ZARONIA CURVE - METHODOLGY DOCUMENT

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1. Document Control

1.1 Document Status

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1.2 Approval

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1.3 Version History

Version	Date	Summary of changes	Author
1.0	01/11/2025	Initial framework for the ZARONIA curve	NM
2.0	13/06/2026	Illiquid tenors removed, Cashflow frequency updated from quarterly to Annual.	NM

1. INTRODUCTION

With the introduction of an alternative reference rate in the South African financial market, and the subsequent trading of swaps that reference the South African Overnight Index Average (ZARONIA), the need has arisen for a new ZARONIA curve for market participants. The publication of this curve is intended to support the industry, particularly institutions that are not able to develop and maintain their own curve.
There is no perfect curve, and this methodology cannot reflect every characteristic or feature desired. Where there are differing views or proprietary models, institutions are encouraged to develop their own curves.

2. The South African Reserve Bank (SARB) Market Practitioners Group (MPG) Cash Market Workstream on ZARONIA delegated the mandate for curve construction to the Curve Construction Sub-Working Group. The JSE was an active member of this group and played a key role in testing and validating the proposed methodology on its behalf. Based on industry feedback, the group recommended a monotone-preserving interpolation methodology with granular short-end points to support accurate forecasting and a smooth market transition. The JSE and the Curve Construction Sub-Working Group believe this approach will support the transition to ZARONIA by providing a familiar structure and improved precision at the short end.

3. BACKGROUND

The South African interest rate swap market is well developed and actively traded. The Johannesburg Stock Exchange (JSE) currently produces a swap curve based on a methodology proposed by du Preez and Maré (2013), which generates a curve with forward rates that are both positive and continuous. The curve is well established and widely used in the industry for valuation, audit, risk management, pension modelling, and insurance modelling. However, there are important differences in the behaviour and composition of the ZARONIA rate compared with the Johannesburg Interbank Average Rate (Jibar), which make the existing curve bootstrapping methodology less suitable. The most significant behavioural difference is that the new overnight rate is expected to exhibit jumps after Monetary Policy Committee (MPC) dates, whereas Jibar-implied overnight rates do not. This behaviour is evident in the historical ZARONIA data shown in Figure 1 below.

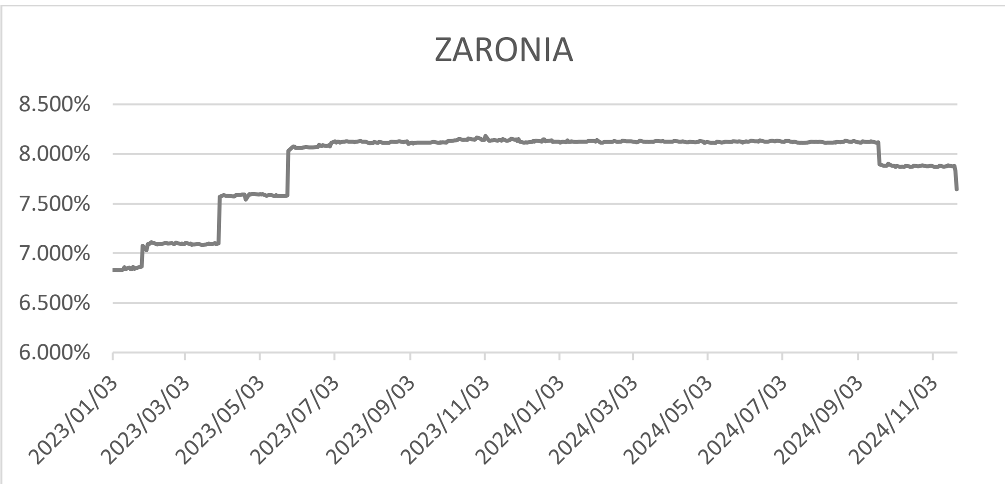

Figure 1: Historical ZARONIA behaviour

The current swap curve bootstrapping methodology is primarily designed to produce the most accurate possible forecast of the 3-month Jibar rate. As a result, it also generates a smooth forward overnight rate.

