Verus

# PERSPECTIVES THAT DRIVE ENTERPRISE SUCCESS

**OCTOBER 2024**

Asset-Liability Study

## Pennsylvania Public School Employees' Retirement System

# Executive Summary

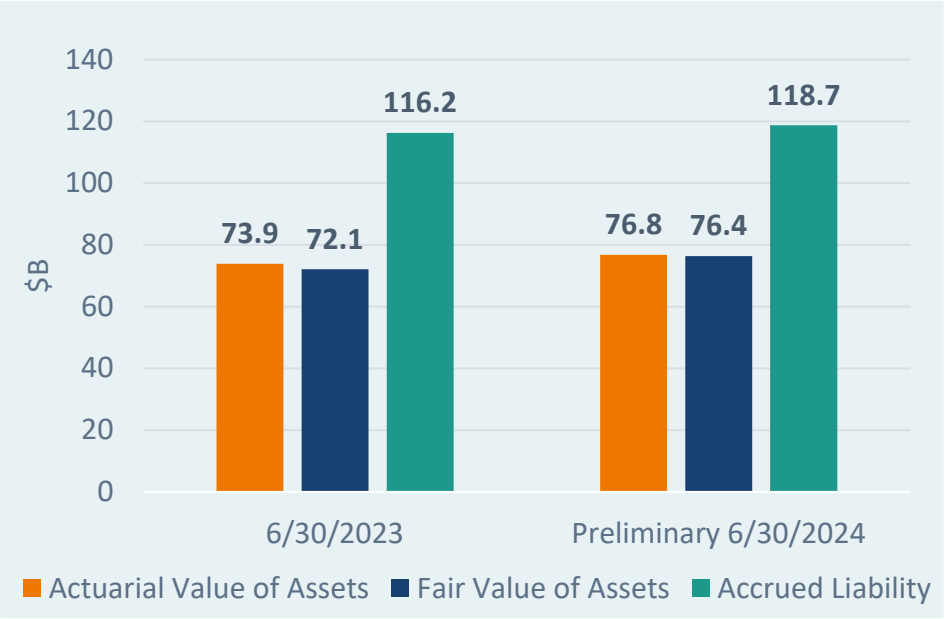
— Verus has conducted an asset-liability study for PSERS

- Based on Verus' 2024 10-year capital market assumptions
- Numerous allocations were evaluated and winnowed down to five for review
- The five allocations include:

1. PSERS Current SAA
2. Adjusted (0% Leverage) – simplified structure; eliminates emerging markets debt and collapses gold into the commodities allocation
3. 4% Leverage – reintroduces moderate leverage at the total portfolio level
4. Long term SAA (8% Leverage) – represents the long-term SAA approved in December 2021
5. 60/40 allocation - included as a baseline

# Current state

**ASSETS AND LIABILITIES ($B)**




| Asset Class | Current Policy |
|---|---|
| **Total Equity** | **42.0** |
| Global Public Equity | 30.0 |
| Private Equity | 12.0 |
| **Total Fixed Income** | **33.5** |
| Core Fixed income | 6.0 |
| US Long Treasury | 8.0 |
| High Yield Corp. Credit | 3.5 |
| EMD (Hard and Local) | 1.0 |
| US TIPS | 9.0 |
| Private Credit | 6.0 |
| **Total Real Assets** | **24.5** |
| Commodities | 2.5 |
| Gold | 2.5 |
| Private Real Estate | 7.0 |
| REITs | 2.5 |
| Public Infrastructure | 5.0 |
| Private Infrastructure | 5.0 |

| 6/30/2023[1] | | Preliminary 6/30/2024[2] |
|---|---|---|
| 64% | AVA Funded Ratio | 65% |
| 62% | MVA Funded Ratio | 64% |
| 7.00% | Discount Rate | 7.00% |

[1]*Based on PSERS' 2023 valuation report.*

[2]*Based on projection results provided by Buck and Verus' Q2 performance report.*

- Excess returns improved the plan's funding on an AVA basis during fiscal 2024
- Future employer contributions are expected to meet the ADC. Employees share in investment risk and are currently contributing at the basic rate.
- 10-year return forecast of current allocation is 7.6%, relative to 7.0% actuarial requirement

# Asset mixes and portfolio analysis

# Potential asset allocation mixes

| | Current SAA 0% Lev. | Adjusted 0% Lev. | Adjusted 4% Lev. | LT SAA 8% Lev. | 60/40 |
|---|---|---|---|---|---|
| Global Public Equity | 30.0 | 32.0 | 28.0 | 36.0 | 60.0 |
| Private Equity | 12.0 | 12.0 | 12.0 | 12.0 | 0.0 |
| ***Total Equity*** | ***42.0*** | ***44.0*** | ***40.0*** | ***48.0*** | ***60.0*** |
| Core Fixed Income | 6.0 | 8.0 | 5.0 | 4.0 | 40.0 |
| US Long Treasury | 8.0 | 8.0 | 6.0 | 8.0 | 0.0 |
| High Yield Corp. Credit | 3.5 | 4.0 | 3.5 | 4.0 | 0.0 |
| EMD (Hard and Local) | 1.0 | 0.0 | 2.0 | 2.0 | 0.0 |
| US TIPS | 9.0 | 7.0 | 10.0 | 10.0 | 0.0 |
| Private Credit | 6.0 | 7.0 | 6.0 | 6.0 | 0.0 |
| ***Total Fixed Income*** | ***33.5*** | ***34.0*** | ***32.5*** | ***34.0*** | ***40.0*** |
| Commodities | 2.5 | 4.0 | 5.0 | 2.5 | 0.0 |
| Gold | 2.5 | 0.0 | 5.0 | 2.5 | 0.0 |
| Private Real Estate | 7.0 | 6.0 | 7.0 | 7.0 | 0.0 |
| REITs | 2.5 | 2.0 | 3.5 | 4.0 | 0.0 |
| Public Infrastructure | 5.0 | 5.0 | 6.0 | 5.0 | 0.0 |
| Private Infrastructure | 5.0 | 5.0 | 5.0 | 5.0 | 0.0 |
| ***Total Real Assets*** | ***24.5*** | ***22.0*** | ***31.5*** | ***26.0*** | ***0.0*** |
| Net Cash | 0.0 | 0.0 | -4.0 | -8.0 | 0.0 |
| **Total Allocation** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |
| | | | | | |
| ***Total Private Markets*** | ***30.0*** | ***30.0*** | ***30.0*** | ***30.0*** | ***0.0*** |

*May not sum due to rounding*

# PSERS expected risk and return: Verus CMAs

| | Current SAA 0% Lev. | Adjusted 0% Lev. | Adjusted 4% Lev. | LT SAA 8% Lev. | 60/40 |
|---|---|---|---|---|---|
| Equity | 42.0 | 44.0 | 40.0 | 48.0 | 60.0 |
| Fixed Income | 33.5 | 34.0 | 32.5 | 34.0 | 40.0 |
| Real Assets | 24.5 | 22.0 | 31.5 | 26.0 | 0.0 |
| Net Cash | 0.0 | 0.0 | -4.0 | -8.0 | 0.0 |
| **Total Allocation** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |

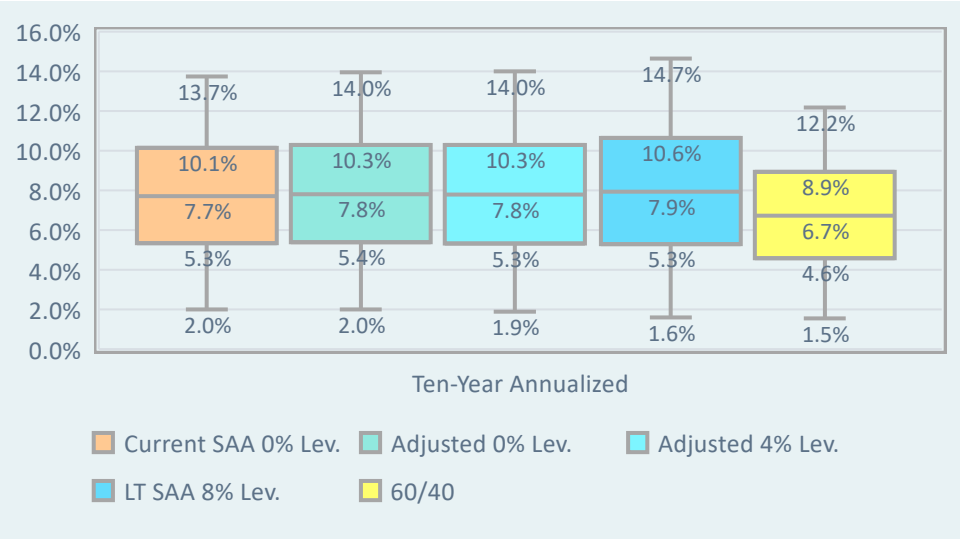
| 30-Year CMAs | Current SAA 0% Lev. | Adjusted 0% Lev. | Adjusted 4% Lev. | LT SAA 8% Lev. | 60/40 |
|---|---|---|---|---|---|
| ***Forecast Return*** | ***7.7*** | ***7.8*** | ***7.8*** | ***7.9*** | ***6.7*** |
| Standard Deviation | 11.4 | 11.6 | 11.7 | 12.7 | 10.3 |
| *25th percentile ret. 1yr* | *0.4* | *0.3* | *0.2* | *-0.2* | *0.1* |
| *5th percentile ret. 1yr* | *-9.3* | *-9.5* | *-9.8* | *-10.8* | *-8.8* |
| *Sharpe Ratio* | 0.4 | 0.4 | 0.4 | 0.4 | 0.3 |

| 10-Year CMAs | Current SAA 0% Lev. | Adjusted 0% Lev. | Adjusted 4% Lev. | LT SAA 8% Lev. | 60/40 |
|---|---|---|---|---|---|
| ***Forecast Return*** | ***7.6*** | ***7.7*** | ***7.7*** | ***7.9*** | ***6.6*** |
| Standard Deviation | 11.4 | 11.6 | 11.7 | 12.7 | 10.3 |
| *25th percentile ret. 1yr* | *0.3* | *0.3* | *0.1* | *-0.3* | *-0.1* |
| *5th percentile ret. 1yr* | *-9.4* | *-9.6* | *-9.8* | *-10.9* | *-9.0* |
| *Sharpe Ratio* | 0.4 | 0.4 | 0.4 | 0.4 | 0.3 |

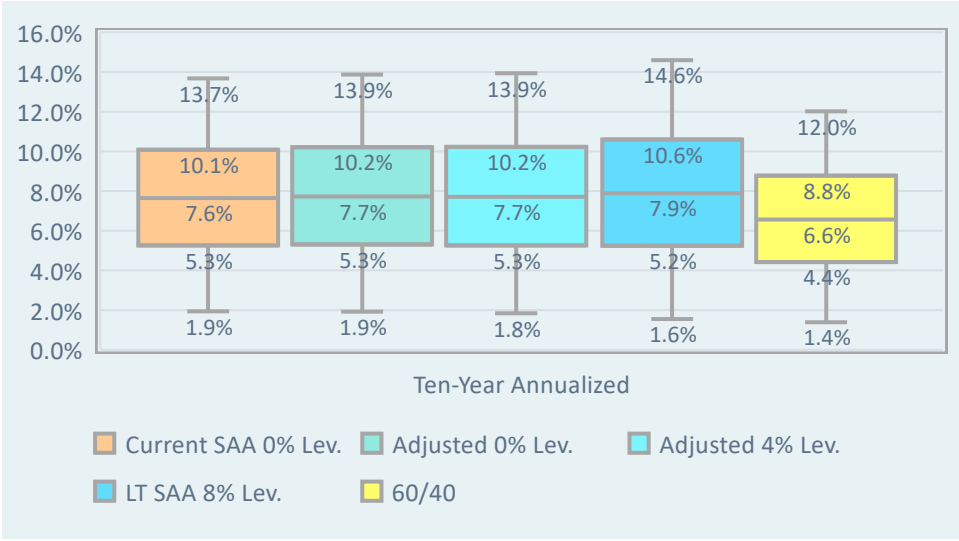
*Based on Verus' 2024 Capital Market Assumptions*

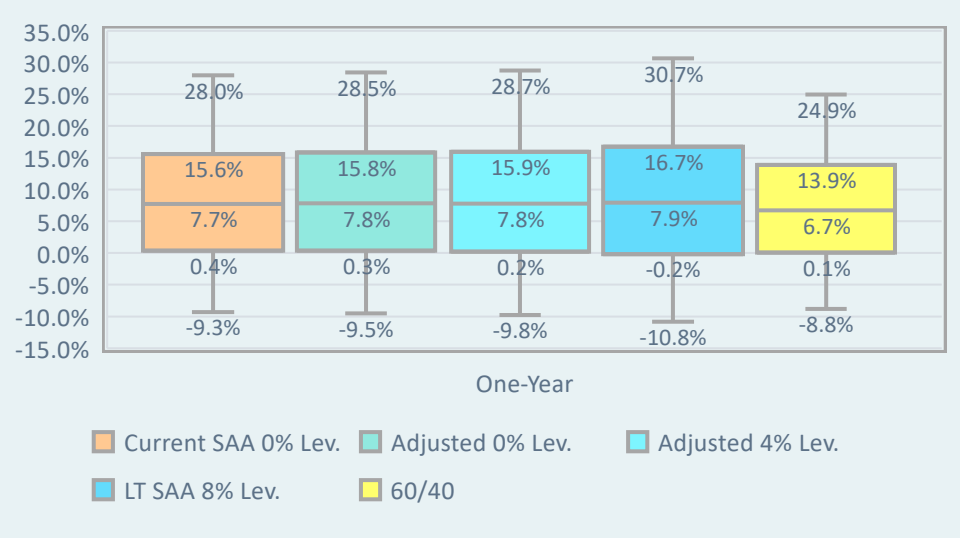
# PSERS distribution of returns

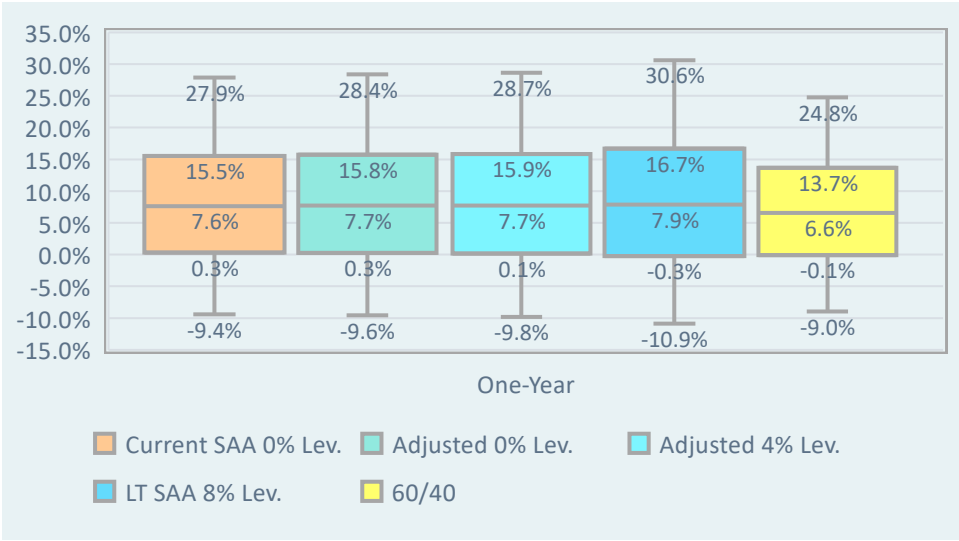
**30-YEAR CMAS**




**10-YEAR CMAS**

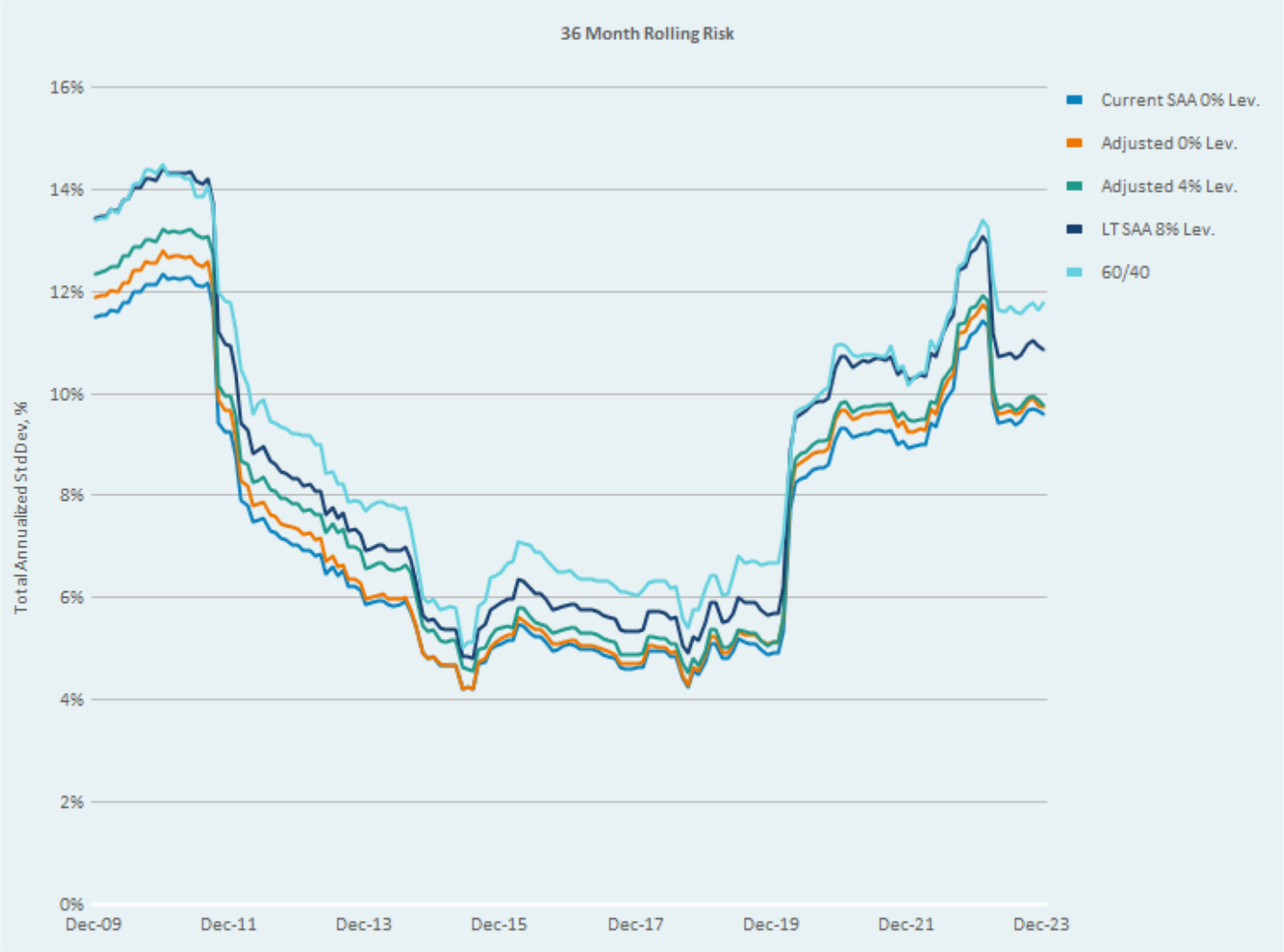


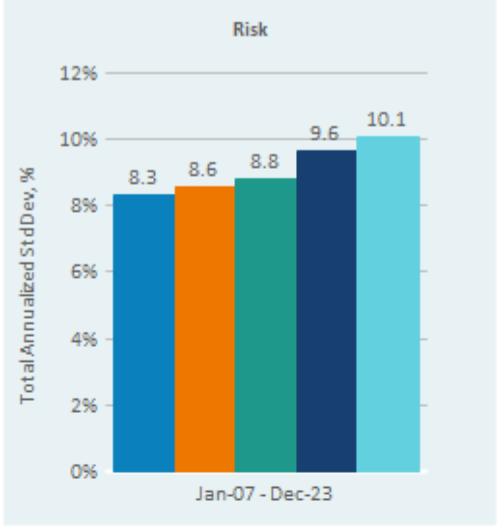



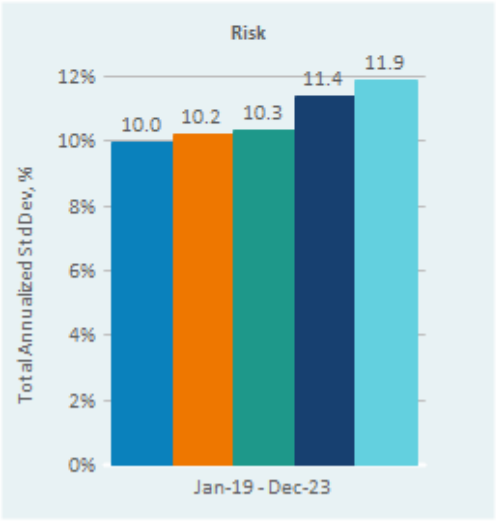




*Based on Verus' 2024 Capital Market Assumptions*

# Risk




Left chart illustrates the historical annualized volatility (3-year rolling) of the current portfolio mix over time, if the current portfolio were held for this historical period and rebalanced according to the specified rebalancing frequency.

Right chart illustrates the historical annualized volatility of the current portfolio mix for the full time period analyzed, given the specified rebalancing frequency.

