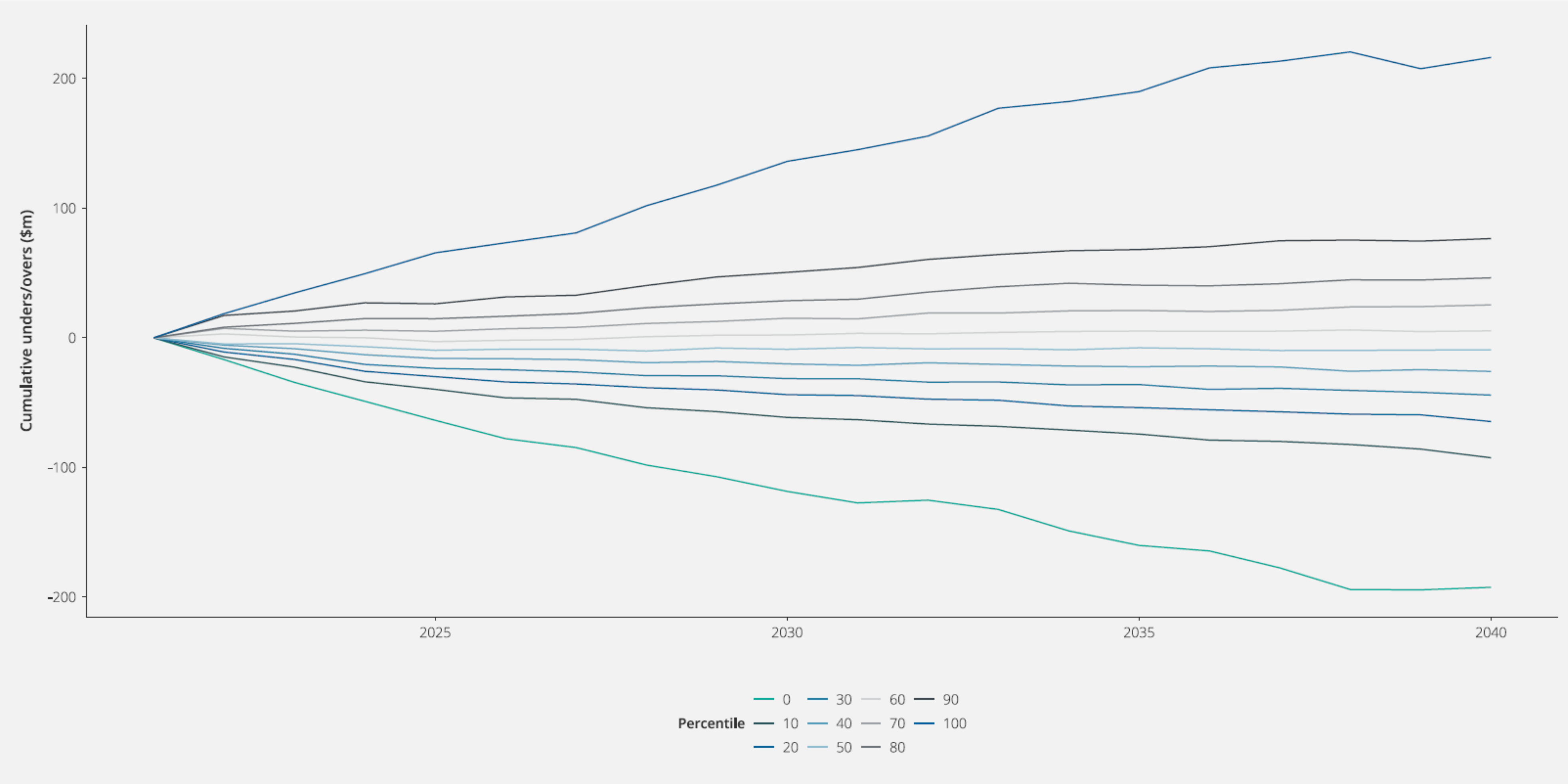
Source: Frontier Economics analysis

Figure 14: Cumulative total unders/overs – all simulations



Source: Frontier Economics analysis

Figure 15: Cumulative total unders/overs – deciles



Source: Frontier Economics analysis

3.3 Indicative estimates of efficient borrowing costs

3.3.1 Total efficient borrowing costs for the first upcoming regulatory period

We have calculated the efficient self-insurance costs for the first upcoming regulatory period in line with the methodology set out in section 2.4. The total cost is made up of two components:

- The commitment fee, calculated with reference to the 5th percentile outcome of over/under-recovery; and
- The average drawdown/interest fee across the 1,000 simulations.

