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Duration and Asset/Liability Management (ALM): Practical Approach, Theory and Case Study.

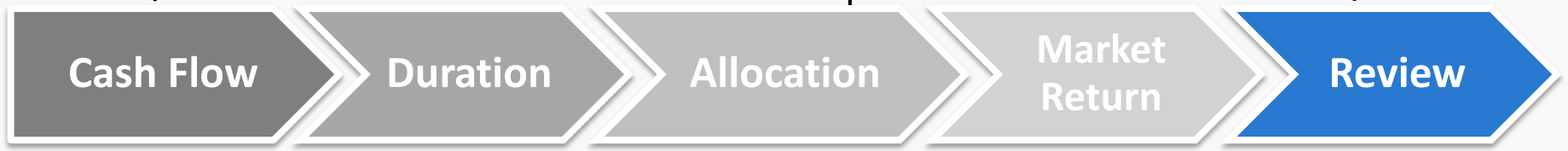
California Debt and Investment Advisory Commission
Public Funds Investment: Strategy in Practice
January 25, 2023 – Montebello, CA

Strategy Development Steps for Public Investors

Cash flow forecast / liquidity analysis is key. asset-liability (ALM) approach mitigates large liquidity needs

Set a strategic allocation among sectors to reflect cashflow profile and risk tolerances for a stable, legal and diversified portfolio

Review at least annually and make necessary changes



Setting a portfolio duration target tackles the core risk you face, interest-rate risk

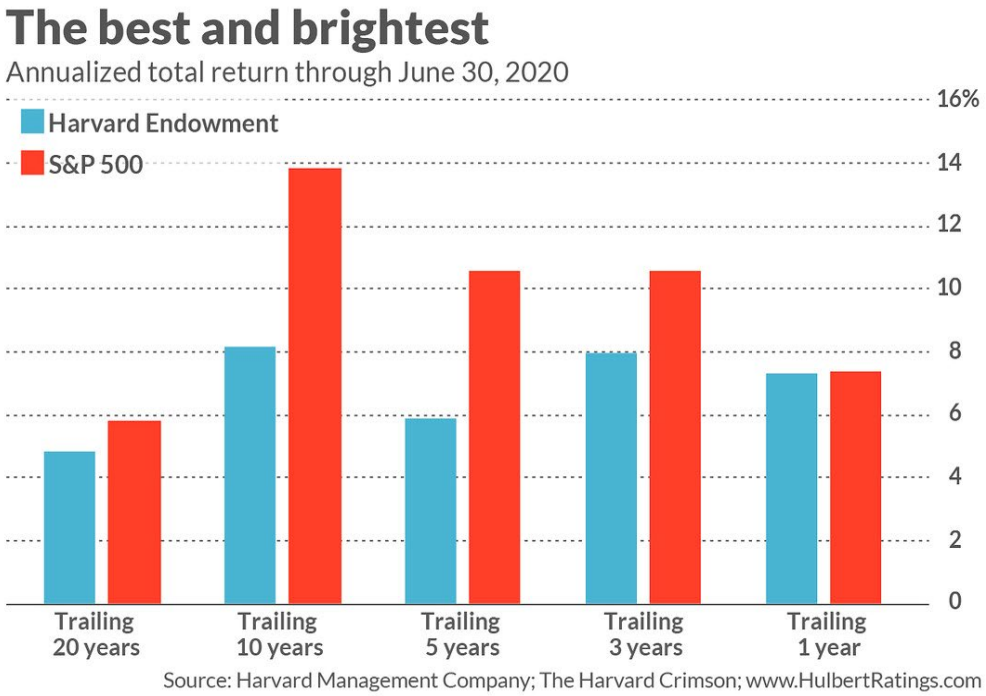
Utilize both excess liquidity investing and market opportunities to maintain a “market rate of return”

“Don’t Beat the Market, Be the Market”

Harvard Endowment: Had 230 employees until 2017, Top 6 executives took home over $40MM in compensation.

Lost to S&P index by over 100bp over last 20 years and almost 500Bp over past 10 years.