# Performance during historical stress periods

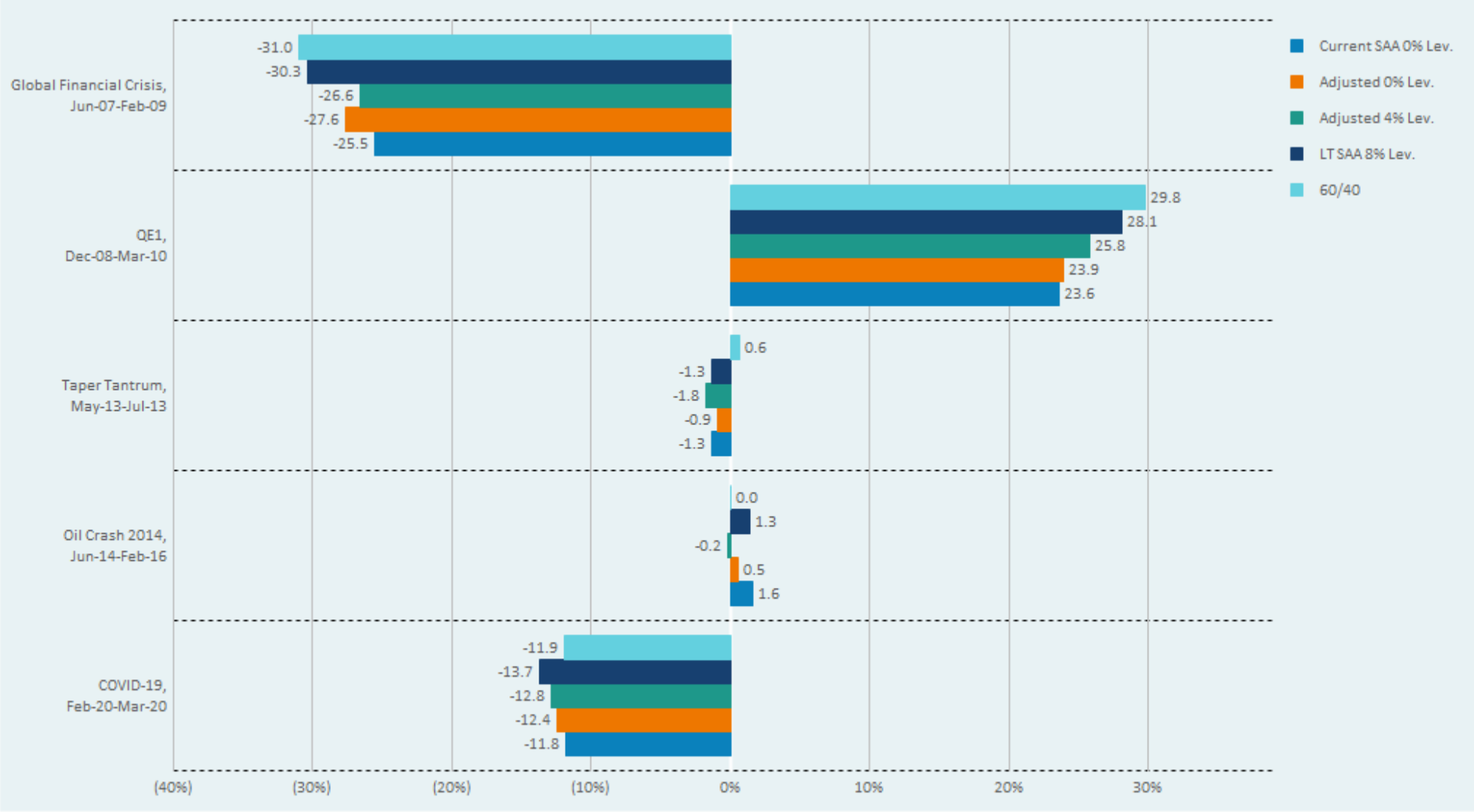



Chart illustrates how each portfolio asset mix performed during a variety of historical periods, given conditions at that historical time, and given the specified rebalancing frequency.

# Performance during historical stress scenarios


Chart estimates the total portfolio performance of each asset mix, given a specific shock to the portfolio. This is calculated based on the sensitivity of all of the exposures in an asset mix to a given shock. For example, the historical sensitivity of each exposure to a 50 basis point rise in the 10-year U.S. Treasury yield.

# Performance during historical stress scenarios

| Scenario Name | Description |
|---|---|
| Bond Market Stress | Treasury rates at 2-Year, 5-Year, and 20-Year maturities rise simultaneously with investment grade and high yield spreads, all by 100 bps. (Note: This shock will only work appropriately in Stylus v11.5 and above) |
| Yield Curve Parallel +100 bps | Parallel upward shift of the yield curve at 2-Year, 5-Year, and 20-Year constant maturity rates. (Note: This shock will only work appropriately in Stylus v11.5 and above) |
| Yield Curve Steepens 2Y, 5Y, 20Y | Upward steepening of the Treasury yield curve with 2-Year, 5-Year, and 20-Year constant maturity rates. (Note: This shock will only work appropriately in Stylus v11.5 and above) |

SYSTEMATIC SHOCK

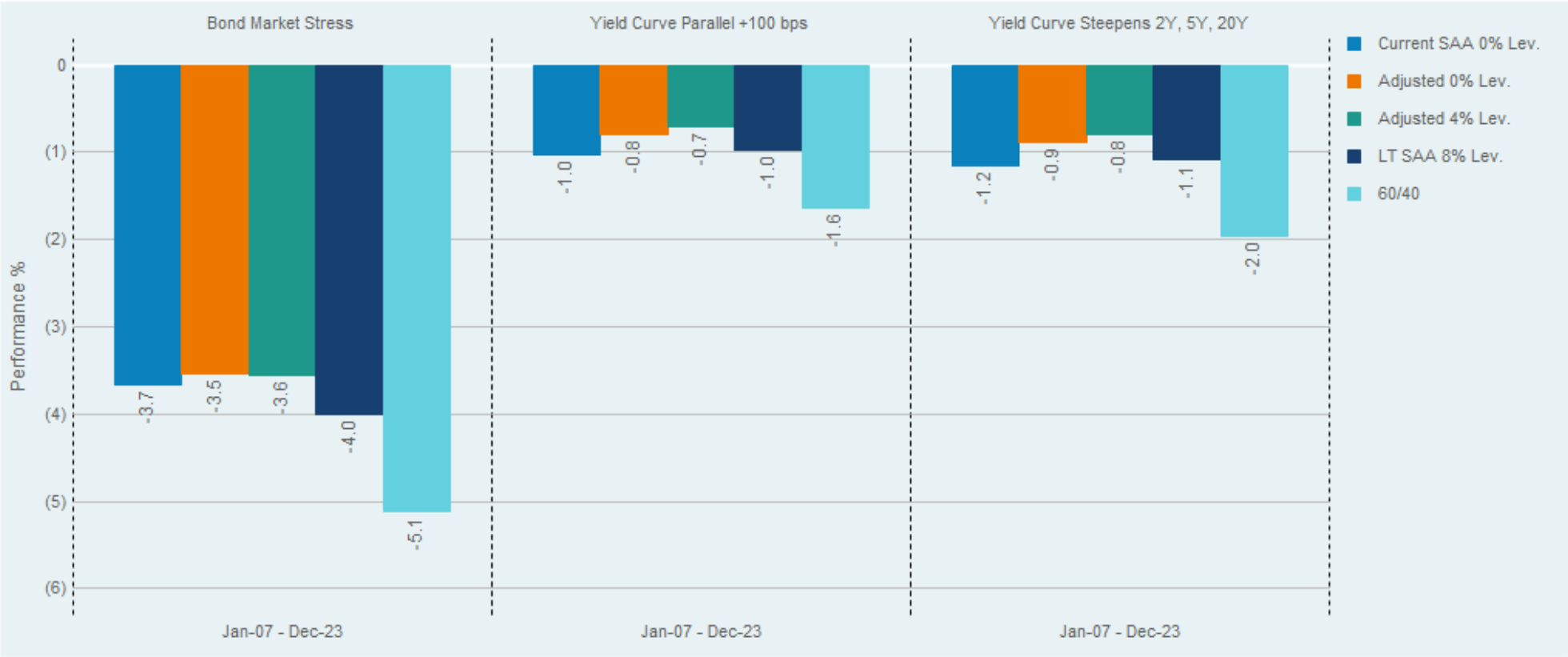
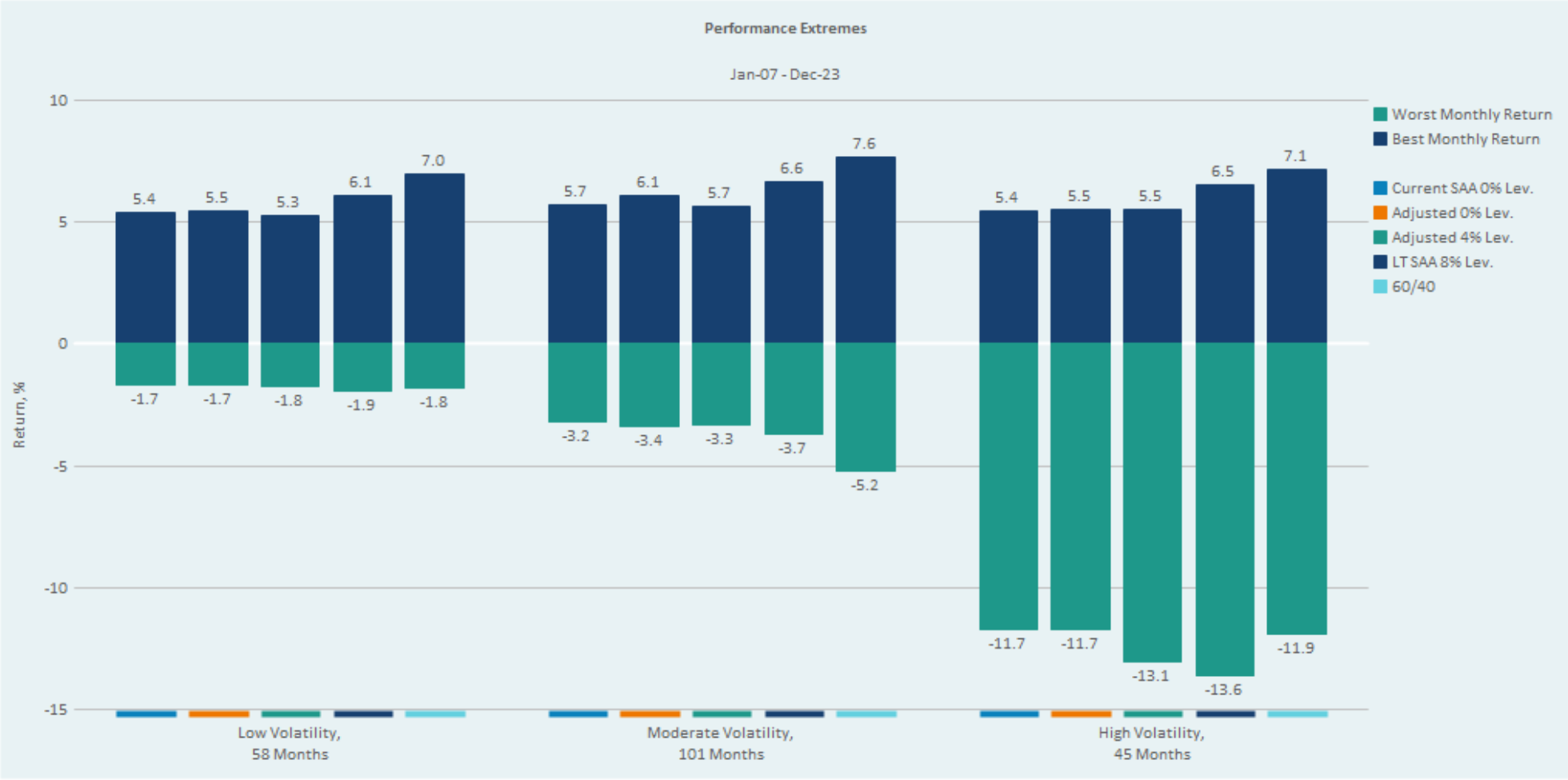



Chart estimates the total portfolio performance of each asset mix, given a specified shock to the portfolio. This is calculated based on the current asset loadings of the portfolio across all asset classes, which then estimates the sensitivity of total portfolio to a given shock. For example, the historical sensitivity of all asset classes (the portfolio) to a 50 basis point rise in the 10-year U.S. Treasury yield.

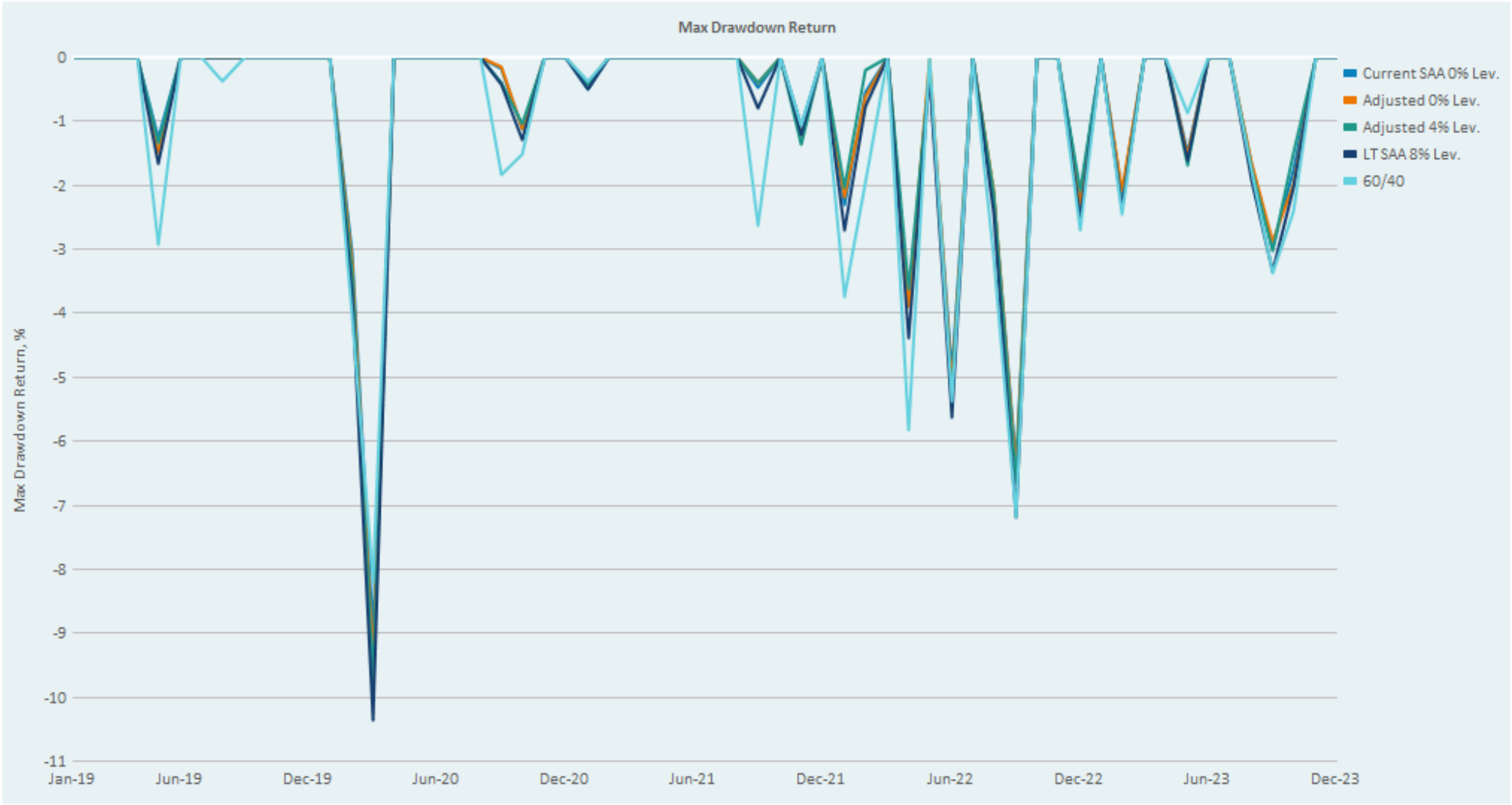
# Performance extremes during VIX regimes

| Regime Group | Description |
|---|---|
| Volatility by Threshold | Volatility regimes by CBOE VIX with breaks at 15 and 25. |




This chart illustrates the best and worst portfolio monthly returns during different market volatility environments. High volatility environments of course tend to result in wider performance outcomes, but most importantly can result in larger portfolio losses relative to portfolio gains.

# Max drawdown




The Max Drawdown statistics show the highest percentage loss a fund investor could have realized on their investment, assuming they bought at the peak and sold at the trough. The Period and Duration measures can be used to determine if a manager is able to recover quickly from losses.

# Liquidity analysis

# Liquidity coverage ratio (LCR)

## Will PSERS' need to sell illiquid assets to cover cash outflows?

$$Liquidity\ Coverage\ Ratio\ (LCR) = \frac{\begin{matrix} Starting\ Liquid\ Financial\ Assets \\ \sum(Distributions\ from\ Illiquid\ Assets) \\ \sum(Contributions) \\ \sum(Liquid\ Investment\ Return) \end{matrix}}{\begin{matrix} \sum Benefit\ Payments \\ \sum Administrative\ Expenses \\ \sum(Capital\ Calls\ for\ Illiquid\ Assets) \end{matrix}}$$

**Modeled stochastically**

| LCR Value | Implication |
|---|---|
| **<1** | Yes |
| **>1** | No |

# PSERS' liquidity assumptions

## By asset class

| Liquidity Grouping | Asset Class | Current SAA 0% Lev. | Adjusted 0% Lev. | Adjusted 4% Lev. | LT SAA 8% Lev. | 60/40 |
|---|---|---|---|---|---|---|
| Liquid Assets | Global Public Equity | 30.0% | 32.0% | 28.0% | 36.0% | 60.0% |
| | Core Fixed Income | 6.0% | 8.0% | 5.0% | 4.0% | 40.0% |
| | US Long Treasury | 8.0% | 8.0% | 6.0% | 8.0% | 0.0% |
| | High Yield Corp. Credit | 3.5% | 4.0% | 3.5% | 4.0% | 0.0% |
| | EMD (Hard and Local) | 1.0% | 0.0% | 2.0% | 2.0% | 0.0% |
| | US TIPS | 9.0% | 7.0% | 10.0% | 10.0% | 0.0% |
| | Commodities | 2.5% | 4.0% | 5.0% | 2.5% | 0.0% |
| | Gold | 2.5% | 0.0% | 5.0% | 2.5% | 0.0% |
| | REITs | 2.5% | 2.0% | 3.5% | 4.0% | 0.0% |
| | Public Infrastructure | 5.0% | 5.0% | 6.0% | 5.0% | 0.0% |
| | Net Cash | 0.0% | 0.0% | -4.0% | -8.0% | 0.0% |
| | **Total Liquid** | **70.0%** | **70.0%** | **70.0%** | **70.0%** | **100.0%** |
| Illiquid Assets | Private Equity | 12.0% | 12.0% | 12.0% | 12.0% | 0.0% |
| | Private Credit | 6.0% | 7.0% | 6.0% | 6.0% | 0.0% |
| | Private Real Estate | 7.0% | 6.0% | 7.0% | 7.0% | 0.0% |
| | Private Infrastructure | 5.0% | 5.0% | 5.0% | 5.0% | 0.0% |
| | **Total Illiquid** | **30.0%** | **30.0%** | **30.0%** | **30.0%** | **0.0%** |

# PSERS' baseline cash flow projection

| ($Millions) | | | | Net Cash Flow (w/out Private Markets) | | | | Net Cash Flow (w/ Private Markets) | |
|---|---|---|---|---|---|---|---|---|---|
| Calendar Year Beginning | Market Value of Assets (BOY) | Contributions | Benefit Payments & Admin Expenses | Net Cash Flow % | Net Cash Flow ($) | Illiquid Distributions | Illiquid Capital Calls | Net Cash Flow % | Net Cash Flow ($) |
| 2024 | 72,200 | 6,400 | (8,100) | -2.4% | -1,700 | 2,800 | (2,600) | -2.1% | (1,500) |
| 2025 | 75,900 | 6,400 | (8,000) | -2.1% | -1,600 | 7,300 | (3,400) | 3.0% | 2,300 |
| 2026 | 79,800 | 6,500 | (8,200) | -2.1% | -1,700 | 7,200 | (3,300) | 2.8% | 2,200 |
| 2027 | 84,100 | 6,600 | (8,400) | -2.1% | -1,800 | 8,200 | (3,200) | 3.8% | 3,200 |
| 2028 | 88,500 | 6,800 | (8,600) | -2.0% | -1,800 | 6,200 | (2,800) | 1.8% | 1,600 |
| 2029 | 93,200 | 6,900 | (8,900) | -2.1% | -2,000 | 5,800 | (2,800) | 1.1% | 1,000 |
| 2030 | 98,200 | 7,100 | (9,100) | -2.0% | -2,000 | 5,600 | (2,800) | 0.8% | 800 |
| 2031 | 103,500 | 7,200 | (9,300) | -2.0% | -2,100 | 5,300 | (2,800) | 0.4% | 400 |
| 2032 | 109,100 | 7,400 | (9,600) | -2.0% | -2,200 | 5,000 | (2,800) | 0.0% | 0 |
| 2033 | 115,000 | 7,600 | (9,800) | -1.9% | -2,200 | 5,000 | (2,800) | 0.0% | 0 |

PSERS' expected contributions and benefit payments result in a steady net cash flow position of (2%) annually when excluding capital calls and distributions from private investments.