4. METHODOLOGY

The construction of the ZARONIA Overnight Index Swap (OIS) curve involves transforming market-observed instruments into a continuous term structure of discount factors and zero rates. The methodology is built on two core components: bootstrapping, which derives discount factors from liquid instruments, and monotone-preserving interpolation, which is applied consistently across the curve to ensure smoothness, stability, and the absence of arbitrage. This approach captures expected jumps around Monetary Policy Committee (MPC) dates while maintaining a shape that reflects both market pricing and economic intuition. Extrapolation techniques are applied beyond the longest liquid tenor to support a realistic long-term convergence. Overall, the design prioritises accuracy, robustness, and market consistency, while drawing on industry best practice throughout the curve construction process.

4.1. MODEL PURPOSE AND SCOPE

The purpose of the model is to produce a zero-coupon yield curve implied by the liquid ZAR OIS swap and FRA market. This curve forms the basis for calculations that require the determination of present or future cash-flow values, as well as for calculations performed within a risk-neutral valuation framework. It is used in the valuation of listed ZARONIA-linked floating-rate cash bonds, as well as in the fair-value valuation of equity derivatives.

4.2. INPUTS

4.2.1. The selection of curve constituents should be guided primarily by instrument liquidity, as highly liquid instruments provide more reliable pricing and improve curve accuracy. However, given the evolving nature of the market, uncertainty remains around which instruments will ultimately prove to be most liquid, particularly at the short end, where both overnight index swaps (OIS) and forward rate agreements (FRAs) are quoted. Including all available quotes would result in an overdetermined curve. While these quotes should, in theory, be arbitrage-free and produce consistent curve outcomes, small discrepancies are to be expected because of liquidity differences. The liquid instrument inputs may include: **ZARONIA OVERNIGHT**

As there are no direct overnight quotes, the most recent available ZARONIA fixing is used as the initial anchor point for the curve. This anchor is then adjusted for any known MPC rate change effective on the following day. This approach ensures that the curve reflects near-term expectations as accurately as possible, even in the absence of instruments shorter than the 1-week OIS swap.

4.2.2. ZARONIA OVERNIGHT INDEX SWAPS

Overnight Indexed Swaps (OIS) are fixed-for-floating interest rate swaps in which the floating leg is based on the ZARONIA index, reflecting overnight lending rates in the South African market. These swaps may be spot-starting or forward-starting and are commonly used to hedge interest rate risk or align cash flows. Forward-starting OIS swaps are particularly important for curve construction because they provide pricing points beyond the spot date and help shape the short end of the curve. These instruments are therefore central to building a robust ZARONIA-based term structure that supports accurate pricing and risk management. The following OIS tenors will be included, with standard 1-month and 3-month forward-starting OIS swaps explicitly forming part of the set:

7d, 14d, 21d, 1m, 2m, 3m, 4m, 5m, 6m, 7m, 8m, 9m, 1y, 15m, 18m, 21m, 2y, 3y, 4y, 5y, 6y, 7y, 8y, 10y, 12y, 20y, 25y, 30y

In addition to these tenors, Forward-Starting OIS (formerly known as FRAs) will be included:

1-month instruments: 1x2m, 2x3m, 3x4m, 4x5m, 5x6m, 6x7m, 7x8m, 8x9m, 9x10m, 10x11m, 11x12m
3-month instruments: 1x4m, 2x5m, 3x6m, 4x7m, 5x8m, 6x9m, 7x10m, 8x11m, 9x12m, 12x15m, 15x18m, 18x21m

In addition, MPC forward-starting OIS instruments may be included. These instruments align with the intervals between Monetary Policy Committee (MPC) meetings, improving price discovery and simplifying curve construction by reducing overlap and avoiding over-parameterisation. Synthetic MPC OIS instruments can also be inferred by interpolating standard OIS or forward-starting OIS rates to the nearest MPC date, providing a more intuitive structure for short-end pricing.