Lost to the S&P annually for the last 12 years straight.



5 Takeaway’s:

- Performance Persistance is Rare:
  - Harvard’s few moments of glory have been dwarfed by it’s failures.
- Overconfidence is an obstacle:
  - Those who have seen success get complacent and assume they are smarter than they really are.
- Reversion to the mean is powerful:
  - Sector outperformance comes and goes and is hard to predict.
- Many years of skill required to beat luck:
  - Statistically speaking, you would need many decades to understand if manager is superior.
- Indexes are hard to beat:
  - Harvard would have even lost out to a blended portfolio of 60% stocks, 40% US Bonds over last 20 years.

Source: Marketwatch - “What the Harvard Endowment’s Below Average Grade Can Teach You About Index Funds and Your Investments”, October 10, 2020

Interest Rate Speculation

The Truth About Flat Yield Curves

Rates: Dec 1986 to Dec 2022
$100MM Portfolio

Buy: 3Mo, Roll 3Mo
Buy: 2Yr

Speculate Holding 3Mo Tbill in Lieu of Longer Bond
Dates Reviewed: 12/31/1986 To 12/31/2022

Buy 3MoTBill

Start Date	12/31/1986	Portfolio Size	$100,000,000.00
End Date	12/31/2022		

3Mo TBill vs.	Observations in Months	Observations in Years	Number of Times Shorter Bond Wins	% of Wins	Number of Times Shorter Bond Loses	% of Losses	Average Annual Basis Point Win	Average Annual Basis Point Loss	Average Performance of Staying in Short Bond Over Period in Basis Points Annually	Average Performance of Staying in Short Bond Over Holding Period in Dollars	Average Spread of Shorter Bond to Buy Bond at Decision Time
Buy 2YrTsy	433	36.08	85	19.63%	348	80.37%	39.73	(108.97)	(79.78)	($1,595,588.91)	(61.78)
Buy 5YrTsy	433	36.08	20	4.62%	413	95.38%	19.48	(199.82)	(189.69)	($9,484,336.03)	(134.45)

Speculate Holding 3Mo Tbill in Lieu of Longer Bond
Dates Reviewed: 12/31/1986 To 12/31/2022

Buy 3MoTBill

Start Date	12/31/1986	Portfolio Size	$100,000,000.00
End Date	12/31/2022	3Mo Spread at Decision	0

3Mo TBill vs.	Observations in Months	Observations in Years	Number of Times Shorter Bond Wins	% of Wins	Number of Times Shorter Bond Loses	% of Losses	Average Annual Basis Point Win	Average Annual Basis Point Loss	Average Performance of Staying in Short Bond Over Period in Basis Points Annually	Average Performance of Staying in Short Bond Over Holding Period in Dollars	Average Spread of Shorter Bond to Buy Bond at Decision Time
Buy 2YrTsy	42	3.50	2	4.76%	40	95.24%	22.63	(156.17)	(147.65)	($2,953,095.24)	21.45
Buy 5YrTsy	26	2.17	0	0.00%	26	100.00%		(302.57)	(302.57)	($15,128,653.85)	30.38

Can’t Beat the Market, So Now What?

- Public entities generally exhibit predictive cash flows in both magnitude and timing.
- This allows public funds to create duration optimized (interest rate risk centric) allocations.
- Allocations should reflect the legal guidance of the investment policy and the desired weights of allowable sectors based on risk/reward and ALM preferences.
- Portfolio construction: Safety (IR Risk, credit), liquidity, diversified, legal, market rate of return.

CDIAC

Duration, Duration, Duration!

Being invested is more important than the allocation decision!