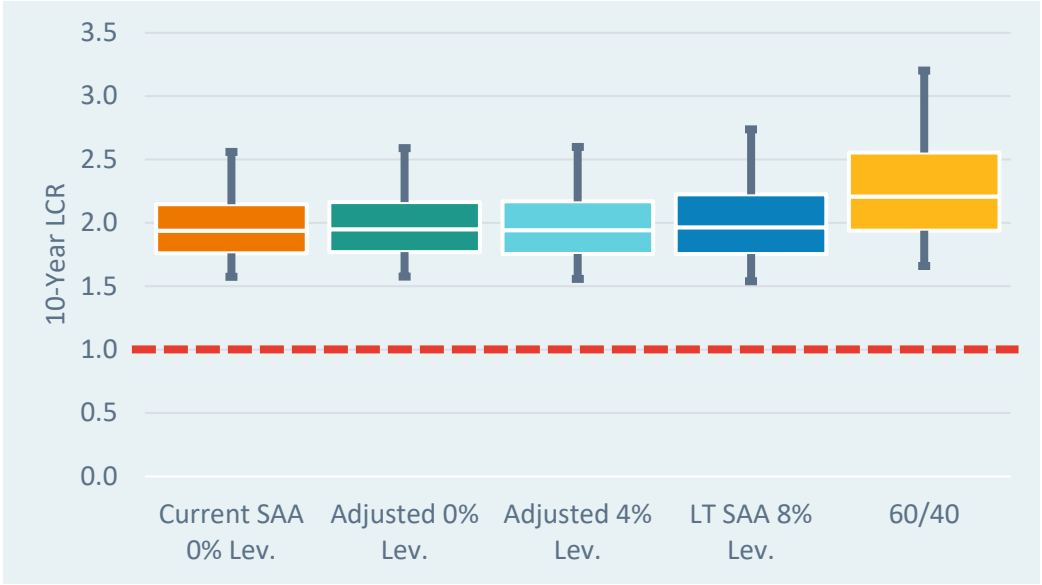
The plan's cashflow position is expected to be positive after year 1 when including private investments.

*See appendix for additional details.*

# LCR analysis

## Baseline private market cashflows

**DISTRIBUTION OF 10-YEAR LCR OUTCOMES**




| 10-Year LCR | Current SAA 0% Lev. | Adjusted 0% Lev. | Adjusted 4% Lev. | LT SAA 8% Lev. | 60/40 |
|---|---|---|---|---|---|
| **Percentile** | | | | | |
| 95% Percentile | 2.6 | 2.6 | 2.6 | 2.7 | 3.2 |
| 75% Percentile | 2.1 | 2.2 | 2.2 | 2.2 | 2.6 |
| 50% Percentile | 1.9 | 1.9 | 1.9 | 2.0 | 2.2 |
| 25% Percentile | 1.8 | 1.8 | 1.8 | 1.8 | 1.9 |
| 5% Percentile | 1.6 | 1.6 | 1.6 | 1.5 | 1.7 |
| **Probability of Liquidity Event** | **<0.1%** | **<0.1%** | **<0.1%** | **<0.1%** | **<0.1%** |

The fund is expected to have sufficient liquidity to meet cashflow needs over the next 10 years, even in adverse return scenarios.

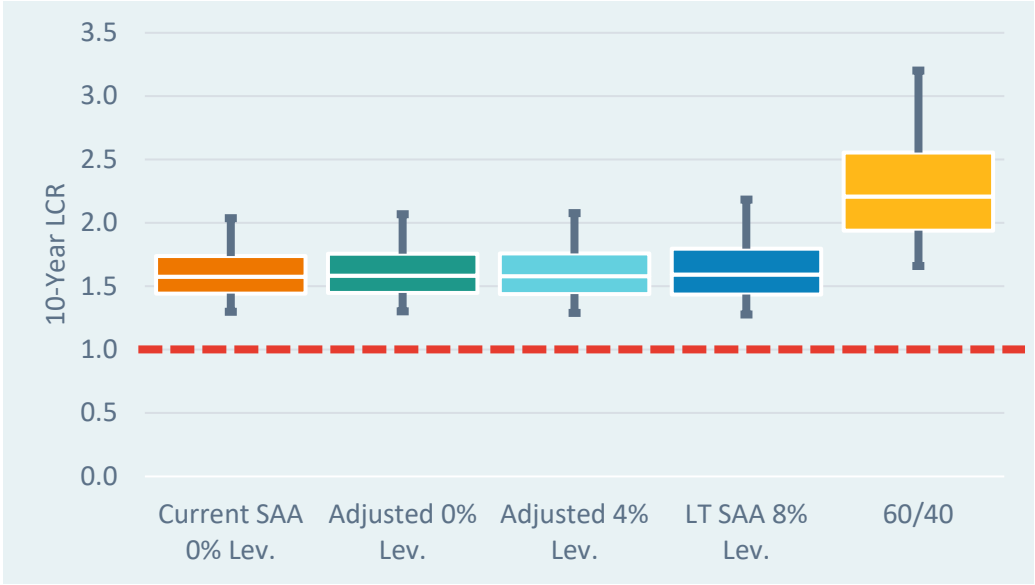
This scenario assumes contributions, benefit payments, and private market cashflows are as expected.

*Based on 1,000 monte carlo simulations of liquidity coverage ratio. See appendix for additional details.*

# Liquidity coverage ratio analysis

## Pessimistic private market cashflows

**DISTRIBUTION OF 10-YEAR LCR OUTCOMES**




| 10-Year LCR | Current SAA 0% Lev. | Adjusted 0% Lev. | Adjusted 4% Lev. | LT SAA 8% Lev. | 60/40 |
|---|---|---|---|---|---|
| **Percentile** | | | | | |
| 95% Percentile | 2.0 | 2.1 | 2.1 | 2.2 | 3.2 |
| 75% Percentile | 1.7 | 1.8 | 1.8 | 1.8 | 2.6 |
| 50% Percentile | 1.6 | 1.6 | 1.6 | 1.6 | 2.2 |
| 25% Percentile | 1.4 | 1.4 | 1.4 | 1.4 | 1.9 |
| 5% Percentile | 1.3 | 1.3 | 1.3 | 1.3 | 1.7 |
| **Probability of Liquidity Event** | **<0.1%** | **<0.1%** | **<0.1%** | **<0.1%** | **<0.1%** |

The fund is expected to have sufficient liquidity to meet cashflow needs over the next 10 years, even in adverse return and cashflow scenarios.

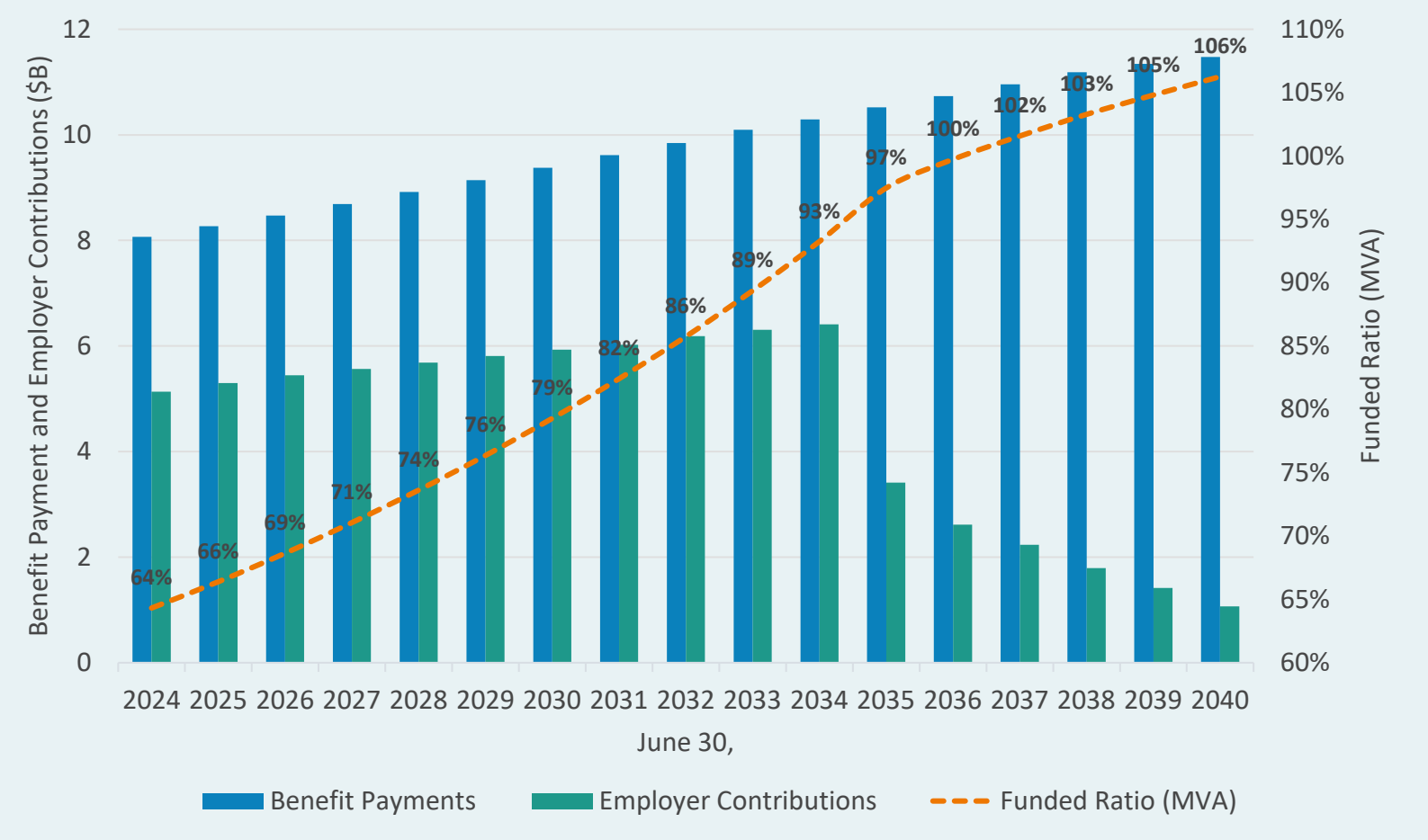
This scenario assumes that private market distributions are equal to capital calls (i.e., are less than expected). All other cashflows are as expected.

*Based on 1,000 monte carlo simulations of liquidity coverage ratio. See appendix for additional details.*

# Deterministic asset-liability projections

# Funded status and cashflow projection

## Baseline return scenario



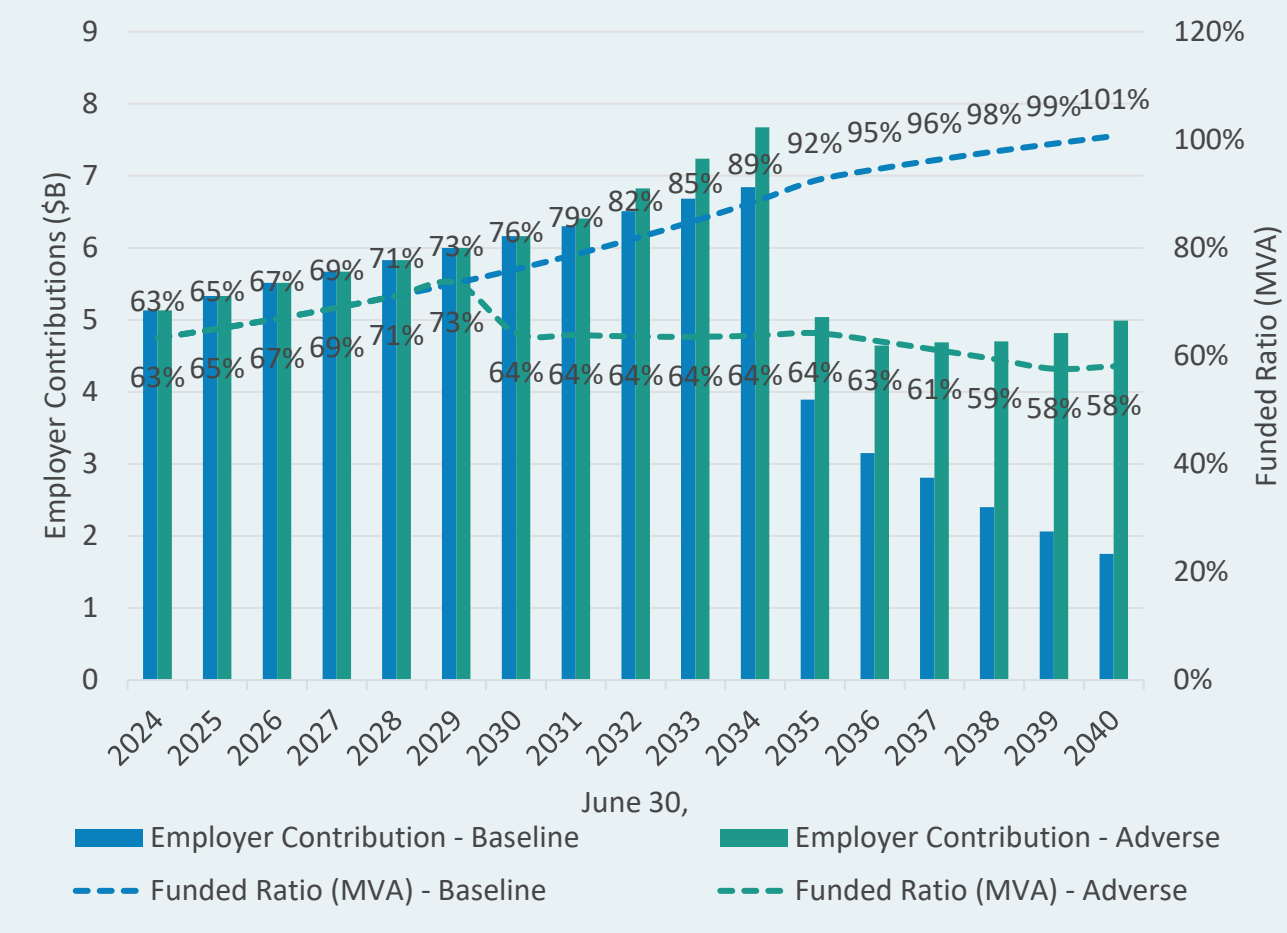

With an annual return of 7.6%, the plan reaches full funding in 2036.

Contributions drop off significantly after fiscal 2035.

*Assumes returns of 7.6% each year. See appendix for additional details.*

# Funded status and cashflow projection

## Adverse return scenario




The adverse scenarios is intended to reflect a 1-in-20 worst case performance outcome for ten years combined with baseline returns for the remainder of the projection:

| Time | Return | Descriptions |
|---|---|---|
| Year 1 - 5 | 7.6 | Baseline |
| Year 6 | -9.4 | 1-in-20 1-year performance |
| Year 7 - 15 | 3.6 | 1-in-20 10-year performance |
| Year 16+ | 7.6 | Baseline |

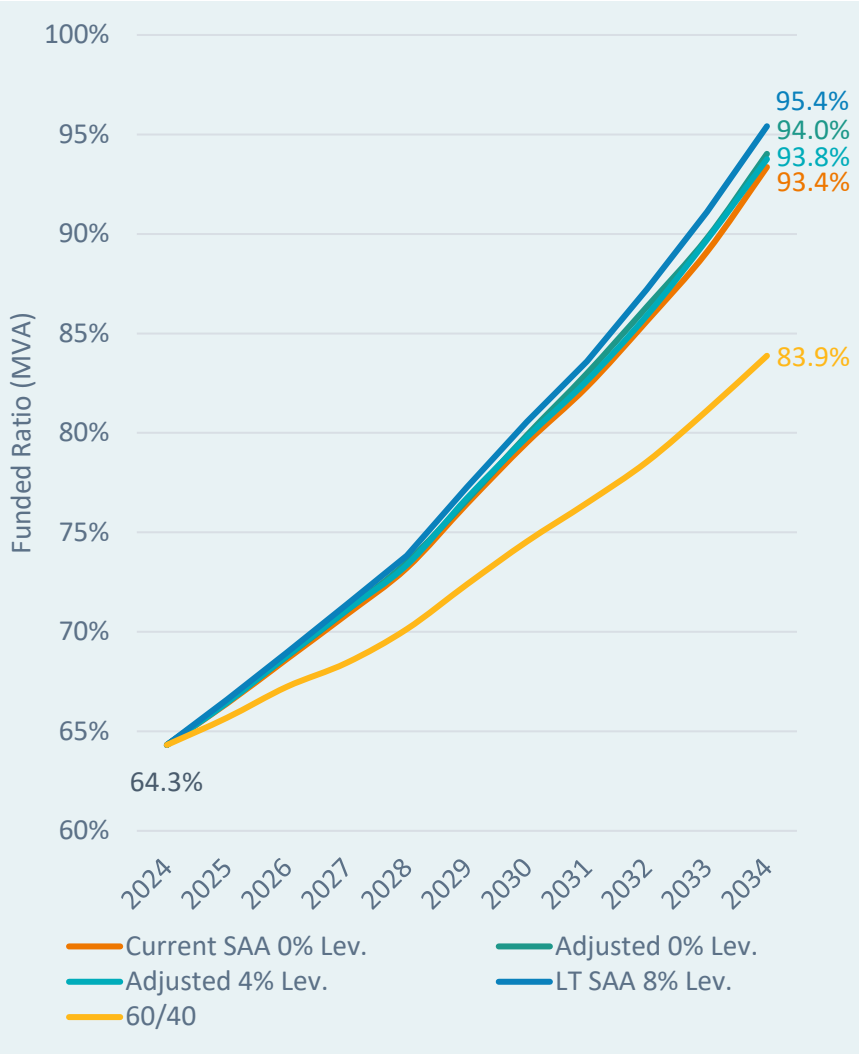
The adverse scenario associated with the current allocation results in a 43% funded ratio reduction and an additional $16B of contributions. The contribution impact is phased in slowly.

*Assumes returns of 7.6% each year in baseline scenario and as stated on slide for adverse scenario. See appendix for additional details.*

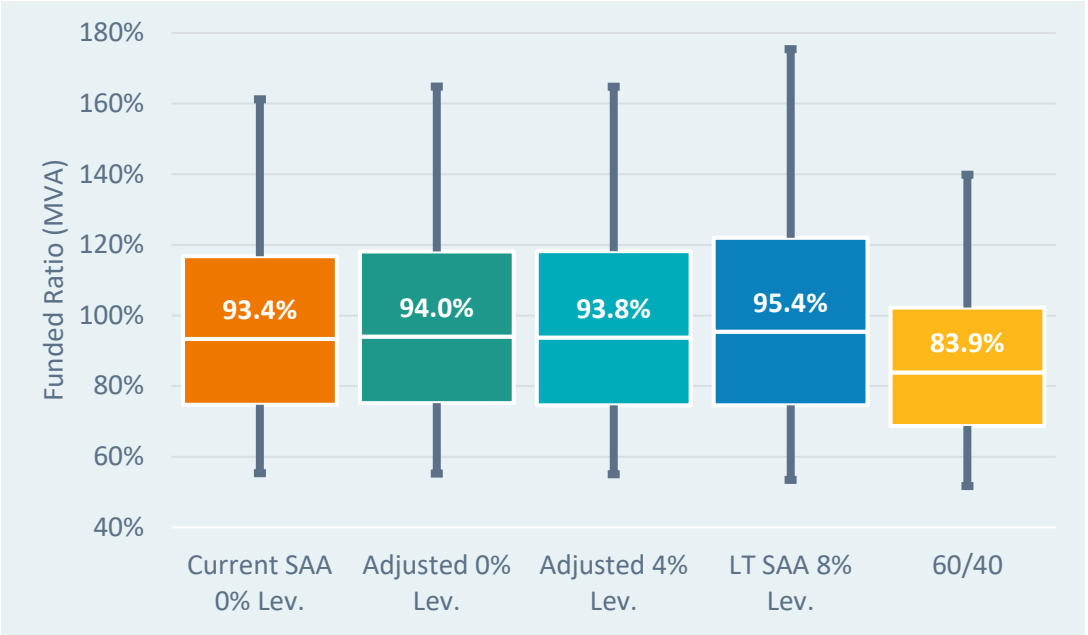
# Stochastic asset-liability projections

# Funded ratio (MVA)

FUNDED RATIO (MVA) MEDIAN PROJECTION




JUNE 30, 2034 FUNDED RATIO (MVA) DISTRIBUTION

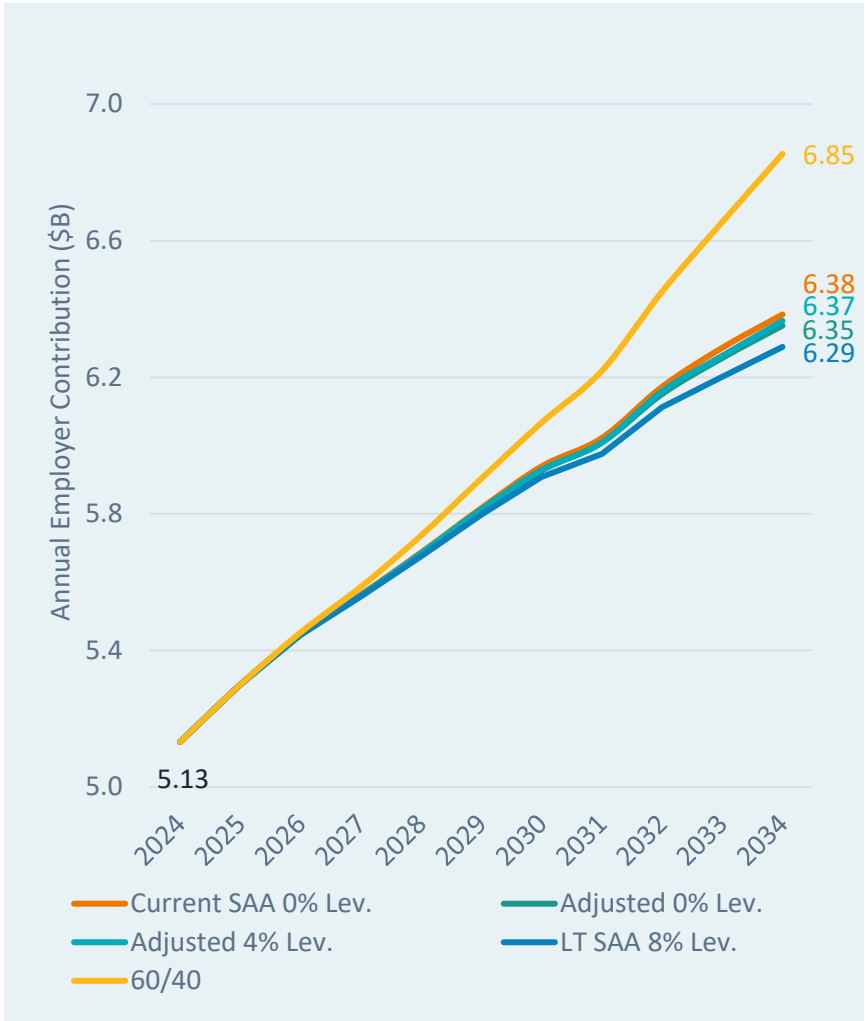



| 2034 Funded Ratio (MVA) | Current SAA 0% Lev. | Adjusted 0% Lev. | Adjusted 4% Lev. | LT SAA 8% Lev. | 60/40 |
|---|---|---|---|---|---|
| **Percentile** | | | | | |
| 95% | 161.2% | 164.8% | 164.8% | 175.4% | 139.9% |
| 75% | 116.8% | 118.1% | 118.2% | 122.0% | 102.2% |
| **50%** | **93.4%** | **94.0%** | **93.8%** | **95.4%** | **83.9%** |
| 25% | 74.7% | 75.2% | 74.6% | 74.6% | 68.7% |
| **5%** | **55.3%** | **55.2%** | **55.0%** | **53.4%** | **51.7%** |
| **Probability > Current** | **N/A** | **72%** | **62%** | **72%** | **14%** |