4.2.3. FUTURES

In many jurisdictions, futures have become prevalent, and these can be used instead of FRAs or Forward-Starting OIS as an alternative input. Constant monitoring of the market is necessary to determine whether any changes should be made to the chosen curve to ensure it remains relevant.

Out of the three inputs described above, there are no direct overnight quotes, but quotes are available for ZARONIA Overnight Index Swaps (OIS). Quote providers for ZARONIA OIS used in a curve should reflect where trades can be executed in the market. The working group considered both broker and bank quotes and concluded that regularly updated broker quotes should be used together with bank quotes. All quotes should be routinely tested for relevance and consistency to ensure curve integrity. The Futures market is not yet developed, but when available, futures rates can be based on quotes or actual trades if listed on the JSE.

4.2.4. EXCLUSION OF NON-LIQUID TENORS

Excluded Non-Liquid Tenors: The JSE has excluded the following tenors from the bootstrapping process due to observed illiquidity or limited quote contributions in the ZARONIA Overnight Index Swap (OIS) market:

7d; 14d; 15m; 18m; 21m

4.2.5. FINAL LIST OF ELIGIBLE TENORS

This decision was taken due to the lack of observable market contributions for these tenors. As a result, the inputs became stale and no longer reflected current market conditions. To maintain the integrity and robustness of the curve, these tenors were excluded from the curve calibration.

Should sufficient and reliable market contributions become available in the future, we will reassess their inclusion in the ZARONIA Swap curve.

Old Swap curve constituents'		New Swap curve constituents'	
Swap Curve		Swap Curve	
Code	MTM	Code	MTM
Zaronia	6.850	Zaronia	6.850
OIS_SWAP 1W	6.855	OIS_SWAP 1M	6.872
OIS_SWAP 2W	6.860	OIS_SWAP 2M	6.933
OIS_SWAP 3W	6.865	OIS_SWAP 3M	7.019
OIS_SWAP 1M	6.872	OIS_SWAP 4M	7.083
OIS_SWAP 2M	6.933	OIS_SWAP 5M	7.148
OIS_SWAP 3M	7.019	OIS_SWAP 6M	7.202
OIS_SWAP 4M	7.083	OIS_SWAP 7M	7.254
OIS_SWAP 5M	7.148	OIS_SWAP 8M	7.301
OIS_SWAP 6M	7.202	OIS_SWAP 9M	7.339
OIS_SWAP 7M	7.254	OIS_SWAP 10M	7.368
OIS_SWAP 8M	7.301	OIS_SWAP 11M	7.402
OIS_SWAP 9M	7.339	OIS_SWAP 1Y	7.452
OIS_SWAP 10M	7.368	OIS_2y	7.509
OIS_SWAP 11M	7.402	OIS_3y	7.513
OIS_SWAP 1Y	7.452	OIS_4y	7.560
OIS_15M	7.428	OIS_5y	7.632
OIS_18M	7.437	OIS_6y	7.728
OIS_21M	7.460	OIS_7y	7.833
OIS_2y	7.509	OIS_8y	7.934
OIS_3y	7.513	OIS_9y	8.033
OIS_4y	7.560	OIS_10y	8.119
OIS_5y	7.632	OIS_12y	8.286
OIS_6y	7.728	OIS_15y	8.413
OIS_7y	7.833	OIS_20y	8.449
OIS_8y	7.934	OIS_25y	8.409
OIS_9y	8.033	OIS_30y	8.361
OIS_10y	8.119		
OIS_12y	8.286		
OIS_15y	8.413		
OIS_20y	8.449		
OIS_25y	8.409		
OIS_30y	8.361		

Table 1: New ZARONIA Swap Curve Constituents (4 June 2026)