Table 3 presents results for the 'Central' scenario, and the two sensitivities on the target pricing arrangement (70:30 and 90:10 fixed charge ratio). **Table 9** presents corresponding results for the three sensitivities on the BRC and MDBA fixed charge ratio.

All costs presented in **Table 3** and **Table 9** are net present values over the regulatory period.

Table 8: Estimates of efficient borrowing costs – BRC and MDBA current fixed share at 80:20

	Current – 40:60 Target - 80:20	Current – 40:60 Target - 70:30	Current – 40:60 Target - 90:10
Commitment fee ($m)	1.651	1.088	2.237
Drawdown / interest ($m)	0.393	0.259	0.532
Total ($m)	2.044	1.347	2.769

Source: Frontier Economics analysis

Overall, we estimate the total efficient cost of self-insurance to be $2.04m over the forthcoming regulatory period in the 'Central' scenario. The commitment fee is the largest component, approximately 80% of the total cost. The cost is lower in the 70:30 sensitivity and higher in the 90:10 sensitivity, in line with expectations.

Table 9: Estimates of efficient borrowing costs – BRC and MDBA current fixed share at 40:60

	Current – 40:60 Target - 80:20	Current – 40:60 Target - 70:30	Current – 40:60 Target - 90:10
Commitment fee ($m)	2.292	1.717	2.866
Average interest ($m)	0.538	0.404	0.676
Total ($m)	2.830	2.121	3.543

Source: Frontier Economics analysis

There is additional cost if the current BRC and MDBA fixed charge ratios were set to 40%, rather than 80%. The difference to the corresponding results in in **Table 3** is approximately $0.8m over the regulatory period.

3.3.2 Allocation between valleys for the first upcoming regulatory period

The costs may be allocated between valleys using the approach set out in Section 2.4. The results of this approach for the Central scenario are set out in **Table 4**.

Table 10: Cost allocation by valley (Central scenario)

Valley	Proportion (%)	Cost ($m NPV)
Border	1.6%	0.033
Gwydir	14.2%	0.290
Hunter	0.3%	0.006
Lachlan	25.5%	0.522
Lowbidgee	0.0%	0.000
Macquarie	19.1%	0.390
Murray	10.7%	0.219
Murrumbidgee	14.7%	0.300
Namoi	13.9%	0.285
North Coast	0.0%	0.000
Peel	0.0%	0.000
South Coast	0.0%	0.000

Source: Frontier Economics analysis

The highest share of the overall cost is allocated to the Lachlan valley, approximately 25% of the total cost. This is due to the high variability in consumption outcomes from year to year in the Lachlan, combined with the relatively high revenue requirements in that valley. Although some valleys (such as the Murrumbidgee) have higher revenue requirements, consumption in those valleys is less variable than Lachlan, and therefore the contribution to the covariance of the total under/over-recovery is not as large.