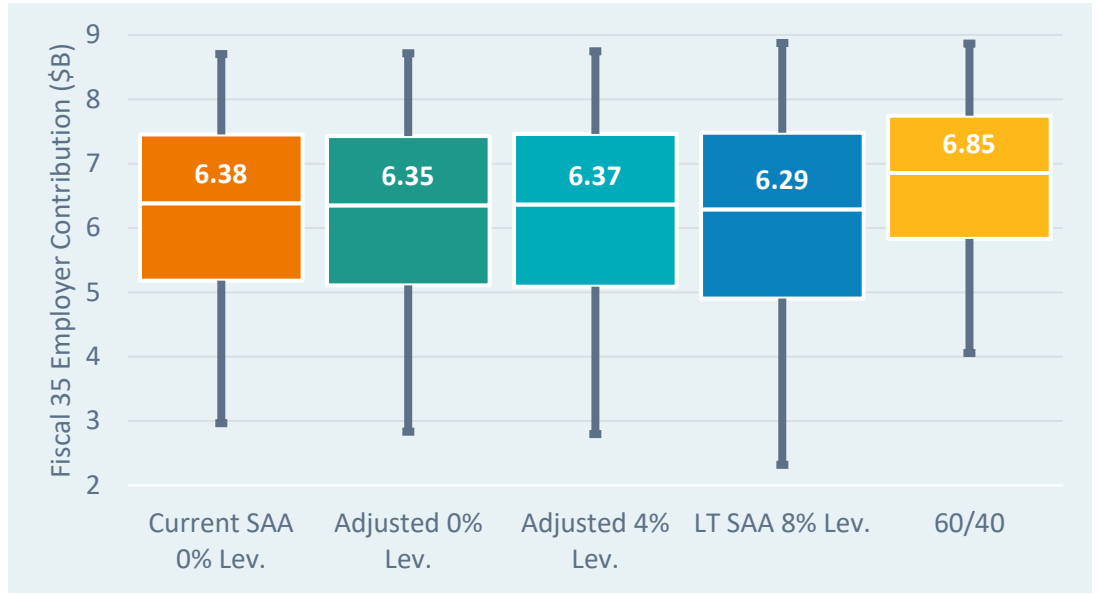
*Source: Reflects 5,000 simulations of assets and liabilities based on Verus' 2024 capital market assumptions. See appendix for additional details.*

# Annual employer contributions ($B)

ANNUAL EMPLOYER CONTRIBUTION ($B)




FISCAL 2035 EMPLOYER CONTRIBUTION ($B) DISTRIBUTION




| Fiscal 2035 Employer Cont. ($B) | Current SAA 0% Lev. | Adjusted 0% Lev. | Adjusted 4% Lev. | LT SAA 8% Lev. | 60/40 |
|---|---|---|---|---|---|
| **Percentile** | | | | | |
| **95%** | **8.70** | **8.72** | **8.75** | **8.87** | **8.87** |
| 75% | 7.45 | 7.43 | 7.46 | 7.48 | 7.74 |
| **50%** | **6.38** | **6.35** | **6.37** | **6.29** | **6.85** |
| 25% | 5.18 | 5.11 | 5.09 | 4.90 | 5.83 |
| 5% | 2.97 | 2.83 | 2.80 | 2.32 | 4.06 |
| **Fiscal 2035 EE Shared-Risk Cont.** | | | | | |
| Prob > 0 | 32% | 32% | 32% | 32% | 43% |

*Source: Reflects 5,000 simulations of assets and liabilities based on Verus' 2024 capital market assumptions. Contributions reflects actuarially determined amount, which are based on actuarial value of assets rather than market value. See appendix for additional details.*

# Total full funding cost

TOTAL COST DISTRIBUTION ($B)

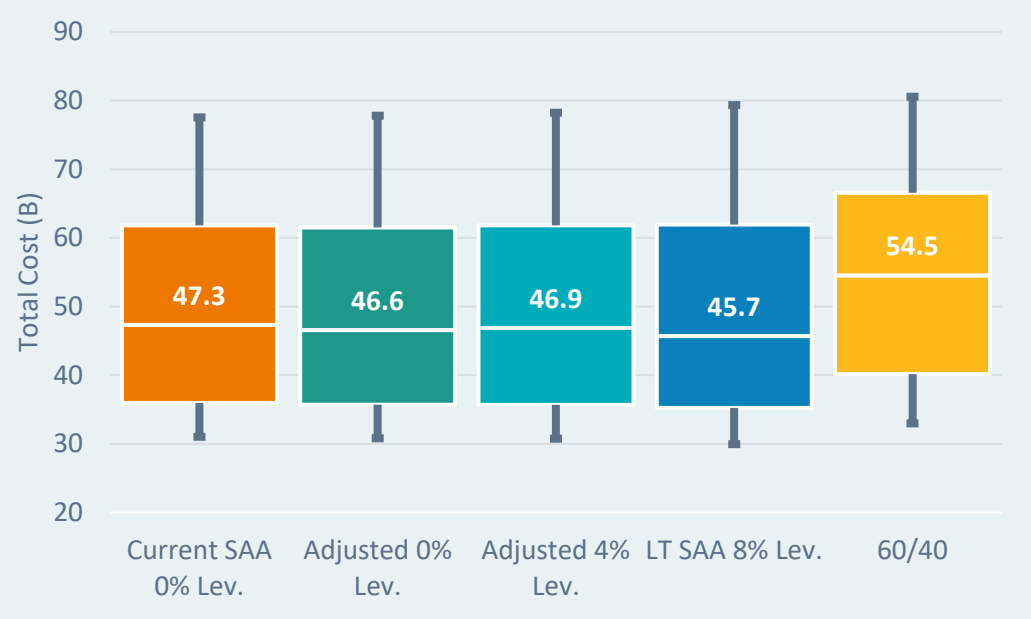
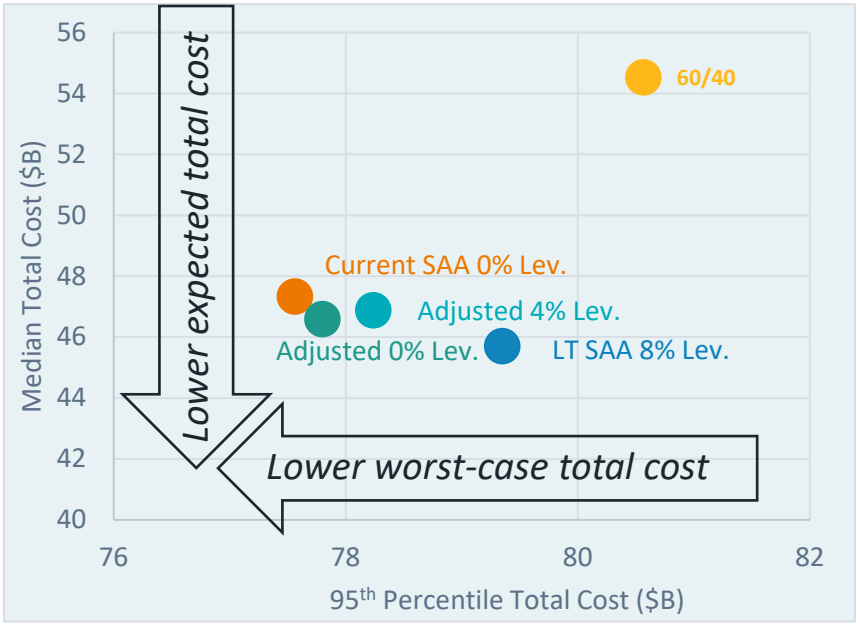



ILLUSTRATION OF RISK REWARD TRADEOFF




| Total full funding cost ($B) | Current SAA 0% Lev. | Adjusted 0% Lev. | Adjusted 4% Lev. | LT SAA 8% Lev. | 60/40 |
|---|---|---|---|---|---|
| **Percentile** | | | | | |
| **95%** | **77.6** | **77.8** | **78.2** | **79.3** | **80.6** |
| 75% | 61.8 | 61.5 | 61.8 | 61.9 | 66.6 |
| **50%** | **47.3** | **46.6** | **46.9** | **45.7** | **54.5** |
| 25% | 36.0 | 35.7 | 35.7 | 35.2 | 40.2 |
| 5% | 31.0 | 30.8 | 30.8 | 30.0 | 33.0 |
| **Return/Risk Tradeoff** | **N/A** | **3.2** | **0.7** | **0.9** | **-2.4** |

Metric estimates the total cost to achieve full funding, by summing together the following:

- Fiscal 2025 through 2034 cumulative contributions:
  - "What did we contribute during the projection?"
- Remaining deficit at 6/30/2034:
  - "What would we still need to contribute at the end of the projection to achieve full funding?"

*Source: Reflects 5,000 simulations of assets and liabilities based on Verus' 2024 capital market assumptions. Metric is calculated on a present value basis with a 7% discount rate. See appendix for additional details.*

# Appendix

# Asset-liability projections

# Heat map

## Funded status and contributions

| Funded Ratio (MVA) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| June 30, | 2024 | 2026 | 2028 | 2030 | 2032 | 2034 | 2036 | 2038 | 2040 |
| Annual Investment Return 2.0% | 64% | 61% | 58% | 56% | 54% | 54% | 52% | 48% | 44% |
| Annual Investment Return 3.0% | 64% | 63% | 61% | 60% | 59% | 59% | 59% | 55% | 52% |
| Annual Investment Return 4.0% | 64% | 64% | 64% | 64% | 64% | 66% | 66% | 63% | 61% |
| Annual Investment Return 5.0% | 64% | 65% | 66% | 68% | 69% | 72% | 74% | 72% | 71% |
| Annual Investment Return 6.0% | 64% | 66% | 69% | 72% | 75% | 80% | 83% | 83% | 82% |
| Annual Investment Return 7.0% | 64% | 68% | 72% | 76% | 82% | 88% | 93% | 95% | 96% |
| Annual Investment Return 8.0% | 64% | 69% | 75% | 81% | 88% | 97% | 104% | 108% | 112% |
| Annual Investment Return 9.0% | 64% | 70% | 78% | 86% | 95% | 106% | 115% | 122% | 129% |

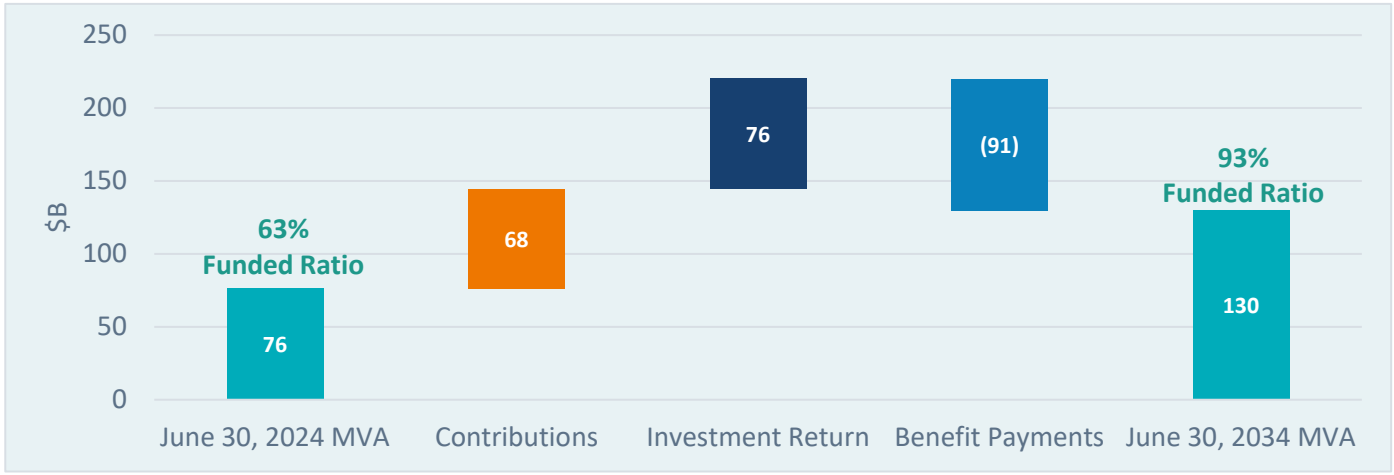
The heat map shows the impacts of varying returns to the plan's funded status and contribution requirements.

| Annual Contributions ($B \| % of Payroll) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Fiscal Year | 2025 | 2027 | 2029 | 2031 | 2033 | 2035 | 2037 | 2039 | Total (Fiscal 2025-2040) |
| Annual Investment Return 2.0% | 5.1 \| 34% | 5.5 \| 36% | 5.9 \| 38% | 6.6 \| 42% | 7.5 \| 46% | 8.5 \| 52% | 5.6 \| 34% | 5.8 \| 35% | 100 |
| Annual Investment Return 3.0% | 5.1 \| 34% | 5.5 \| 36% | 5.9 \| 38% | 6.5 \| 41% | 7.2 \| 45% | 8.1 \| 50% | 5.2 \| 31% | 5.2 \| 31% | 96 |
| Annual Investment Return 4.0% | 5.1 \| 34% | 5.5 \| 36% | 5.8 \| 38% | 6.4 \| 40% | 7.0 \| 44% | 7.8 \| 48% | 4.7 \| 28% | 4.6 \| 27% | 92 |
| Annual Investment Return 5.0% | 5.1 \| 34% | 5.5 \| 36% | 5.8 \| 37% | 6.3 \| 40% | 6.8 \| 42% | 7.5 \| 46% | 4.2 \| 25% | 3.9 \| 23% | 88 |
| Annual Investment Return 6.0% | 5.1 \| 34% | 5.5 \| 36% | 5.8 \| 37% | 6.1 \| 39% | 6.6 \| 41% | 7.1 \| 43% | 3.6 \| 22% | 3.2 \| 19% | 84 |
| Annual Investment Return 7.0% | 5.1 \| 34% | 5.4 \| 36% | 5.7 \| 37% | 6.0 \| 38% | 6.3 \| 39% | 6.7 \| 41% | 3.0 \| 18% | 2.4 \| 14% | 79 |
| Annual Investment Return 8.0% | 5.1 \| 34% | 5.4 \| 36% | 5.7 \| 36% | 5.9 \| 37% | 6.1 \| 38% | 6.3 \| 38% | 2.4 \| 14% | 1.5 \| 9% | 73 |
| Annual Investment Return 9.0% | 5.1 \| 34% | 5.4 \| 36% | 5.6 \| 36% | 5.8 \| 36% | 5.9 \| 36% | 5.8 \| 36% | 1.8 \| 11% | 0.6 \| 4% | 69 |

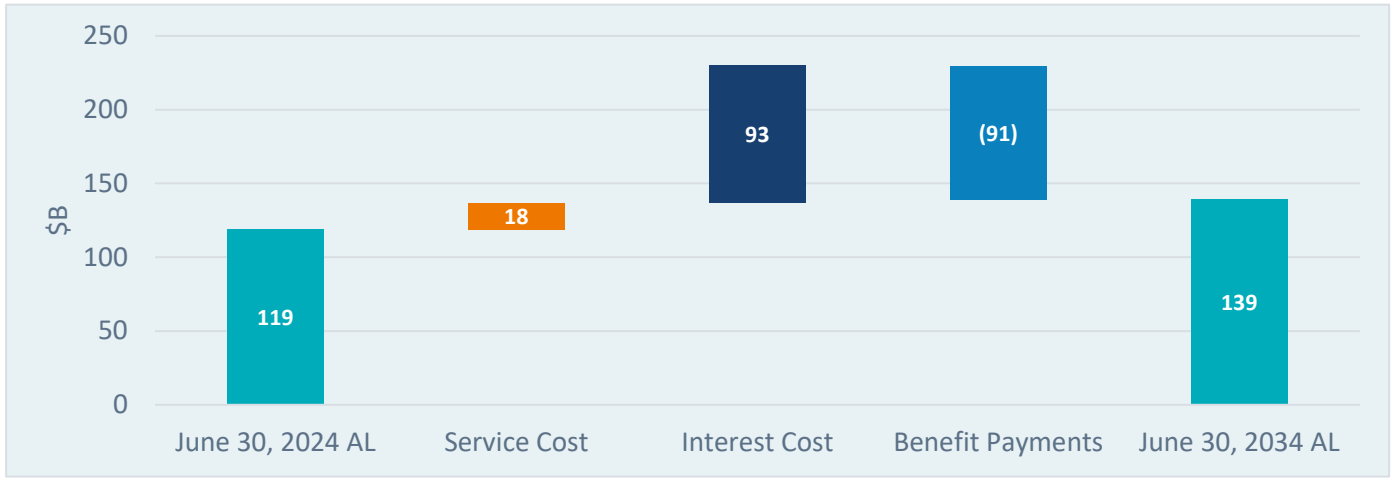
*Assumes returns are as stated on slide. See appendix for additional details.*

# Median stochastic projection

**10-YEAR MEDIAN STOCHASTIC ASSET (MVA) PROJECTION**




**10-YEAR MEDIAN STOCHASTIC ACCRUED LIABILITY PROJECTION**



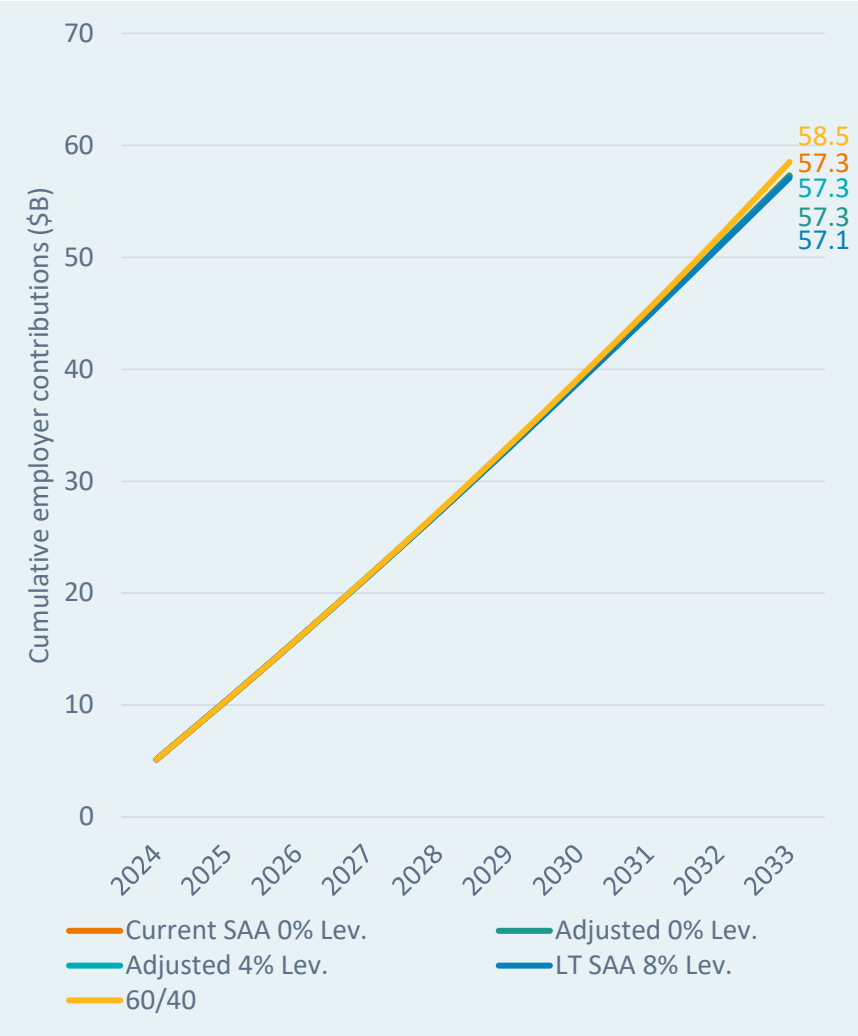

| Metric | Median | 1-in-20 Worst Case |
|---|---|---|
| 2034 MVA Funded Ratio | 93% | 54% |
| 10-Year Total Employer Contributions | $70B | $77B |
| 2033 Contribution | $6.7B | $8.5B |

When reflecting the current allocation, the plan's funded ratio is expected to improve from 63% to 88% in 10 years.