4.3. BOOTSTRAPPING FRAMEWORK AND CURVE CONSTRUCTION PROCESS

Bootstrapping is the process of constructing the zero-coupon yield curve by sequentially solving for discount factors from observed market instruments. Starting with the shortest maturity, the method uses known cashflows and market rates to calculate discount factors, then iteratively progresses to longer maturities, ensuring that every instrument used as an input is repriced exactly by the curve. This produces a perfect-fit and internally consistent term structure. Because bootstrapping yields zero rates only at instrument maturities, an interpolation method is required to obtain rates at all intermediate points. A monotone-preserving cubic interpolation is applied to ensure that the resulting curve is smooth, stable, and free of unrealistic oscillations, while guaranteeing positive and continuous forward rates. This interpolation approach is consistent with the principles set out by Du Preez and Maré (2013), who demonstrated that monotone-preserving schemes effectively maintain economic plausibility and prevent arbitrage-inducing shapes in bootstrapped yield curves. Together, the bootstrapping and interpolation components form a coherent and robust framework for constructing the ZARONIA zero-coupon curve.

Initialisation Step:

- Begin with the last available ZARONIA overnight fixing, adjusted for any known MPC rate change effective the next day. This serves as the anchor point for the curve.
- Incorporate short-tenor OIS instruments (e.g., 1-month, 2-month, 3-month) as the first bootstrapping nodes.
- Set the initial zero curve using market rates for spot-starting OIS swaps and forward-starting OIS instruments (including MPC-aligned forwards) across the defined tenors.
- Solve for the AIP (All-In Price) for each swap curve constituent tenor from JSE market-observed ZARONIA Overnight Indexed Swap (OIS) rates, then determine the discount factors for these market-observed par values.
- The swap reset period was updated from quarterly (JIBAR) to annual (ZARONIA OIS), in line with SARB recommendations.
- If futures become available, they may replace or complement forward-starting OIS as inputs for short-end pricing.

Iterative Step:

- Using the previous generation of the zero curve as inputs, re-estimate zero rates by re-pricing each instrument (e.g., OIS swaps, Futures) and applying the interpolation model to obtain updated discount factors across all maturities.
- Each instrument's cashflows are valued using discount factors derived from earlier maturities, ensuring internal consistency between the theoretical instrument price and the market-quoted rate.
- The updated discount factors and zero rates form the next generation of the curve.

Convergence Test:

- Compare the difference in yields across all maturities between two successive iterations.
- Convergence is achieved when the difference between the yield calculated by the equation of value and that obtained via the bootstrapping process is less than 1e-10 (0.0000000001).
- Repeat the iterative step until convergence is confirmed.

The following sections provide the mathematical functions used in the iterative steps outlined above. These are separated into the Bootstrapping Function, which determines discount factors and zero rates at instrument maturities, and the Interpolation Function, which fills in rates between those maturities.

Bootstrapping Function:

The bootstrapping function defines how new discount factors and zero rates are solved at each instrument maturity. For a fixed-vs-ZARONIA OIS with fixed rate R_n, accrual fractions $\{\alpha_i\}_{i=1}^{n}$, and discount factors $\{Z(t_i)\}$, the par-pricing condition is:

$$\sum_{i=1}^{n} \alpha_i \; R_n \, Z(t_i) \;=\; 1 \;-\; Z(t_n),$$

Rearranged to bootstrap the new node:

$$Z(t_n) \;=\; \frac{1 \;-\; R_n \sum_{i=1}^{n-1} \alpha_i \, Z(t_i)}{1 \;+\; R_n \alpha_n}$$

Then obtain the zero rate as:

$$r(t_n) \;=\; -\frac{1}{t_n} \ln \, Z(t_n)$$

Interpolation Function:

Once discount factors and zero rates have been bootstrapped at instrument maturities, the interpolation function determines the rate $r(t)$ at any time $t$between nodes t_i and t_{i+1}. Here, $r_i$and $t_i$represent the zero rate and time point obtained from the bootstrap iteration. The monotone-preserving cubic interpolation is defined by:

$$r(t)\,t = a_i + b_i(t - t_i) + c_i(t - t_i)^2 + d_i(t - t_i)^3,$$

with coefficients:

$$a_i = r_i t_i, \qquad b_i = f_i, \qquad c_i = \frac{3m_i - b_{i+1} - 2b_i}{h_i}, \qquad d_i = \frac{b_{i+1} + b_i - 2m_i}{h_i^2}.$$