3.3.3 Indicative costs for the second upcoming regulatory period

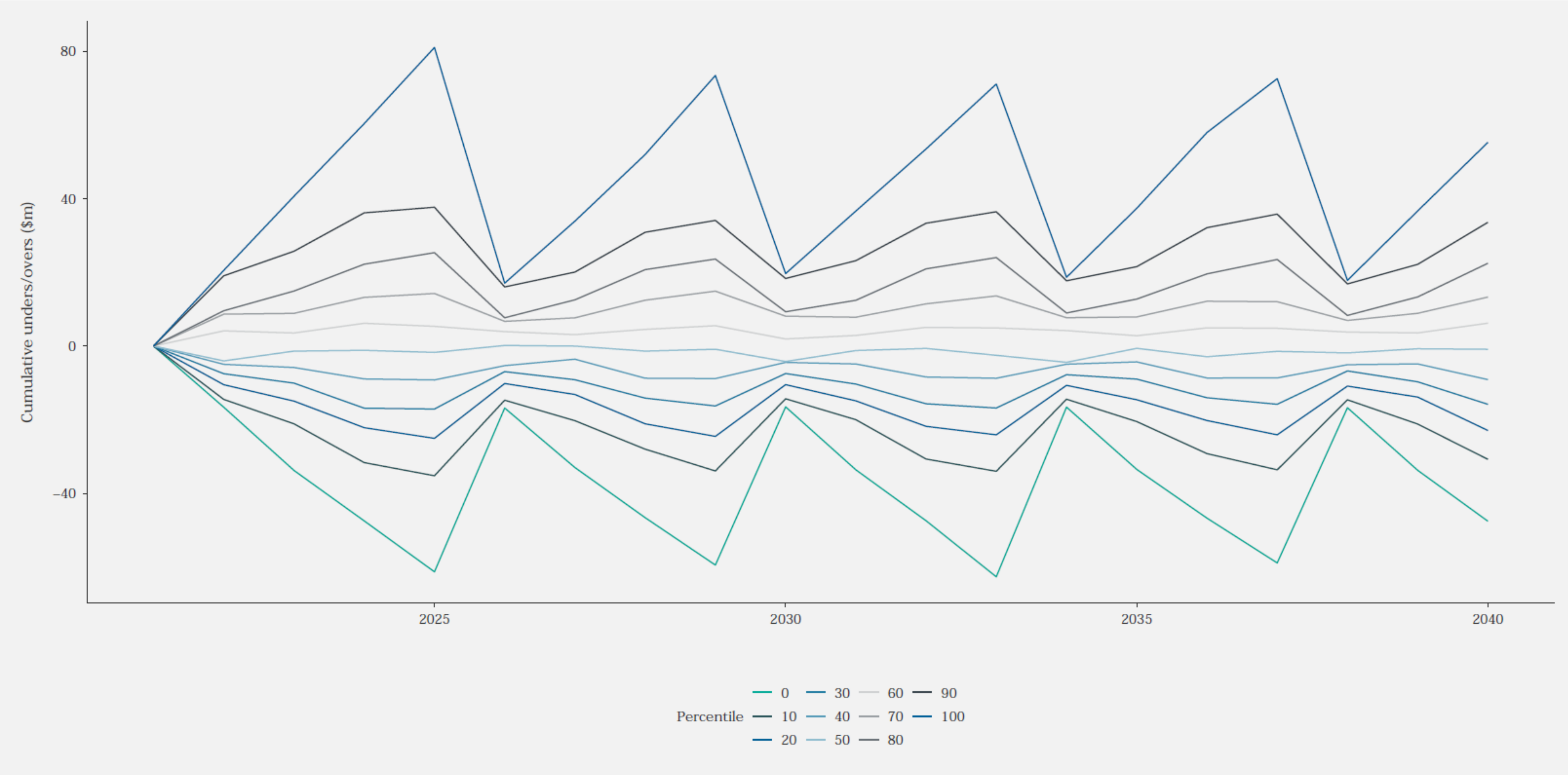
We have calculated indicative estimate costs for the second upcoming regulatory period under each of the two methods described in Section 2.3.

Method 1: Reset the opening balance of unders/overs each period

To estimate the cost under the first method, we reset the cumulative unders/overs account balance to zero at the beginning of every regulatory period. The cumulative unders/overs account balance evolves through each regulatory period, fanning out, but this is limited to within each period.

Figure 16 presents the deciles of the account balance for each year, ranging from the highest over recovery (100^{th}), to lowest under recovery (0^{th}). For the period up to 2025, this figure is consistent with **Figure 14**, but thereafter the unders/overs are capped. The distribution of outcomes in each subsequent period is broadly similar to the first, ranging from approximately $80m surplus to $60m deficit.

Figure 16: Cumulative total unders/overs reset each regulatory period – deciles



Source: Frontier Economics analysis

The estimated indicative regulatory allowance for the second period in the Central scenario is presented in **Table 11:** Indicative estimate of efficient borrowing costs in second regulatory period– Central scenarioIt comprises the same components as the efficient cost for the first regulatory period, and is a similar magnitude.