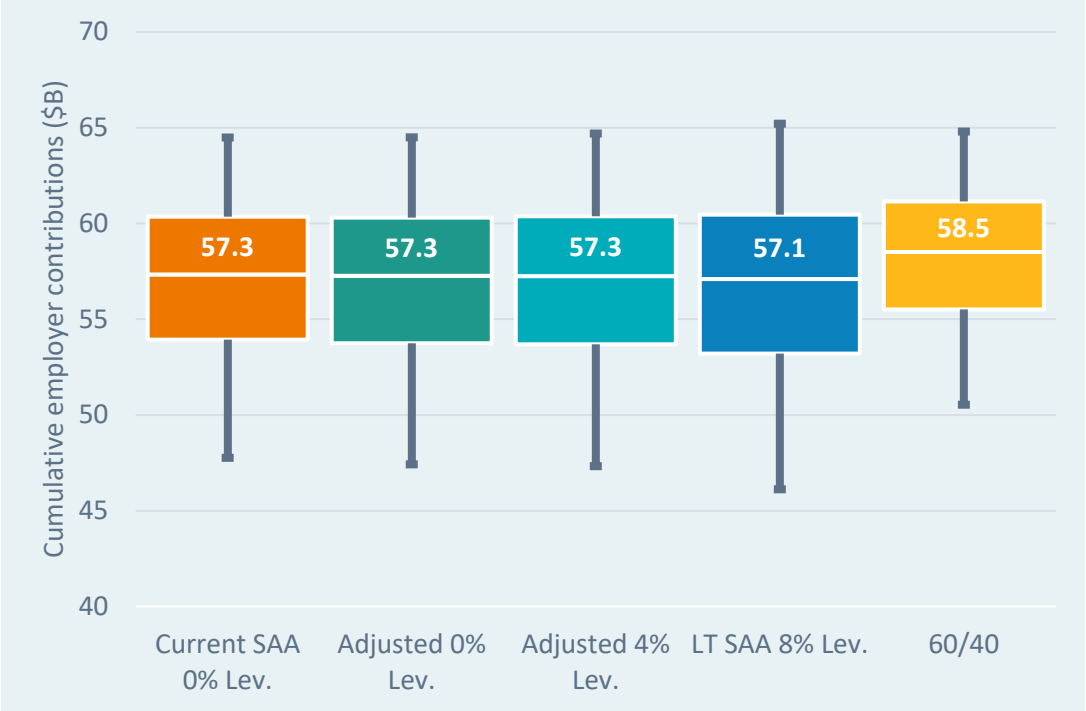
*Reflects the median stochastic projection under the current allocation. See appendix for additional details.*

# Cumulative employer contributions

CUMULATIVE EMPLOYER CONTRIBUTIONS ($B)




FISCAL 2025 – 2034 CUMULATIVE EMPLOYER CONTRIBUTIONS DISTRIBUTION ($B)

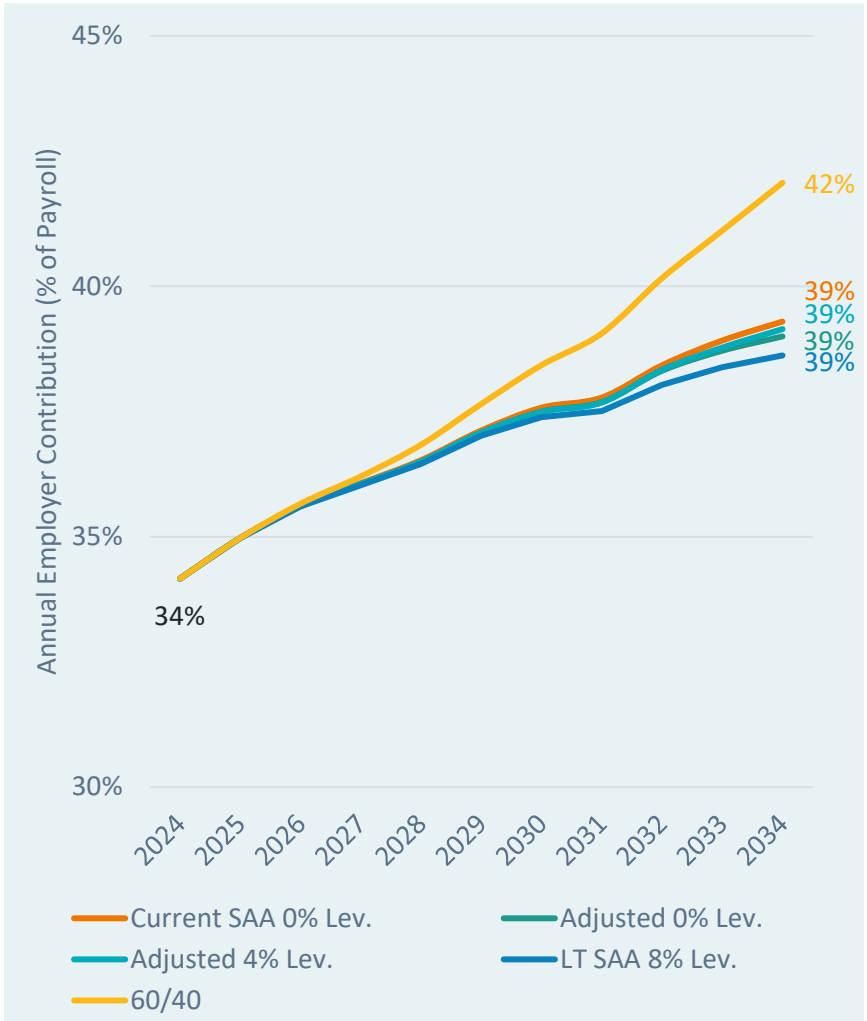



| Fiscal 2025 – 34 ER Contributions ($B) | Current SAA 0% Lev. | Adjusted 0% Lev. | Adjusted 4% Lev. | LT SAA 8% Lev. | 60/40 |
|---|---|---|---|---|---|
| **Percentile** | | | | | |
| **95%** | **64.5** | **64.5** | **64.7** | **65.2** | **64.8** |
| 75% | 60.4 | 60.3 | 60.4 | 60.5 | 61.1 |
| **50%** | **57.3** | **57.3** | **57.3** | **57.1** | **58.5** |
| 25% | 53.9 | 53.7 | 53.7 | 53.2 | 55.5 |
| 5% | 47.8 | 47.4 | 47.3 | 46.1 | 50.5 |

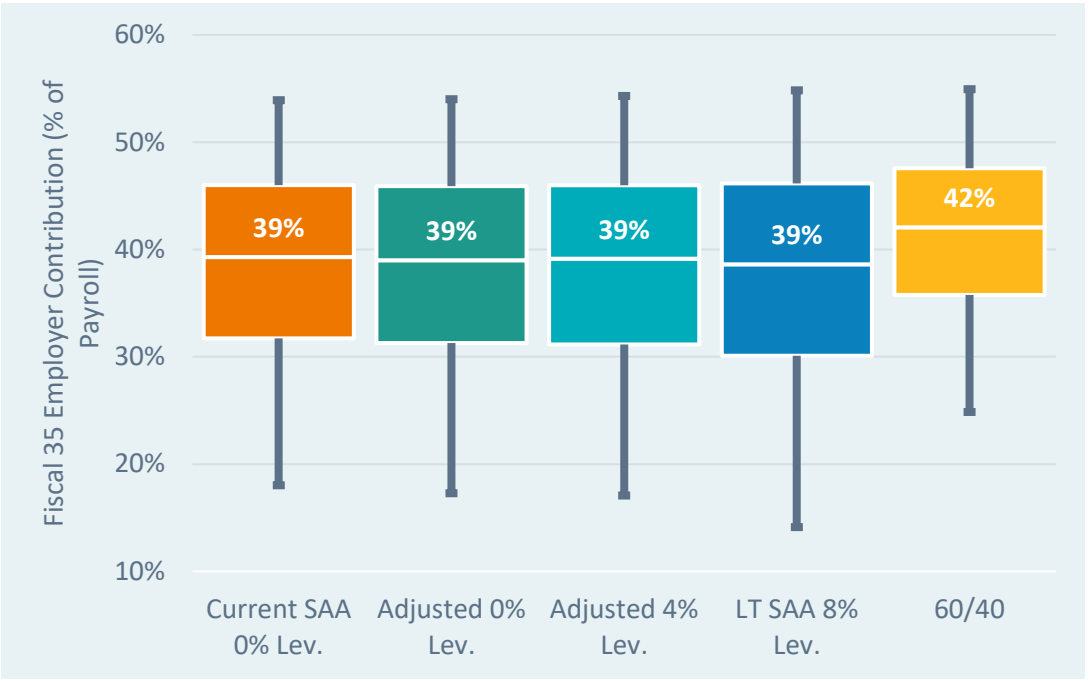
*Source: Reflects 5,000 simulations of assets and liabilities based on Verus' 2024 capital market assumptions. See appendix for additional details.*

# Annual employer contributions (% of payroll)

ANNUAL EMPLOYER CONTRIBUTION (% OF PAYROLL)




FISCAL 2035 EMPLOYER CONTRIBUTION (% OF PAYROLL) DISTRIBUTION

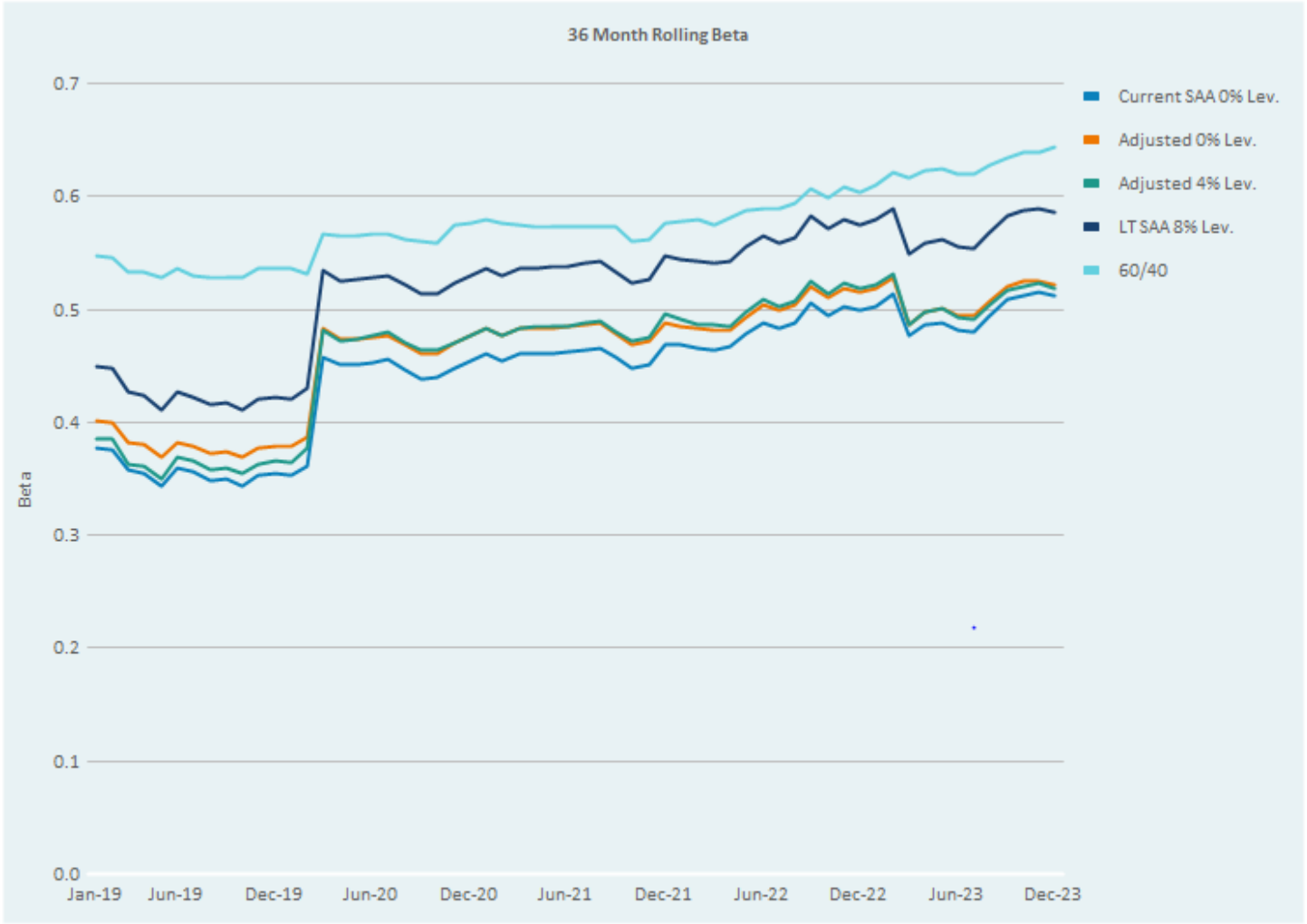


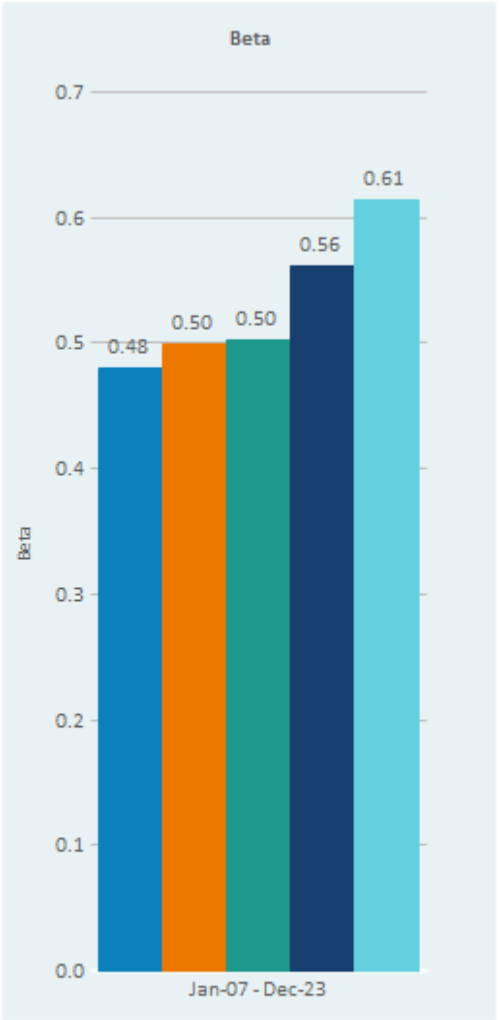

| Fiscal 2035 Employer Cont. (% of payroll) | Current SAA 0% Lev. | Adjusted 0% Lev. | Adjusted 4% Lev. | LT SAA 8% Lev. | 60/40 |
|---|---|---|---|---|---|
| **Percentile** | | | | | |
| **95%** | **54%** | **54%** | **54%** | **55%** | **55%** |
| 75% | 46% | 46% | 46% | 46% | 48% |
| **50%** | **39%** | **39%** | **39%** | **39%** | **42%** |
| 25% | 32% | 31% | 31% | 30% | 36% |
| 5% | 18% | 17% | 17% | 14% | 25% |

*Source: Reflects 5,000 simulations of assets and liabilities based on Verus' 2024 capital market assumptions. Contributions reflects actuarially determined amount, which are based on actuarial value of assets rather than market value. See appendix for additional details.*

# Portfolio risk analysis

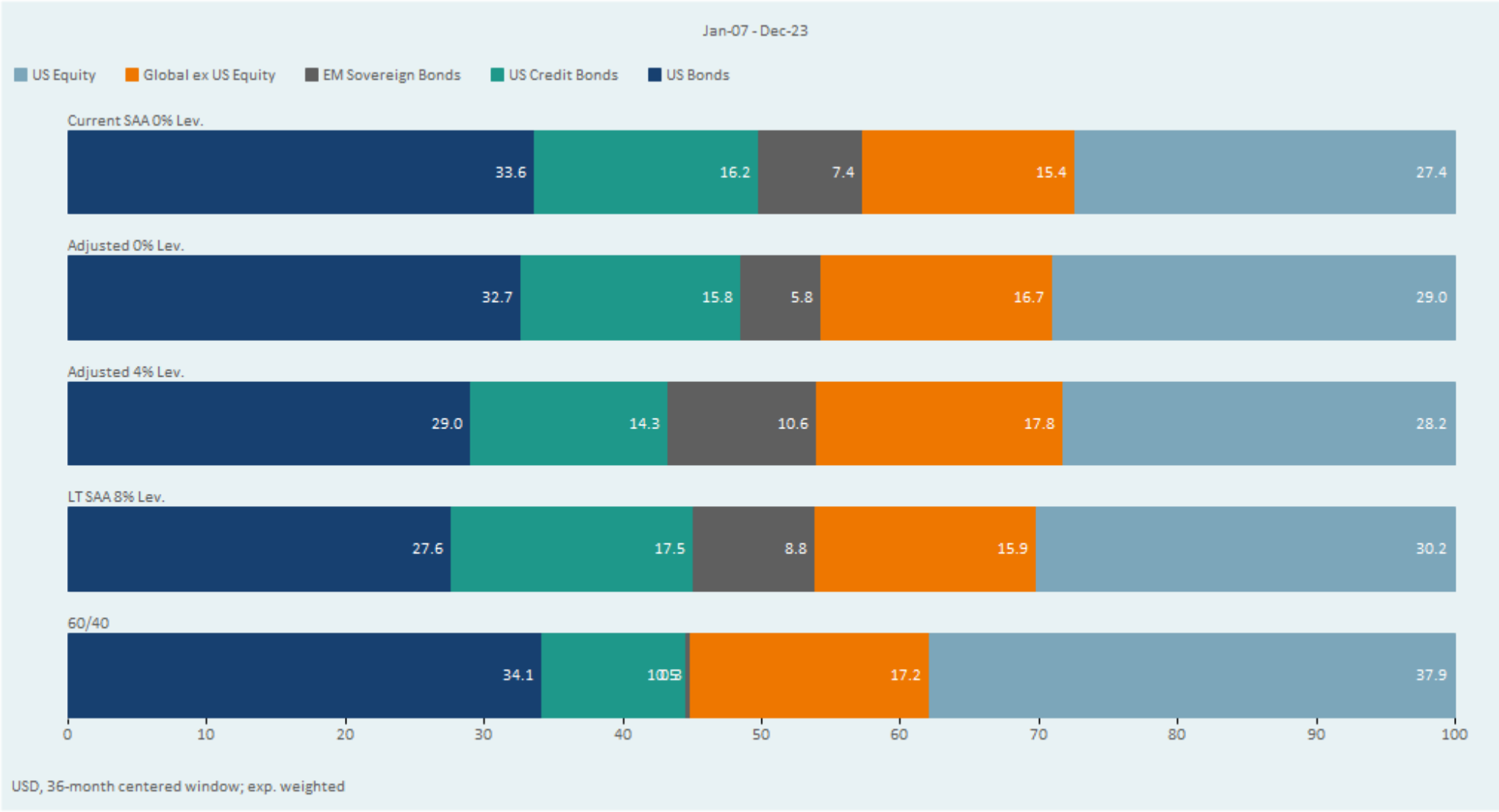
# Beta vs. S&P 500 Index



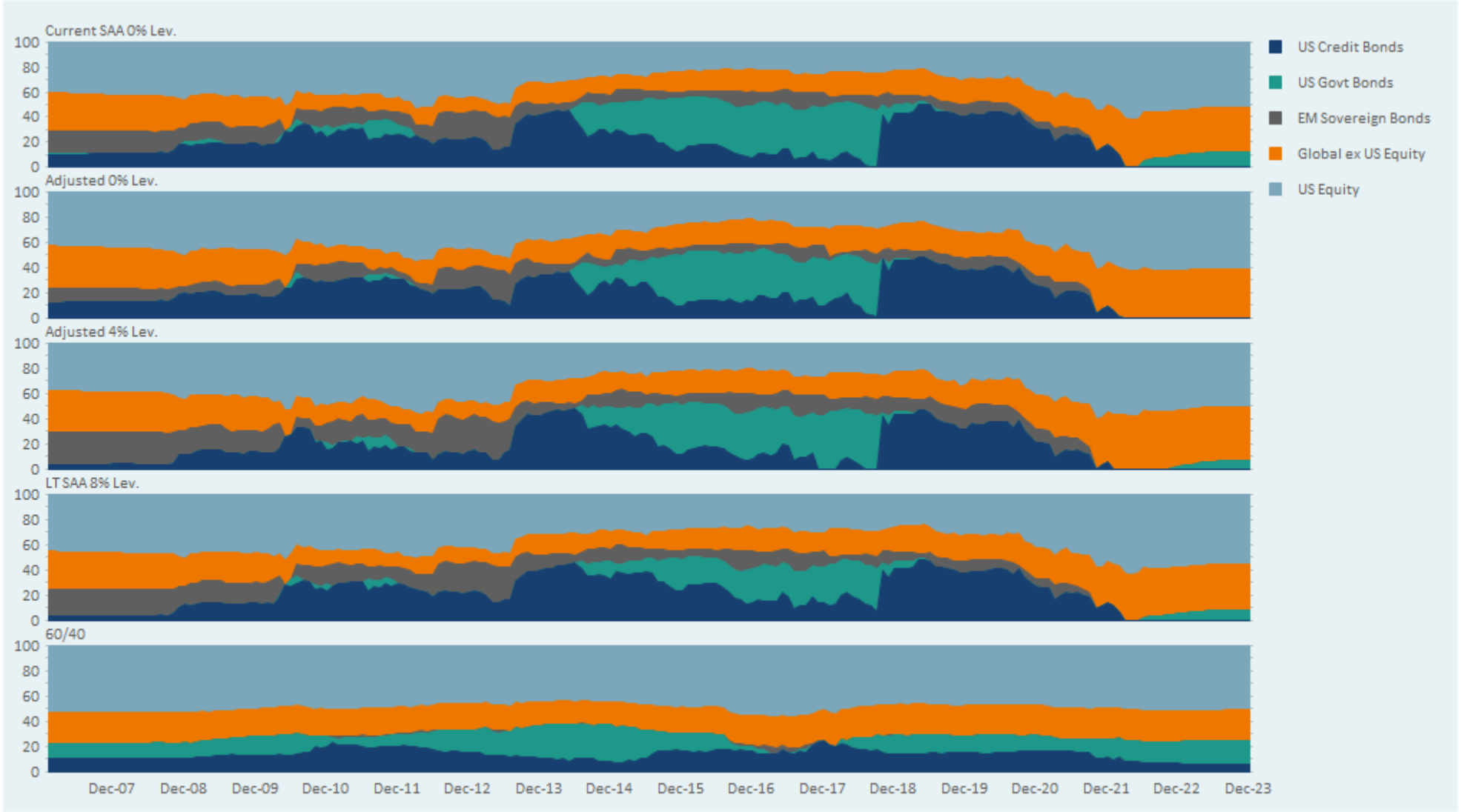

Left chart illustrates the equity Beta (3-year rolling) of the current portfolio mix over time, if the current portfolio asset mix was held for this historical period and rebalanced according to the specified rebalancing frequency. Beta is calculated based on every exposure in the portfolio and how sensitive each exposure has been to equity market movements through history, using a regression of monthly returns.
Right chart illustrates the average equity Beta of the current portfolio mix for the full time period analyzed, given the specified rebalancing frequency.