The slope terms are:

$$m_i = \frac{r_{i+1}t_{i+1} - r_i t_i}{t_{i+1} - t_i}, \qquad h_i = t_{i+1} - t_i.$$

The internal slopes $f_i$are given by:

$$f_i = \frac{t_i - t_{i-1}}{t_{i+1} - t_{i-1}}\, m_i + \frac{t_{i+1} - t_i}{t_{i+1} - t_{i-1}}\, m_{i-1},$$

with boundary conditions:

$$m_0 = 0, \qquad r_0 = t_0 = 0, \qquad f_1 = m_0, \qquad f_n = m_{n-1}.$$

To preserve monotonicity, the slopes are constrained as:

$$f_i \leftarrow \min\left(f_i,\, 3\min\left(m_{i-1}, m_i\right)\right) \quad \text{for } i = 2, \dots, n-1.$$

Extrapolation Function:

Extrapolation extends the yield curve beyond the longest maturity implied by available market instruments. Because long-dated points cannot be observed directly, the aim is not to forecast market expectations but to maintain a smooth, stable, and arbitrage-free curve consistent with the behaviour of the fitted region. The extrapolation procedure assumes that, after the final bootstrapped maturity t_N, the forward rate stabilises toward a long-run constant level. This ensures that the extended portion of the curve remains well-behaved, avoids unrealistic long-term volatility, and preserves continuity with the final observed segment. The zero and forward curves are therefore extended using formulas that maintain smoothness and prevent artificial kinks or discontinuities.

Beyond the last bootstrapped maturity, the instantaneous forward rate is held constant at its terminal value:

$$f(t) = f(t_N) \quad \text{for all } t > t_N.$$

This is the forward rate implied by the final interval of the bootstrapped curve.
The zero rate for any maturity $t > t_N$is derived by integrating the constant forward rate:

$$r(t) = \frac{1}{t}\left(r(t_N)\,t_N + f(t_N)\,(t - t_N)\right).$$

This yields a smooth, gradually flattening zero-rate curve that converges toward the long-run forward rate $f(t_N)$.

5. CONCLUSION

The transition to ZARONIA marks a significant structural shift in the South African interest-rate landscape, requiring a robust, transparent, and market-aligned methodology for constructing an overnight index-based yield curve. The approach outlined in this document provides a consistent and replicable framework that balances theoretical soundness with practical market realities. By leveraging liquid OIS and forward-starting OIS instruments, the curve captures both the current structure of the ZARONIA market and the expected behaviour of overnight rates around Monetary Policy Committee (MPC) dates. Bootstrapping ensures that the curve is a perfect fit to observable market prices, while the monotone-preserving cubic interpolation technique produces smooth, economically intuitive forward rates that avoid artificial oscillations or arbitrage-inducing shapes. This interpolation method also provides the flexibility needed to incorporate structural features unique to ZARONIA, such as MPC-driven jumps, without compromising curve stability.

Where market instruments cease to provide direct guidance, the extrapolation methodology extends the curve in a disciplined manner that ensures long-term consistency and avoids unrealistic rate dynamics. Together, these components yield a curve that is suitable for broad industry use, supporting valuation, risk management, hedge effectiveness testing, and financial reporting across a wide range of applications. While this methodology reflects industry consensus and the best available techniques at the time of publication, it is not intended to constrain innovation. Institutions with proprietary needs remain free to enhance or adapt their own models. Nevertheless, this ZARONIA curve provides a reliable and accessible reference point for the market, supporting the broader transition away from JIBAR and contributing to a more resilient interest-rate environment in South Africa.

6. REFERENCES

Du Preez, P.F. and Maré, E., 2013. Interpolating yield curve data in a manner that ensures positive and continuous forward curves. *South African Journal of Economic and Management Sciences*, *16*(4), pp.395-406.