Table 11: Indicative estimate of efficient borrowing costs in second regulatory period– Central scenario

	Central scenario (second regulatory period)
Commitment fee ($m)	1.476
Drawdown / interest ($m)	0.676
Total ($m)	2.152

Source: Frontier Economics analysis

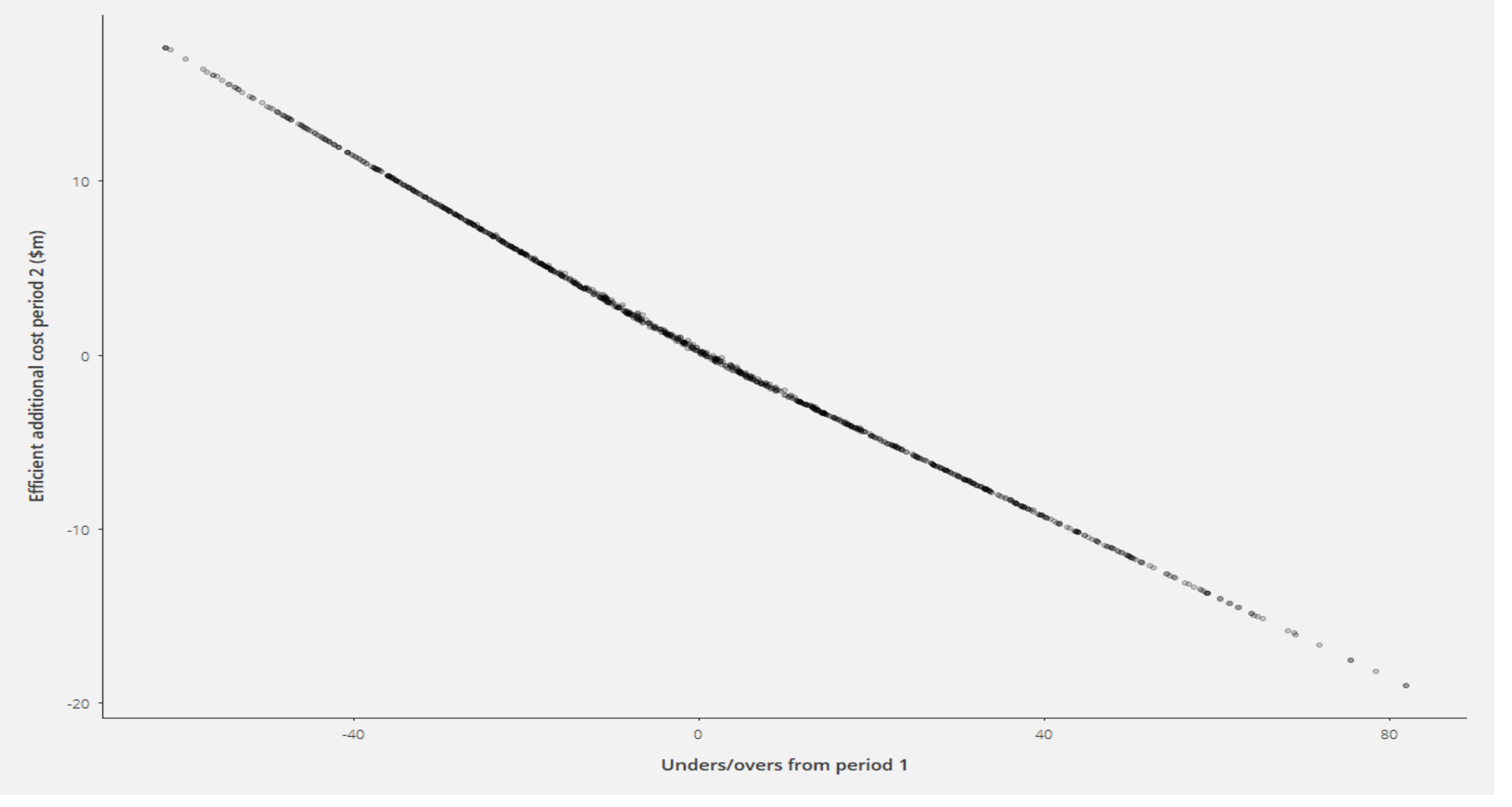
Method 2: Account for the ongoing efficient cost of managing the opening unders/overs balance