# Historical asset loadings




This chart is used to demonstrate the likely allocation of the fund's assets to different factors (US Equity, Global ex-US Equity, U.S Bonds, U.S Credit Bonds, and EM Sovereign Bonds). This chart is exponentially-weighted, meaning more emphasis is placed on more recent market behavior and less emphasis is placed on older data.-

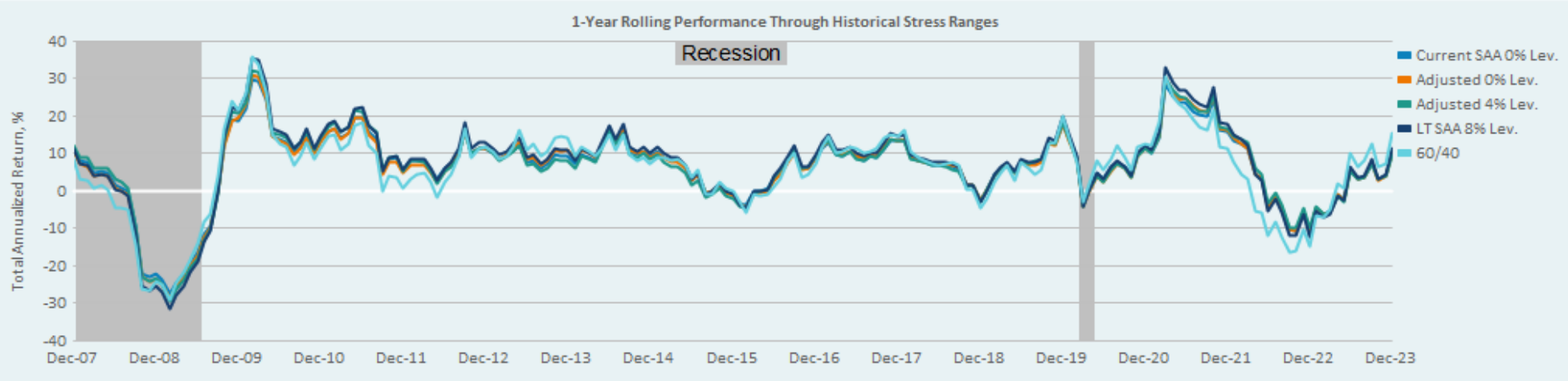
# Historical asset loadings – 3yr rolling

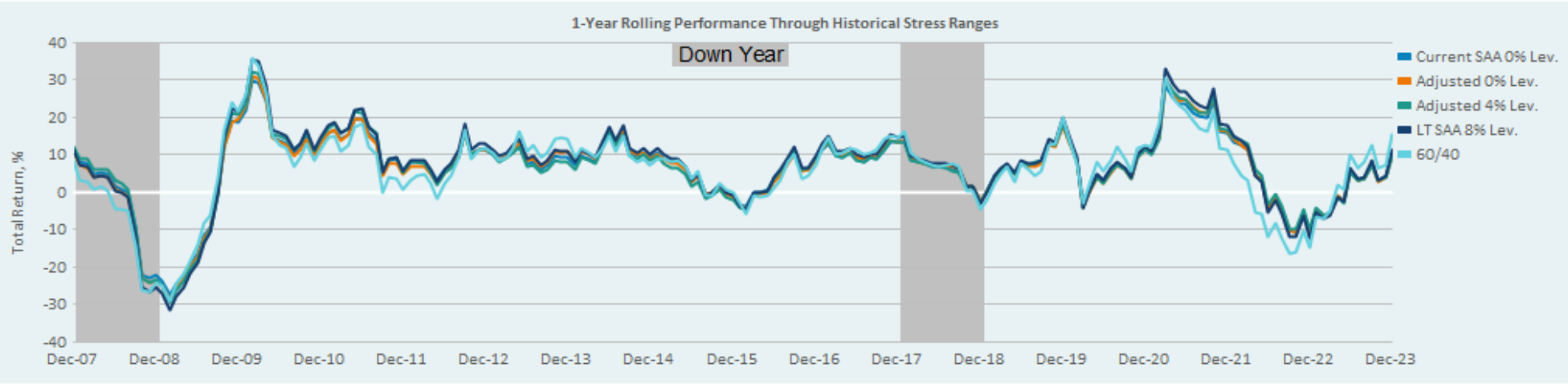



This chart is used to demonstrate the likely allocation of the fund's assets to different factors (US Equity, Global ex-US Equity, U.S Bonds, U.S Credit Bonds, and EM Sovereign Bonds) through time. This beta regression is using a 36 month centered rolling window.

# Returns during recession and S&P 500 down years

| Regime Group | Description |
|---|---|
| Market Up/Down Years | Positive and Negative Calendar Year Returns for the S&P 500 |
| Recession/Expansion | Recession regimes using NBER based Recession Indicators for the United States. |

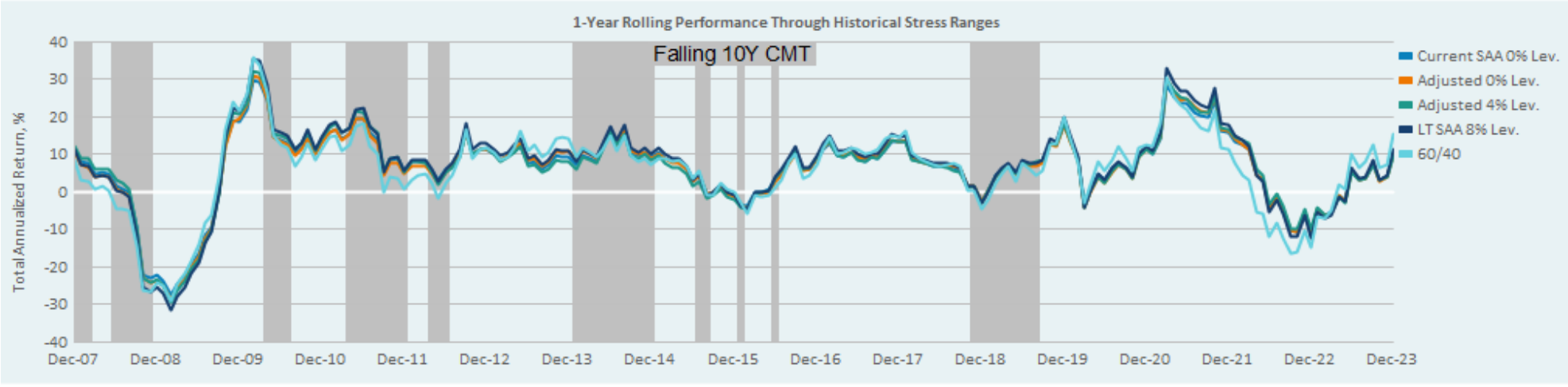


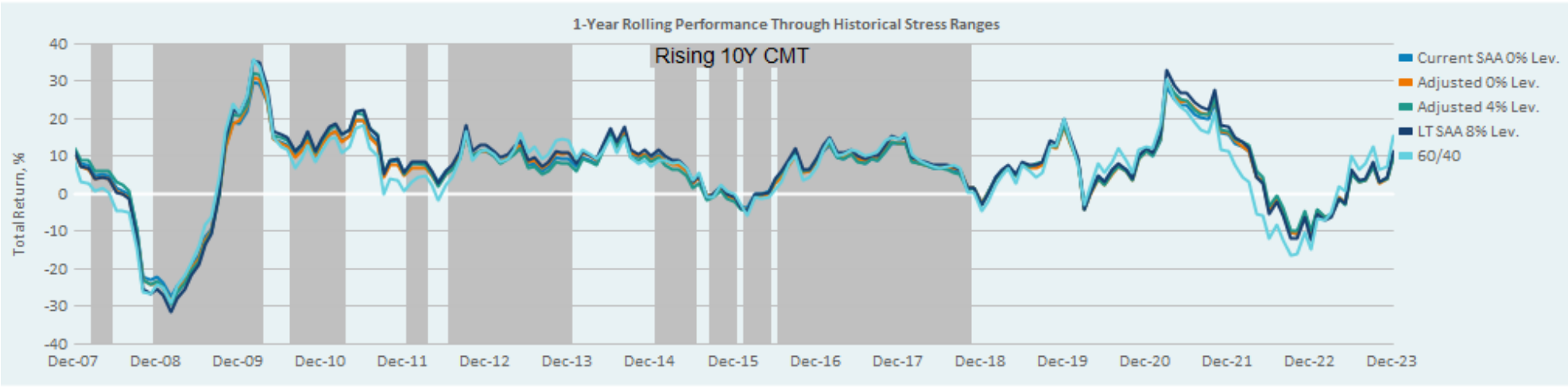




This chart shows 1 year rolling performance of the portfolio, assuming current asset mix weights. Then, times of Recession or market Down Years are highlighted in order to illustrate portfolio performance that occurred during those environments.

# Returns during rising/falling 10y yields

| Regime Group | Description |
|---|---|
| Rising/Fallling 10Y CMT Rate | Rate regimes by 10-Year Constant Maturity Rate increase or decrease by more than 5% of its previous level over rolling 3-month periods. |

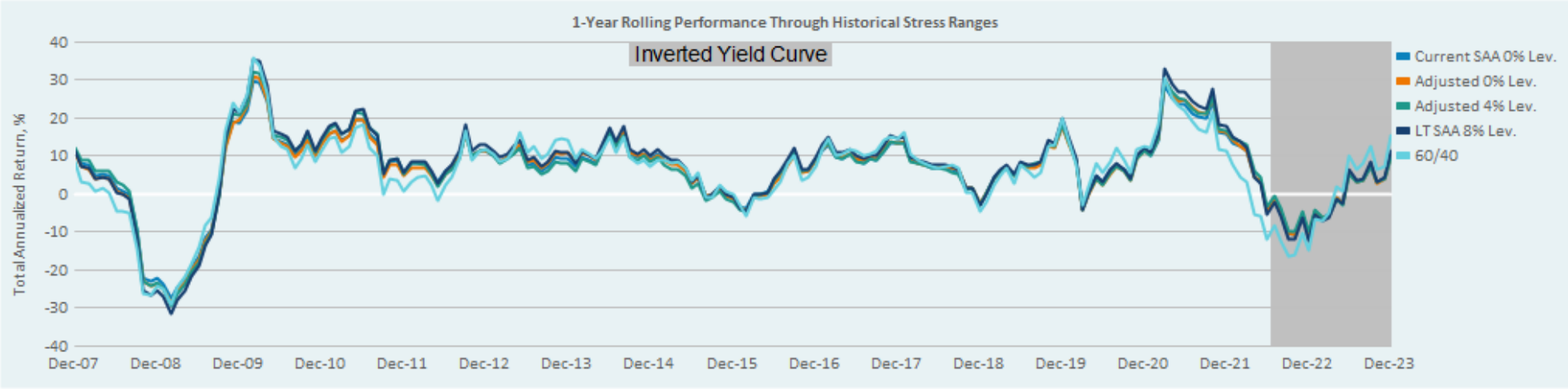


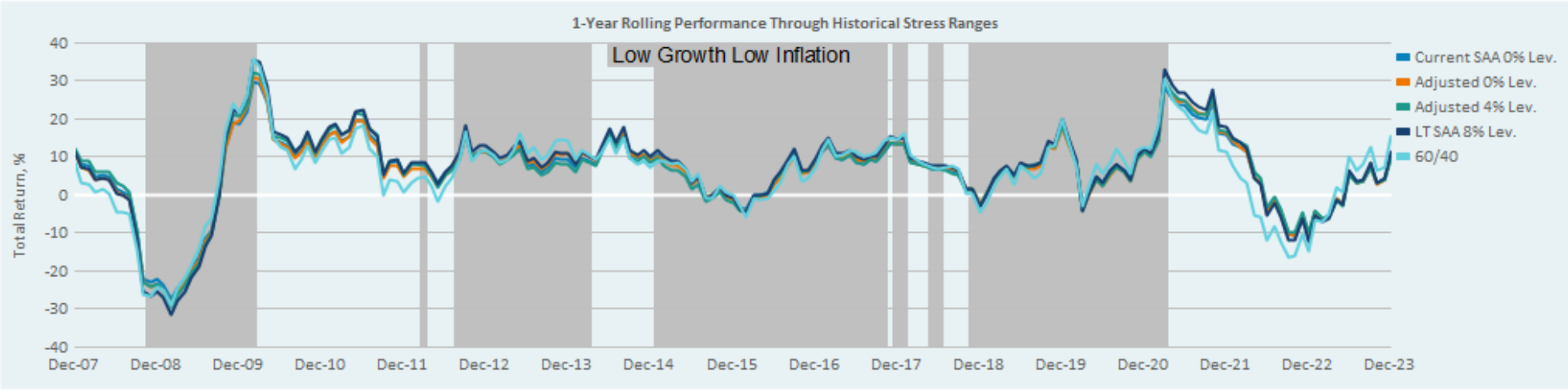




This chart shows 1 year rolling performance of the portfolio, assuming current asset mix weights. Then, times of Falling 10-Year US Treasury Yields or Rising 10-Year US Treasury Yields are highlighted in order to illustrate portfolio performance that occurred during those environments.

# Returns during inversion & low growth/inflation

| Regime | Rule |
|---|---|
| Normal/Flat/Inverted Yield Curve | Yield curve regimes by 10-Year minus 2-Year Treasury Constant Maturity Rate Spread with breaks at 0% and 0.8%. |
| Low Growth Low Inflation | Industrial Production Index and Consumer Price Index for all Urban Consumers: All Items are both equal to or below 50th percentile YoY |

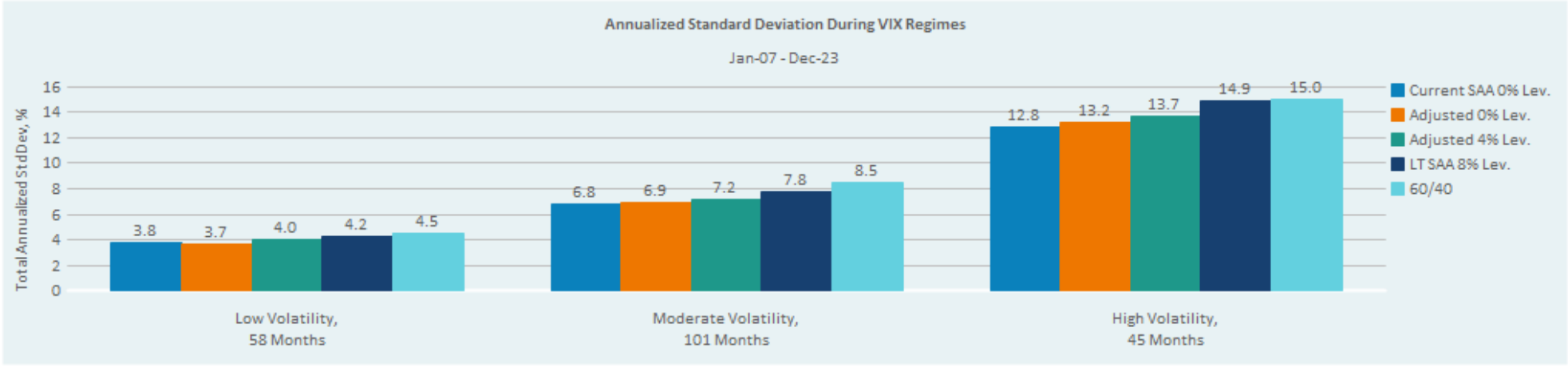


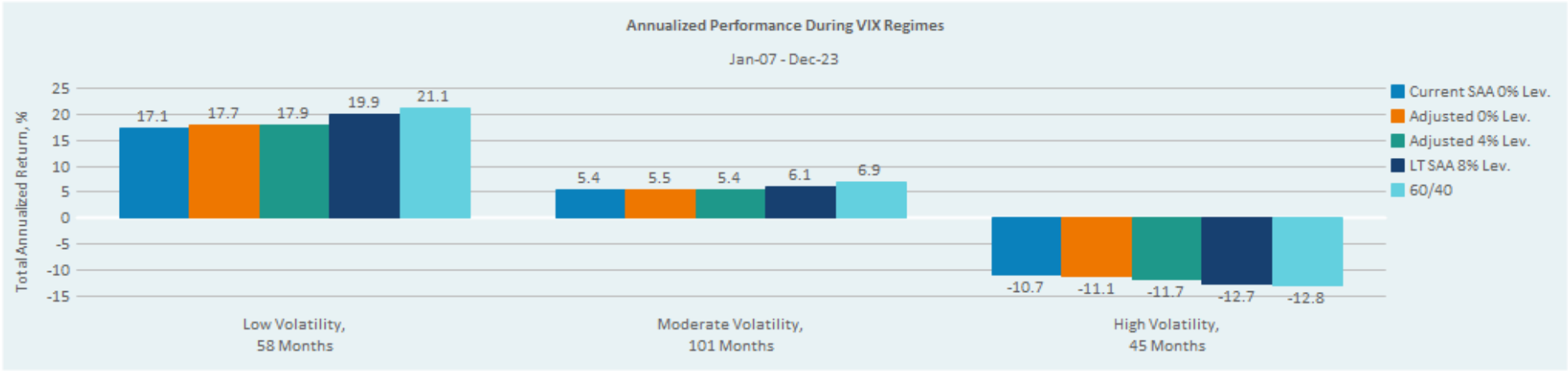




This chart shows 1 year rolling performance of the portfolio, assuming current asset mix weights. Then, times of an Inverted Yield Curve or Low Growth / Low Inflation are highlighted in order to illustrate portfolio performance that occurred during those environments.

# Risk and return during VIX regimes

| Regime Group | Description |
|---|---|
| Volatility by Threshold | Volatility regimes by CBOE VIX with breaks at 15 and 25. |

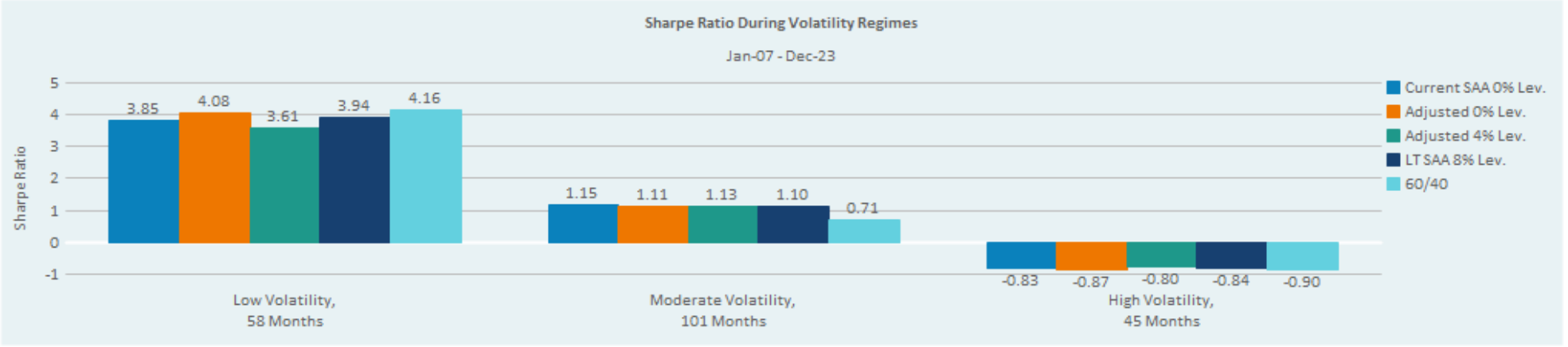


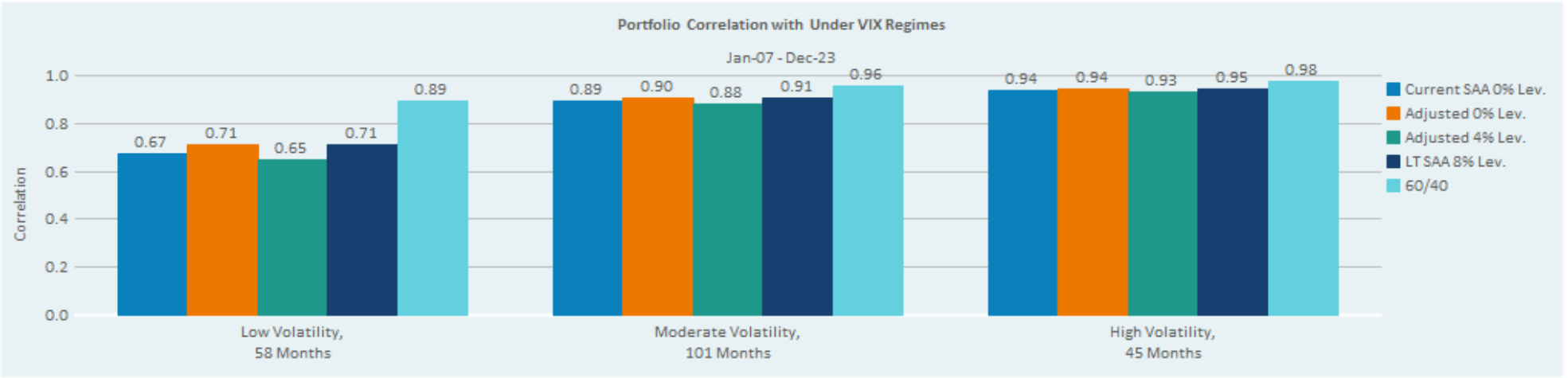




The top chart illustrates portfolio volatility during different market volatility environments. Markets often go through extended periods of muted or elevated volatility. Each month in history is bucketed into either Low, Moderate, or High Volatility, and the average characteristics of all of those months are shown.
The bottom chart illustrates the performance of each portfolio during each of these market volatility environments. Lower volatility environments tend to coincide with strong risk asset performance.

# Sharpe and equity correlation during VIX regimes

| Regime Group | Description |
|---|---|
| Volatility by Threshold | Volatility regimes by CBOE VIX with breaks at 15 and 25. |




The top chart illustrates portfolio Sharpe Ratio during different market volatility environments. Each month in history is bucketed into either Low, Moderate, or High Volatility, and the average characteristics of all of those months are shown.

The bottom chart illustrates the correlation of each portfolio with the US Equity market during each of these market volatility environments. Correlations tend to be higher during stressed, high volatility environments.

# Actuarial documentation

# Asset-liability process overview

Key Inputs:

**Liabilities / Actuarial**
- *Census data*
- *Demographic and economic assumptions*
- *Funding policy and other actuarial methods*

**Assets**
- *Starting financial position*
- *Alternative portfolios*
- *Capital market assumptions*

Analytical Modeling Tools:

**MPI**
*Risk and Return Analysis*

**Asset-Liability Model**
*Integrated Projections*

**Decision factors:**

- Return expectations
- Stress tests
- Scenario analysis
- Funded status
- Contribution requirements
- Total full funding cost

# Assumptions and methods

Unless otherwise stated, all assumptions and methods are consistent with PSERS' 2023 actuarial valuation report.

| | |
|---|---|
| **Assets** | **Cashflows:** Contributions are assumed to be made at the end of the fiscal year. Benefit payments and administrative expenses are assumed to occur at mid-year.<br><br>**Stochastic assumptions:** Modeled using Verus 2024 CMAs. See appendix for details. Returns in stochastic scenarios are modeled randomly starting June 30, 2024.<br><br>**Allocation:** Allocations are assumed to remain constant during projection. |
| **Liabilities** | **Actuarial projection provider:** Liability projections were provided by Buck on June 15, 2024.<br><br>**Actuarial Cost Method:** Entry Age Normal<br><br>**Census Date:** June 30, 2023<br><br>**Discount Rate:** 7.0%<br><br>**New entrants:** workforce assumed to remain constant during projection. 98% assumed to elect T-G membership, and 1% each T-H and 1% DC. New entrants assumed to have similar demographic characteristics to those who entered between 7/1/2020 and 6/30/2023. |
| **Funding Methodology (ADC)** | Future valuation gains and losses are amortized over a 24-year period, as a level percent of pay. If the plan unfunded accrued liability turns negative, all amortization bases are reset to 0 and the employer continues to contribute their share of the normal cost. |
| **Shared-Risk Contributions** | Actual shared risk contribution provisions reflected. |
| **Actuarial Value of Assets** | Ten-year smoothing, subject to 30% corridor |

# Capital market assumptions

# Methodology

**CORE INPUTS**

— We use a fundamental building block approach based on several inputs, including historical data and academic research to create asset class return forecasts.
— For most asset classes, we use the long-term historical volatility after adjusting for autocorrelation.
— Correlations between asset classes are calculated based on the last 10 years. For illiquid assets, such as private equity and private real estate, we use BarraOne correlation estimates.

| Asset | Return Methodology | Volatility Methodology* |
|---|---|---|
| **Inflation** | 25% weight to the University of Michigan Survey 5-10 year ahead inflation expectation and the Survey of Professional Forecasters (Fed Survey), and the remaining 50% to the market's expectation for inflation as observed through the 10-year TIPS breakeven rate | - |
| **Cash** | 1/3 * current federal funds rate + 1/3 * U.S. 10-year Treasury yield + 1/3 * Federal Reserve long-term interest rate target | Long-term volatility |
| **Bonds** | Nominal bonds: current yield; Real bonds: real yield + inflation forecast | Long-term volatility |
| **International Bonds** | Current yield | Long-term volatility |
| **Credit** | Current option-adjusted spread + U.S. 10-year Treasury – effective default rate | Long-term volatility |
| **International Credit** | Current option-adjusted spread + foreign 10-year Treasury – effective default rate | Long-term volatility |
| **Private Credit** | Levered gross return (SOFR + spread + original issuance discounts) – management fees – carried interest | Estimated volatility |
| **Equity** | Current yield + real earnings growth (historical average) + inflation on earnings (inflation forecast) + expected P/E change | Long-term volatility |
| **Intl Developed Equity** | Current yield + real earnings growth (historical average) + inflation on earnings (intl. inflation forecast) + expected P/E change | Long-term volatility |
| **Private Equity**** | US large cap domestic equity forecast * 1.85 beta adjustment | 1.2 * Long-term volatility of U.S. small cap |
| **Commodities** | Collateral return (cash) + spot return (inflation forecast) + roll return (assumed to be zero) | Long-term volatility |
| **Hedge Funds** | Return coming from traditional betas + 15-year historical idiosyncratic return | Long-term volatility |
| **Core Real Estate** | Cap rate + real income growth – capex + inflation forecast | 65% of REIT volatility |
| **REITs** | Core real estate | Long-term volatility |
| **Value-Add Real Estate** | Core real estate + 2% | Volatility to produce Sharpe Ratio (g) equal to core real estate |
| **Opportunistic Real Estate** | Core real estate + 3% | Volatility to produce Sharpe Ratio (g) equal to core real estate |
| **Infrastructure** | Current yield + real income growth + inflation on earnings (inflation forecast) | Long-term volatility |
| **Risk Parity** | Modeled as the 10-year return expectations of a *representative selection of Risk Parity strategies* | Target volatility |

**Long-term historical volatility data is adjusted for autocorrelation (see Appendix)*

***Private Equity is modeled assuming an 8.0% floor for expected return, and a 3% return premium ceiling over U.S. Large Cap Equity. These adjustments are in place to recognize that higher interest rates (cost of leverage) act as a drag on expected Private Equity returns but that this drag has had limits historically, and to recognize that future Private Equity total universe performance is likely to be more anchored to public equity performance than in past times, given a more competitive market environment*

# 10-year return & risk assumptions

| Asset Class | Index Proxy | Ten Year Return Forecast | | Standard Deviation Forecast | Sharpe Ratio Forecast (g) | Sharpe Ratio Forecast (a) | 10-Year Historical Sharpe Ratio (g) | 10-Year Historical Sharpe Ratio (a) |
|---|---|---|---|---|---|---|---|---|
| | | Geometric | Arithmetic | | | | | |
| **Equities** | | | | | | | | |
| U.S. Large | S&P 500 | 5.9% | 7.0% | 15.5% | 0.12 | 0.19 | 0.72 | 0.75 |
| U.S. Small | Russell 2000 | 6.2% | 8.2% | 21.4% | 0.10 | 0.19 | 0.28 | 0.37 |
| International Developed | MSCI EAFE | 8.1% | 9.5% | 17.6% | 0.23 | 0.31 | 0.18 | 0.25 |
| International Small | MSCI EAFE Small Cap | 8.8% | 10.9% | 21.7% | 0.22 | 0.31 | 0.20 | 0.27 |
| Emerging Markets | MSCI EM | 8.8% | 11.4% | 24.6% | 0.19 | 0.30 | 0.06 | 0.14 |
| Global Equity | MSCI ACWI | 6.9% | 8.2% | 16.7% | 0.17 | 0.25 | 0.44 | 0.50 |
| Global Equity ex USA | MSCI ACWI ex USA | 8.5% | 10.2% | 19.5% | 0.23 | 0.31 | 0.15 | 0.22 |
| Private Equity | CA Private Equity | 8.0% | 10.9% | 25.6% | 0.15 | 0.27 | - | - |
| Private Equity Direct | CA Private Equity | 9.0% | 11.8% | 25.6% | 0.19 | 0.30 | - | - |
| Private Equity (FoF) | CA Private Equity | 7.0% | 9.9% | 25.6% | 0.11 | 0.23 | - | - |
| **Fixed Income** | | | | | | | | |
| Cash | 30 Day T-Bills | 4.1% | 4.1% | 1.1% | - | - | - | - |
| U.S. TIPS | Bloomberg U.S. TIPS 5-10 | 4.7% | 4.8% | 5.5% | 0.11 | 0.13 | 0.13 | 0.15 |
| Non-U.S. Inflation Linked Bonds | Bbg World Govt. Inflation Linked Bond ex U.S. | 3.9% | 4.2% | 7.4% | (0.03) | 0.01 | (0.15) | (0.11) |
| U.S. Treasury | Bloomberg Treasury 7-10 Year | 4.6% | 4.8% | 7.1% | 0.07 | 0.10 | (0.05) | (0.02) |
| Long U.S. Treasury | Bloomberg Treasury 20+ Year | 4.7% | 5.5% | 13.2% | 0.05 | 0.11 | 0.00 | 0.25 |
| Global Sovereign ex U.S. | Bloomberg Global Treasury ex U.S. | 2.7% | 3.2% | 9.9% | (0.14) | (0.09) | (0.40) | (0.36) |
| Global Aggregate | Bloomberg Global Aggregate | 4.1% | 4.3% | 6.6% | 0.00 | 0.03 | (0.27) | (0.24) |
| Core Fixed Income | Bloomberg U.S. Aggregate Bond | 4.9% | 5.0% | 4.8% | 0.17 | 0.19 | 0.00 | 0.02 |
| Core Plus Fixed Income | Bloomberg U.S. Universal | 5.2% | 5.3% | 4.5% | 0.24 | 0.27 | 0.07 | 0.09 |
| Investment Grade Corp. Credit | Bloomberg U.S. Corporate Investment Grade | 5.7% | 6.0% | 8.4% | 0.19 | 0.23 | 0.17 | 0.20 |
| Short-Term Gov't/Credit | Bloomberg U.S. Gov't/Credit 1-3 Year | 4.7% | 4.8% | 3.6% | 0.17 | 0.19 | (0.07) | (0.07) |
| Short-Term Credit | Bloomberg Credit 1-3 Year | 5.1% | 5.2% | 3.6% | 0.28 | 0.31 | 0.23 | 0.24 |
| Long-Term Credit | Bloomberg Long U.S. Credit | 5.7% | 6.3% | 10.9% | 0.15 | 0.20 | 0.15 | 0.20 |
| High Yield Corp. Credit | Bloomberg U.S. Corporate High Yield | 6.6% | 7.2% | 11.0% | 0.23 | 0.28 | 0.42 | 0.44 |
| Bank Loans | Morningstar LSTA Leveraged Loan | 8.0% | 8.4% | 9.0% | 0.43 | 0.48 | 0.58 | 0.59 |
| Global Credit | Bloomberg Global Credit | 5.1% | 5.4% | 7.7% | 0.13 | 0.17 | 0.01 | 0.04 |
| Emerging Markets Debt (Hard) | JPM EMBI Global Diversified | 8.7% | 9.2% | 10.6% | 0.43 | 0.48 | 0.15 | 0.20 |
| Emerging Markets Debt (Local) | JPM GBI-EM Global Diversified | 6.5% | 7.2% | 12.2% | 0.20 | 0.25 | (0.17) | (0.12) |
| Private Credit | Morningstar LSTA Leveraged Loan | 9.2% | 9.8% | 11.9% | 0.43 | 0.48 | - | - |
| Private Credit (Direct Lending - Unlevered) | Morningstar LSTA Leveraged Loan | 8.0% | 8.4% | 9.0% | 0.43 | 0.48 | - | - |
| Private Credit (Direct Lending - Levered) | Morningstar LSTA Leveraged Loan | 9.5% | 10.2% | 12.6% | 0.43 | 0.48 | - | - |
| Private Credit (Credit Opportunities) | Morningstar LSTA Leveraged Loan | 9.6% | 10.3% | 12.8% | 0.43 | 0.48 | - | - |
| Private Credit (Junior Capital / Mezzanine) | Morningstar LSTA Leveraged Loan | 9.0% | 9.6% | 11.4% | 0.43 | 0.48 | - | - |
| Private Credit (Distressed) | Morningstar LSTA Leveraged Loan | 9.1% | 12.7% | 29.1% | 0.17 | 0.30 | - | - |

*Investors wishing to produce expected geometric return forecasts for their portfolios should use the arithmetic return forecasts provided here as inputs into that calculation, rather than the single-asset-class geometric return forecasts. This is the industry standard approach, but requires a complex explanation only a heavy quant could love, so we have chosen not to provide further details in this document – we will happily provide those details to any readers of this who are interested.*

# 10-year return & risk assumptions

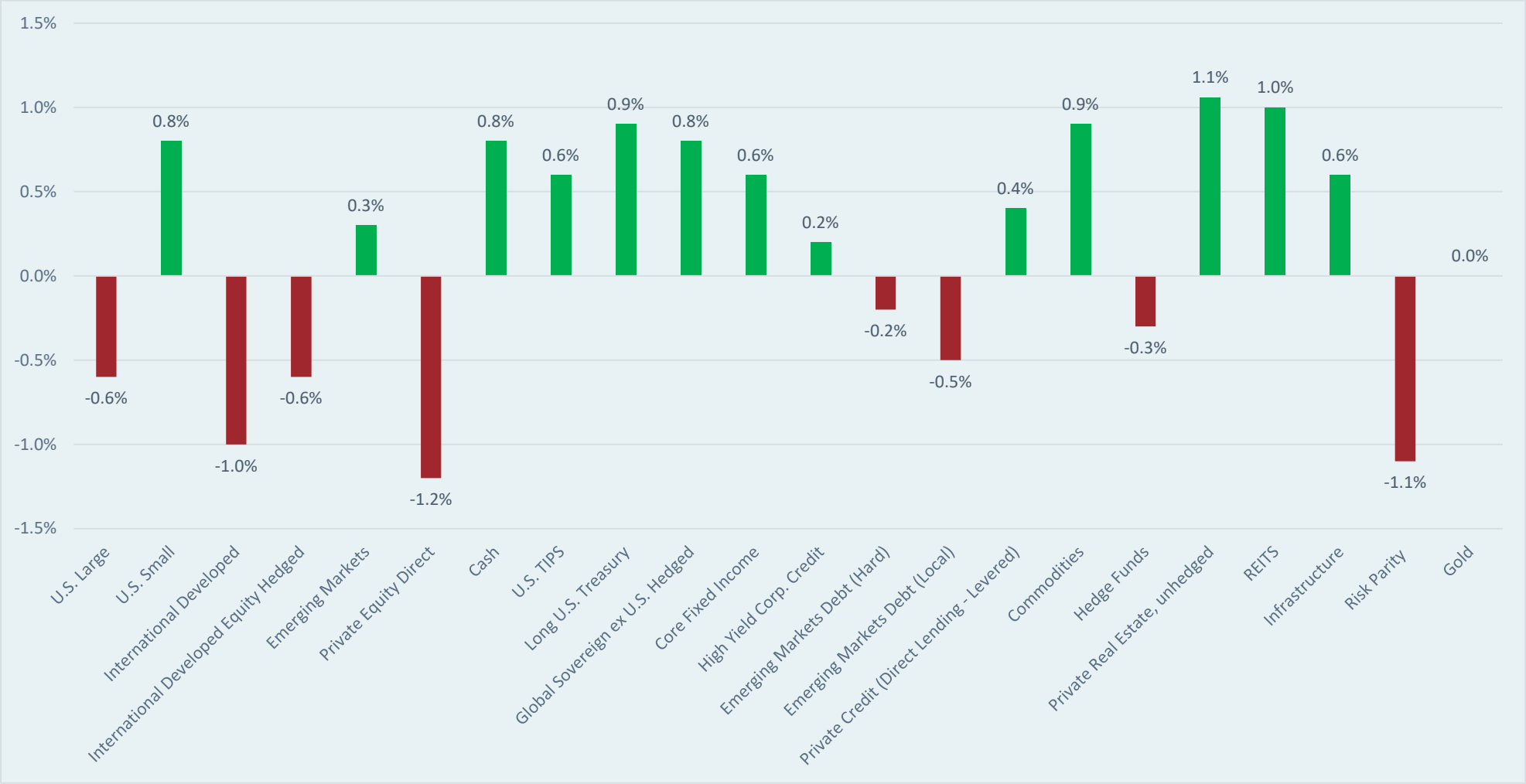
| Asset Class | Index Proxy | Ten Year Return Forecast | | Standard Deviation Forecast | Sharpe Ratio Forecast (g) | Sharpe Ratio Forecast (a) | 10-Year Historical Sharpe Ratio (g) | 10-Year Historical Sharpe Ratio (a) |
|---|---|---|---|---|---|---|---|---|
| | | Geometric | Arithmetic | | | | | |
| **Other** | | | | | | | | |
| Commodities | Bloomberg Commodity | 6.6% | 7.8% | 16.1% | 0.16 | 0.23 | (0.13) | (0.06) |
| Hedge Funds | HFRI Fund Weighted Composite | 4.3% | 4.6% | 7.5% | 0.03 | 0.07 | 0.48 | 0.49 |
| Hedge Fund of Funds | HFRI Fund of Funds Composite | 3.3% | 3.6% | 7.5% | (0.11) | (0.07) | - | - |
| Hedge Funds (Equity Style) | Custom HFRI Benchmark Mix* | 7.2% | 8.1% | 14.1% | 0.22 | 0.28 | - | - |
| Hedge Funds (Credit Style) | Custom HFRI Benchmark Mix* | 7.3% | 7.7% | 9.4% | 0.34 | 0.38 | - | - |
| Hedge Funds (Asymmetric Style) | Custom HFRI Benchmark Mix* | 5.4% | 5.6% | 6.4% | 0.20 | 0.23 | - | - |
| Real Estate Debt | Bloomberg CMBS IG | 7.4% | 7.7% | 7.5% | 0.44 | 0.48 | 0.14 | 0.15 |
| Core Real Estate | NCREIF Property | 6.8% | 7.5% | 12.5% | 0.22 | 0.27 | - | - |
| Value-Add Real Estate | NCREIF Property + 200bps | 8.8% | 9.9% | 15.4% | 0.31 | 0.38 | - | - |
| Opportunistic Real Estate | NCREIF Property + 300bps | 9.8% | 11.7% | 21.1% | 0.27 | 0.36 | - | - |
| REITs | Wilshire REIT | 6.8% | 8.5% | 19.2% | 0.14 | 0.23 | 0.35 | 0.42 |
| Global Infrastructure | S&P Global Infrastructure | 8.4% | 9.7% | 16.9% | 0.25 | 0.33 | 0.20 | 0.28 |
| Risk Parity** | S&P Risk Parity 10% Vol Index | 7.2% | 7.8% | 10.0% | 0.31 | 0.37 | - | - |
| Currency Beta | MSCI Currency Factor Index | 2.3% | 2.4% | 3.4% | (0.52) | (0.49) | (0.06) | 0.21 |
| Inflation | | 2.5% | - | - | - | - | - | - |
| Gold | | 2.5% | 3.6% | 15.5% | (0.10) | (0.03) | - | - |

*Investors wishing to produce expected geometric return forecasts for their portfolios should use the arithmetic return forecasts provided here as inputs into that calculation, rather than the single-asset-class geometric return forecasts. This is the industry standard approach, but requires a complex explanation only a heavy quant could love, so we have chosen not to provide further details in this document – we will happily provide those details to any readers of this who are interested.*

**To represent hedge fund styles, we use a combination of HFRI benchmarks: Equity Style = 33% HFRI Fundamental Growth, 33% HFRI Fundamental Value, 33% HFRI Activist. Credit Style = 20% HFRI Distressed/Restructuring, 20% HFRI Credit Arbitrage, 20% HFRI Fixed Income-Corporate, 20% HFRI Fixed Income-Convertible Arbitrage, 20% HFRI Fixed Income-Asset Backed. Asymmetric Style = 50% HFRI Relative Value, 50% HFRI Macro*

***The Risk Parity forecast shown here assumes a 10% target volatility strategy. We recommend customizing this forecast to the target volatility specifications of the risk parity strategy that an investor wishes to model. Please speak with your Verus consultant for customization needs.*

# 2024 vs. 2023 return forecast – 10 year




*Based on Verus' 2024 and 2023 Capital Market Assumptions*

# 30-year return & risk assumptions

— Occasionally investors may have a specific need for longer-term capital market forecasts. We have developed a set of 30-year assumptions to meet those needs.
— The return forecasts below have been constructed using our existing building block approach, but with longer-term inputs. Risks and correlations are estimated using the same approach as our 10-year forecasts, using full-history autocorrelation-adjusted realized risk and past 10 year realized correlations.
— These return figures must be thought of separately from our 10-year forecasts and are not meant to imply performance for the 20 years *beyond* our 10-year forecasts.
— Please reach out to your Verus consultant with questions regarding whether 30-year Capital Market Assumptions might be appropriate for your needs.