Under the second method, the first part of the efficient insurance cost is the same as the first method. However, there is an additional component that depends on the balance of cumulative unders/overs at the conclusion of the first period. In simulations in which the account is in deficit, there is some additional cost to cover interest on the outstanding balance, and repay some portion of the balance. The inverse applies to simulations in which the account is in surplus. For simulations in which revenue is equal under the current and target pricing arrangements, there is no additional cost.

The relationship between the account balance at the conclusion of the first period, and additional costs incurred in the second, is presented in **Figure 17**. In the cases with most the largest under-recovery, the additional cost is up to approximately $17.7m, corresponding to a first period under recovery of approximately $62m. The majority of the costs ($12.4) relate to repayment of 20% of the balance over the four year period. The remainder ($5.3m) relate to interest charges on the outstanding balance each year.

At the other end of the spectrum, the efficient additional allowance following a large over-recovery would be negative – with some of the surplus repaid to customers.

Figure 17: Scatter plot: First period unders/overs and second period additional allowance



Source: Frontier Economics analysis

The outcomes are also summarised in **Table 12**, which presents the additional allowance additional allowance (over and above the allowance required to recover the estimated forward-looking efficient self-insurance costs over the regulatory period) at each decile of the distribution. The median outcome is a small positive allowance. The mean outcome over the 1,000 simulations is an additional cost of $0.7m, driven by the higher cost of borrowing relative to the risk free rate of return.

Table 12: Indicative estimate of efficient borrowing costs in second regulatory period– Central scenario

Decile	Additional allowance ($m)
0^{th}	17.689
10^{th}	10.200
20^{th}	7.269
30^{th}	4.976
40^{th}	2.696
50^{th}	0.755
60^{th}	-1.237
70^{th}	-3.299
80^{th}	-5.894
90^{th}	-8.843
100^{th}	-19.012

Source: Frontier Economics analysis

Assessment of the two methods for setting allowances for the second regulatory period and beyond

The analysis above has considered two methods for setting the regulatory allowance for any regulatory period in which the benchmark business has accumulated historical under/over-recoveries of revenues at the start of the period. Under one method, IPART would simply ignore those past under/over-recoveries when setting the regulatory allowance for the upcoming regulatory period—on the assumption that under/over-recoveries will average out over time, and that the regulated business able to manage those past under/over-recoveries.

However, our simulation analysis suggests that the accumulated under/over-recoveries can become very large over time. The modelling provides no evidence that the under/over-recoveries would in fact average out over even several regulatory periods.

Under these circumstances:

- The business could experience significant under-recoveries of allowed revenues over several regulatory periods, with no way of recouping those revenues. Since allowed revenues are set in line with the business's efficient costs under IPART's regulatory framework, this would essentially amount to (potentially very material) stranding of the regulated business's efficient costs; or
- The business could enjoy persistent over-recovery of allowed revenues over several regulatory periods. As a consequence, consumers could potentially pay significantly more than the efficient costs required to deliver the regulated services over a number of regulatory periods.

Neither of these outcomes would promote economic efficiency.

Under the second approach IPART would set prices to allow recoupment of past under-recoveries or repayment of surplus revenues, in addition to the efficient self-insurance costs that relate to the forthcoming regulatory period. Our modelling suggests that the second method is expected to produce slightly higher regulatory allowance than the first method (in the second regulatory period), because the business is, on average, expected to under-recover its allowed revenues over the forthcoming regulatory period. Therefore, some additional regulatory allowance would need to be provided over the second regulatory period to permit the business to recoup and finance some of that under-recovery.

In reality, a business that has under-recovered some past revenues will need some means of financing those under-recoveries, and also recouping those losses, if it is to be made whole.

The second method has the advantage (over the first method) of recognising the true efficient costs of self-insurance that the business faces, and setting the regulatory allowance in line with those efficient costs.

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