| Asset Class | Index Proxy | Thirty Year Return Forecast | | Standard Deviation Forecast | Sharpe Ratio Forecast (g) | Sharpe Ratio Forecast (a) |
|---|---|---|---|---|---|---|
| | | Geometric | Arithmetic | | | |
| **Equities** | | | | | | |
| U.S. Large | S&P 500 | 6.3% | 7.4% | 15.5% | 0.14 | 0.21 |
| U.S. Small | Russell 2000 | 6.4% | 8.4% | 21.4% | 0.11 | 0.20 |
| International Developed | MSCI EAFE | 7.6% | 9.0% | 17.6% | 0.20 | 0.28 |
| International Small | MSCI EAFE Small Cap | 7.8% | 9.9% | 21.7% | 0.18 | 0.27 |
| Emerging Markets | MSCI EM | 8.3% | 10.9% | 24.6% | 0.17 | 0.28 |
| Global Equity | MSCI ACWI | 7.0% | 8.3% | 16.7% | 0.17 | 0.25 |
| Global Equity ex-US | MSCI ACWI ex-US | 8.0% | 9.7% | 19.5% | 0.20 | 0.29 |
| Private Equity | Cambridge U.S. Private Equity | 8.1% | 10.9% | 25.6% | 0.16 | 0.27 |
| Private Equity (Direct) | Cambridge U.S. Private Equity | 9.1% | 11.9% | 25.6% | 0.20 | 0.30 |
| Private Equity (Fund of Funds) | Cambridge U.S. Private Equity | 7.1% | 10.0% | 25.6% | 0.12 | 0.23 |
| **Fixed Income** | | | | | | |
| Cash | 30 Day T-Bills | 4.1% | 4.1% | 1.1% | - | - |
| U.S. TIPS | Bloomberg U.S. TIPS 5 - 10 | 4.7% | 4.8% | 5.5% | 0.11 | 0.13 |
| Non-U.S. Inflation Linked Bonds | Bbg World Govt. Inflation Linked Bond ex U.S. | 3.9% | 4.2% | 7.4% | (0.03) | 0.01 |
| U.S. Treasury | Bloomberg Treasury 7-10 Year | 4.7% | 4.9% | 7.1% | 0.08 | 0.11 |
| Long U.S. Treasury | Bloomberg U.S. Treasury 20+ Year | 4.7% | 5.5% | 13.2% | 0.05 | 0.11 |
| Global Sovereign ex U.S. | Bloomberg Global Treasury ex U.S. | 3.2% | 3.7% | 9.9% | (0.09) | (0.04) |
| Global Aggregate | Bloomberg Global Aggregate | 3.7% | 3.9% | 6.6% | (0.06) | (0.03) |
| Core Fixed Income | Bloomberg U.S. Aggregate Bond | 5.5% | 5.6% | 4.8% | 0.29 | 0.31 |
| Core Plus Fixed Income | Bloomberg U.S. Universal | 5.9% | 6.0% | 4.5% | 0.40 | 0.42 |
| Investment Grade Corp. Credit | Bloomberg U.S. Corporate Investment Grade | 5.9% | 6.2% | 8.4% | 0.21 | 0.25 |
| Short-Term Gov't/Credit | Bloomberg U.S. Gov't/Credit 1 - 3 year | 4.9% | 5.0% | 3.6% | 0.22 | 0.25 |
| Short-Term Credit | Bloomberg Credit 1-3 Year | 5.5% | 5.6% | 3.6% | 0.39 | 0.42 |
| Long-Term Credit | Bloomberg Long U.S. Credit | 6.0% | 6.6% | 10.9% | 0.17 | 0.23 |
| High Yield Corp. Credit | Bloomberg U.S. Corporate High Yield | 7.4% | 8.0% | 11.0% | 0.30 | 0.35 |
| Bank Loans | Morningstar Leveraged Loan | 7.6% | 8.0% | 9.0% | 0.39 | 0.43 |
| Global Credit | Bloomberg Global Credit | 3.4% | 3.7% | 7.7% | (0.09) | (0.05) |
| Emerging Markets Debt (Hard) | JPM EMBI Global Diversified | 8.9% | 9.4% | 10.6% | 0.45 | 0.50 |
| Emerging Markets Debt (Local) | JPM GBI EM Global Diversified | 6.5% | 7.2% | 12.2% | 0.20 | 0.25 |
| Private Credit | Morningstar LSTA Leveraged Loan | 9.2% | 9.8% | 11.9% | 0.43 | 0.48 |
| Private Credit (Direct Lending - Unlevered) | Morningstar LSTA Leveraged Loan | 8.0% | 8.4% | 9.0% | 0.43 | 0.48 |
| Private Credit (Direct Lending - Levered) | Morningstar LSTA Leveraged Loan | 9.5% | 10.2% | 12.6% | 0.43 | 0.48 |
| Private Credit (Credit Opportunities) | Morningstar LSTA Leveraged Loan | 9.6% | 10.3% | 12.8% | 0.43 | 0.48 |
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| Private Credit (Distressed) | Morningstar LSTA Leveraged Loan | 9.1% | 12.7% | 29.1% | 0.17 | 0.30 |

# 30-year return & risk assumptions

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— The return forecasts below have been constructed using our existing building block approach, but with longer-term inputs. Risks and correlations are estimated using the same approach as our 10-year forecasts, using full-history autocorrelation-adjusted realized risk and past 10 year realized correlations.
— These return figures must be thought of separately from our 10-year forecasts and are not meant to imply performance for the 20 years *beyond* our 10-year forecasts.
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| Asset Class | Index Proxy | Thirty Year Return Forecast | | Standard Deviation Forecast | Sharpe Ratio Forecast (g) | Sharpe Ratio Forecast (a) |
|---|---|---|---|---|---|---|
| | | Geometric | Arithmetic | | | |
| **Other** | | | | | | |
| Commodities | Bloomberg Commodity | 6.5% | 7.7% | 16.1% | 0.15 | 0.22 |
| Hedge Funds | HFRI Fund Weighted Composite | 4.9% | 5.2% | 7.5% | 0.11 | 0.15 |
| Hedge Fund of Funds | HFRI Fund of Funds Composite | 3.9% | 4.2% | 7.5% | (0.03) | 0.01 |
| Hedge Fund (Equity Style) | Custom HFRI Benchmark Mix* | 7.7% | 8.6% | 14.1% | 0.26 | 0.32 |
| Hedge Fund (Credit Style) | Custom HFRI Benchmark Mix* | 8.0% | 8.4% | 9.4% | 0.41 | 0.46 |
| Hedge Fund (Asymmetric Style) | Custom HFRI Benchmark Mix* | 5.5% | 5.7% | 6.4% | 0.22 | 0.25 |
| Real Estate Debt | Bloomberg IG CMBS | 7.4% | 7.7% | 7.5% | 0.44 | 0.48 |
| Core Real Estate | NCREIF Property | 6.7% | 7.4% | 12.5% | 0.21 | 0.26 |
| Value-Add Real Estate | NCREIF Property + 200bps | 8.7% | 9.8% | 15.4% | 0.30 | 0.37 |
| Opportunistic Real Estate | NCREIF Property + 400bps | 9.7% | 11.6% | 21.1% | 0.27 | 0.36 |
| REITs | Wilshire REIT | 6.7% | 8.4% | 19.2% | 0.14 | 0.22 |
| Global Infrastructure | S&P Global Infrastructure | 8.8% | 10.1% | 16.9% | 0.28 | 0.36 |
| Risk Parity** | Risk Parity | 7.9% | 8.5% | 10.0% | 0.38 | 0.44 |
| Currency Beta | MSCI Currency Factor Mix Index | 2.3% | 2.4% | 3.4% | (0.53) | (0.50) |
| Inflation | | 2.4% | - | - | - | - |
| Gold | | 2.4% | 3.5% | 15.5% | (0.11) | (0.04) |

*Investors wishing to produce expected geometric return forecasts for their portfolios should use the arithmetic return forecasts provided here as inputs into that calculation, rather than the single-asset-class geometric return forecasts. This is the industry standard approach, but requires a complex explanation only a heavy quant could love, so we have chosen not to provide further details in this document – we will happily provide those details to any readers of this who are interested.*

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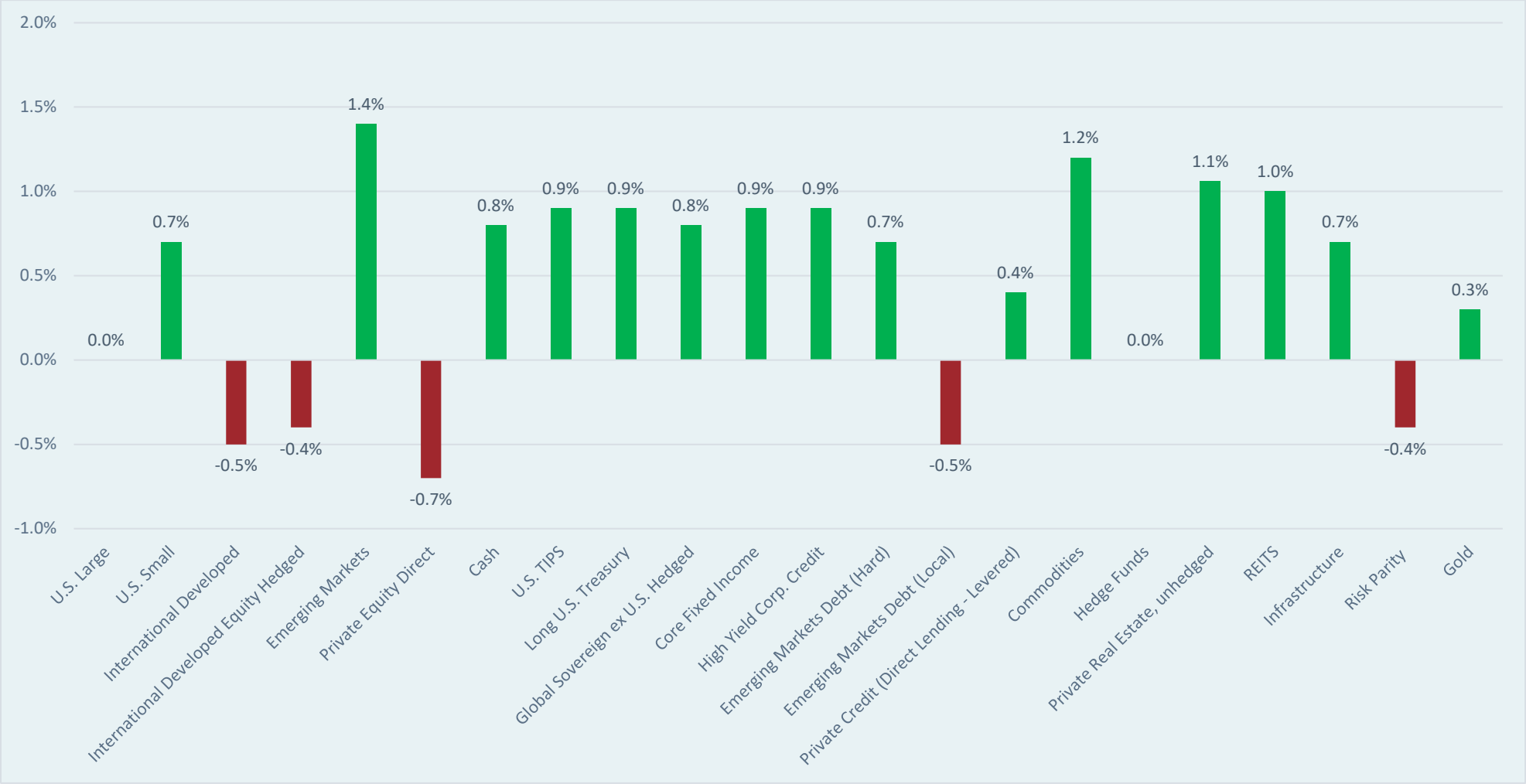
***The Risk Parity forecast shown here assumes a 10% target volatility strategy. We recommend customizing this forecast to the target volatility specifications of the risk parity strategy that an investor wishes to model. Please speak with your Verus consultant for customization needs.*

# 2024 vs. 2023 return forecast – 30 year




*Based on Verus' 2024 and 2023 Capital Market Assumptions*

# Correlation assumptions

| | Cash | US Large | US Small | Intl Large | Intl Small | EM | Global Equity | PE | US TIPS | US Treasury | Global Sovereign ex-US | US Core | Core Plus | Short-Term Gov't/Credit | Short-Term Credit | Long-Term Credit | US HY | Bank Loans | Global Credit | EMD USD | EMD Local | Commodities | Hedge Funds | Real Estate | REITs | Infrastructure | Currency Beta | Risk Parity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cash | 1.0 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| US Large | -0.1 | 1.0 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| US Small | -0.2 | 0.9 | 1.0 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Intl Large | -0.1 | 0.9 | 0.8 | 1.0 | | | | | | | | | | | | | | | | | | | | | | | | |
| Intl Small | -0.1 | 0.9 | 0.8 | 1.0 | 1.0 | | | | | | | | | | | | | | | | | | | | | | | |
| EM | -0.1 | 0.7 | 0.6 | 0.8 | 0.8 | 1.0 | | | | | | | | | | | | | | | | | | | | | | |
| Global Equity | -0.1 | 1.0 | 0.9 | 0.9 | 0.9 | 0.8 | 1.0 | | | | | | | | | | | | | | | | | | | | | |
| PE | -0.2 | 0.7 | 0.7 | 0.6 | 0.6 | 0.6 | 0.7 | 1.0 | | | | | | | | | | | | | | | | | | | | |
| US TIPS | -0.1 | 0.4 | 0.3 | 0.4 | 0.4 | 0.4 | 0.5 | 0.2 | 1.0 | | | | | | | | | | | | | | | | | | | |
| US Treasury | 0.0 | 0.1 | -0.1 | 0.0 | 0.0 | 0.1 | 0.1 | -0.1 | 0.7 | 1.0 | | | | | | | | | | | | | | | | | | |
| Global Sovereign ex-US | 0.1 | 0.3 | 0.2 | 0.4 | 0.4 | 0.5 | 0.4 | 0.1 | 0.7 | 0.6 | 1.0 | | | | | | | | | | | | | | | | | |
| US Core | 0.0 | 0.3 | 0.2 | 0.3 | 0.3 | 0.4 | 0.3 | 0.0 | 0.8 | 0.9 | 0.7 | 1.0 | | | | | | | | | | | | | | | | |
| Core Plus | 0.0 | 0.4 | 0.3 | 0.4 | 0.4 | 0.5 | 0.4 | 0.1 | 0.8 | 0.8 | 0.8 | 1.0 | 1.0 | | | | | | | | | | | | | | | |
| Short-Term Gov't/Credit | 0.2 | 0.2 | 0.0 | 0.2 | 0.2 | 0.3 | 0.2 | 0.0 | 0.7 | 0.8 | 0.6 | 0.8 | 0.8 | 1.0 | | | | | | | | | | | | | | |
| Short-Term Credit | 0.2 | 0.4 | 0.3 | 0.4 | 0.4 | 0.4 | 0.4 | 0.2 | 0.6 | 0.5 | 0.7 | 0.7 | 0.8 | 0.7 | 1.0 | | | | | | | | | | | | | |
| Long-Term Credit | 0.0 | 0.5 | 0.4 | 0.5 | 0.5 | 0.5 | 0.6 | 0.2 | 0.8 | 0.7 | 0.7 | 0.9 | 0.9 | 0.6 | 0.8 | 1.0 | | | | | | | | | | | | |
| US HY | -0.1 | 0.8 | 0.8 | 0.8 | 0.8 | 0.7 | 0.8 | 0.5 | 0.6 | 0.1 | 0.5 | 0.4 | 0.6 | 0.3 | 0.6 | 0.7 | 1.0 | | | | | | | | | | | |
| Bank Loans | -0.1 | 0.6 | 0.6 | 0.6 | 0.7 | 0.6 | 0.6 | 0.5 | 0.3 | -0.2 | 0.2 | 0.1 | 0.3 | 0.0 | 0.5 | 0.4 | 0.8 | 1.0 | | | | | | | | | | |
| Global Credit | 0.0 | 0.7 | 0.5 | 0.7 | 0.7 | 0.7 | 0.7 | 0.3 | 0.7 | 0.5 | 0.8 | 0.8 | 0.9 | 0.6 | 0.8 | 0.9 | 0.8 | 0.6 | 1.0 | | | | | | | | | |
| EMD USD | -0.1 | 0.7 | 0.6 | 0.7 | 0.7 | 0.7 | 0.7 | 0.4 | 0.6 | 0.3 | 0.6 | 0.6 | 0.7 | 0.4 | 0.6 | 0.8 | 0.8 | 0.7 | 0.9 | 1.0 | | | | | | | | |
| EMD Local | 0.0 | 0.5 | 0.4 | 0.7 | 0.6 | 0.8 | 0.7 | 0.4 | 0.4 | 0.2 | 0.6 | 0.4 | 0.5 | 0.4 | 0.5 | 0.6 | 0.7 | 0.5 | 0.8 | 0.8 | 1.0 | | | | | | | |
| Commodities | -0.1 | 0.4 | 0.4 | 0.5 | 0.5 | 0.5 | 0.5 | 0.3 | 0.2 | -0.2 | 0.2 | 0.0 | 0.1 | 0.0 | 0.2 | 0.1 | 0.5 | 0.5 | 0.3 | 0.4 | 0.4 | 1.0 | | | | | | |
| Hedge Funds | -0.1 | 0.8 | 0.9 | 0.8 | 0.9 | 0.8 | 0.9 | 0.6 | 0.3 | -0.2 | 0.3 | 0.2 | 0.3 | 0.0 | 0.4 | 0.5 | 0.8 | 0.8 | 0.6 | 0.7 | 0.6 | 0.6 | 1.0 | | | | | |
| Real Estate | -0.3 | 0.6 | 0.6 | 0.5 | 0.5 | 0.5 | 0.6 | 0.4 | 0.2 | 0.0 | -0.1 | 0.1 | 0.2 | 0.0 | -0.2 | 0.2 | 0.4 | 0.4 | 0.3 | 0.4 | 0.4 | 0.2 | 0.5 | 1.0 | | | | |
| REITs | -0.2 | 0.7 | 0.7 | 0.6 | 0.6 | 0.5 | 0.7 | 0.5 | 0.6 | 0.3 | 0.3 | 0.5 | 0.5 | 0.2 | 0.3 | 0.6 | 0.7 | 0.5 | 0.6 | 0.6 | 0.5 | 0.3 | 0.6 | 0.7 | 1.0 | | | |
| Infrastructure | -0.2 | 0.8 | 0.7 | 0.8 | 0.8 | 0.7 | 0.8 | 0.6 | 0.5 | 0.1 | 0.5 | 0.4 | 0.5 | 0.2 | 0.5 | 0.6 | 0.8 | 0.7 | 0.7 | 0.8 | 0.7 | 0.6 | 0.8 | 0.6 | 0.7 | 1.0 | | |
| Currency Beta | -0.1 | 0.0 | 0.0 | -0.2 | -0.2 | -0.2 | -0.1 | 0.1 | -0.2 | -0.1 | -0.3 | -0.2 | -0.2 | -0.1 | -0.3 | -0.2 | -0.1 | -0.1 | -0.3 | -0.2 | -0.2 | -0.2 | -0.1 | 0.1 | 0.0 | -0.1 | 1.0 | |
| Risk Parity | 0.0 | 0.7 | 0.6 | 0.7 | 0.7 | 0.6 | 0.7 | 0.7 | 0.4 | 0.4 | 0.0 | 0.5 | 0.5 | 0.7 | 0.3 | 0.7 | 0.7 | 0.7 | 0.5 | 0.7 | 0.6 | 0.5 | 0.5 | 0.4 | 0.0 | 0.7 | -0.2 | 1.0 |

*Note: as of 9/30/23 - Correlation assumptions are based on the last ten years. Private Equity and Real Estate correlations are especially difficult to model – we have therefore used BarraOne correlation data to strengthen these correlation estimates.*

# Liquidity assessment documentation

# Liquidity risk assessment overview

## Liquidity should be managed to reasonably ensure that the plan can meet its obligations under various market conditions

To gauge the health of PSERS' liquidity position, we leverage a cash-flow based analysis that is rooted in the Basel 3 banking regulation framework.

**Determining the appropriate Liquidity Coverage Ratio (LCR):**

- While there is no "right" ratio, a value less than 1.0 means there is insufficient liquidity to meet cash outflow needs.
- An appropriate LCR is impacted by several variables:
  - Access to external sources of liquidity (i.e., line of credit)
  - Projected cash flows of the portfolio and their respective volatility
  - Overall risk tolerance

# Liquidity assessment documentation

**GENERAL INPUTS, ASSUMPTIONS, AND METHODS**

| | |
|---|---|
| **Starting Asset Value** | $72,243,146,848 as of 12/31/2023 |
| **Capital market assumptions** | Verus' 2024 CMAs (details in Appendix). |
| **Rebalancing methodology** | The liquid portfolio is rebalanced after every projection year so that each liquid asset class makes up its target weight of the total liquid portfolio. |

**CASHFLOW ASSUMPTIONS[1]**

| Year | Contributions | Benefit Payments | Admin Expenses | Illiquid Distributions | Illiquid Capital Calls |
|---|---|---|---|---|---|
| **2024** | 6,420,279,000 | 8,092,170,000 | 56,555,240 | 2,836,750,000 | 2,568,000,000 |
| **2025** | 6,355,269,000 | 7,970,163,500 | 57,969,121 | 7,258,854,822 | 3,448,352,897 |
| **2026** | 6,506,894,000 | 8,170,427,000 | 59,418,349 | 7,182,854,822 | 3,303,352,897 |
| **2027** | 6,644,666,000 | 8,372,156,500 | 60,903,808 | 8,241,854,822 | 3,226,352,897 |
| **2028** | 6,776,951,500 | 8,582,308,000 | 62,426,403 | 6,188,000,000 | 2,784,000,000 |
| **2029** | 6,919,841,000 | 8,805,841,000 | 63,987,063 | 5,767,000,000 | 2,778,000,000 |
| **2030** | 7,066,776,500 | 9,031,588,500 | 65,586,740 | 5,626,000,000 | 2,788,000,000 |
| **2031** | 7,203,738,000 | 9,258,363,500 | 67,226,408 | 5,292,000,000 | 2,790,000,000 |
| **2032** | 7,367,919,500 | 9,494,390,000 | 68,907,068 | 5,002,000,000 | 2,792,000,000 |
| **2033** | 7,555,026,000 | 9,728,568,000 | 70,629,745 | 5,002,000,000 | 2,792,000,000 |

*Cashflow assumptions are static in each of the simulations. Contributions and benefit payments were provided by Buck. Private markets cashflows were provided by PSERS.*

# Notices & disclosures

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