Moving from Cash to two duration in Treasuries:

Pickup approx. 40Bp Avg Yield

Moving from two duration in Treasuries to two duration in Agency Bullets

Pickup approx. 9Bp Avg Yield

Moving from two duration in Agency Bullets to maturity matched Agency Callables:

Pickup approx. 5Bp in Avg Yield

Custom Model Stats
Analysis Dates: Oct 31, 2010 - Sep 30, 2020

MODEL WEIGHTING		Cash Proxy	Treasury	Agy Blt	Agy Callable
L0US	OVERNIGHT CASH				
G0O1	3Mo T-Bill	100.00%			
G0QA	Treasury 0-1Yr		34.00%		
H541	Agy Composite 0-1Yr			32.00%	32.00%
G1O2	Treasury 1-3Yr		36.00%		
G1PB	Agy Bullet 1-3Yr			37.00%	
G1PC	Agy Callable 1-3Yr				37.00%
G2O2	Treasury 3-5Yr		30.00%		
G2PB	Agy Bullet 3-5Yr			31.00%	
G2PC	Agy Callable 3-5Yr				31.00%

MODEL STATS	Annualized Total Return	Annualized Price Return	Annualized Income Return	Annualized Std Dev Total Return	Avg Yield to Worst	Std Dev Yld	Avg Eff Dur	TR Sharpe Ratio	Yld Sharpe Ratio	Main Street Ratio
Cash Proxy	0.639%	0.639%	0.000%	0.248%	0.582%	0.785%	0.235	0.000	0.000	0.000
Treasury	1.432%	(0.413%)	1.784%	1.076%	0.976%	0.731%	1.997	0.737	0.538	0.197
Agy Blt	1.609%	(0.740%)	2.214%	1.006%	1.065%	0.708%	1.998	0.964	0.682	0.242
Agy Callable	1.163%	(0.415%)	1.524%	0.638%	1.117%	0.753%	1.284	0.820	0.710	0.416

Anatomy of Duration

MACAULAY DURATION

Economist Frederick Macaulay proposed simple formula (1938) to measure the ***time*** required to recover the initial cost of the bond (present value).

Weights are given to the present value of each cash flow (coupon payment) at the applicable interest rate for the life of the bond (YTM) then divided by the market price.

[PV(CF1)*p1+PV(CF2)*p2…PV(CFn)*Pn} / Market Price of Bond

Thus, Macaulay Duration states the time period within which the present value of the bond will be realized.

e.g. Current 5 Year Treasury has duration of 4.805.

The duration of a bond will always be less than its maturity period.

MODIFIED DURATION

Macaulay Duration was a good tool when it was conceived to compare bonds on a relative basis as to when an investor could expect to receive the cost of their investment back. The shorter the Macaulay Duration, the “less risk” was perceived by the investor since the PV of the bond would be received sooner.

However, Macaulay Duration’s shortfall was it’s inability to measure risk associated with holding the bond during its existence. Macaulay Duration lacks the ability to measure changes in value as interest rates fluctuate.

To correct for this, the simple division of the Macaulay Duration by (1+YTM) will convert the Mac Duration from a ***time*** based receipt of cash flows to the ***approximate change*** in price given a 100bp move in rates.

EFFECTIVE DURATION

Same as Modified Duration but accounts for prepayment risk in callables and amortizing product. Requires additional sophistication (OAS Model) to obtain.

Effective Duration ***SHOULD ALWAYS*** be used when a portfolio invests in callable or MBS type securities.

Why Do We Care?

- We know modified duration measures the approximate change in value for a 100bp change in interest rates.
- Because Modified Duration has Macaulay Duration as an input, we know that TVM (time value of money) principles apply.
- Thus, we can show that in normal markets over long periods of time, the more duration we take on (risk), the more return we can achieve.
- Since earning a Market Rate of Return is a core objective (albeit a lower priority one), maximizing duration given safety and liquidity are taken care of is important. It will be the **core** determinant of how much income/return can be derived from the portfolio.
- Sector and structure profile is of secondary importance to duration.

CDIAC

Approaches for Determining Portfolio Duration

Market Based – Curve(s)

- Manager uses a single or set of interest rate curves and measures risk/reward profile to establish duration.
- Example: A Treasury curve is used to remove credit risk and determine optimal spot on the curve over some period of time.
- Manager could also use a set of curves and based on sector and structure preference could weight each curve accordingly to get blended duration.

Market Based Approach

Single or Multiple Curve Analysis

MAXQ Analytics
POWERED BY QUANTRIX

Interest Rate Risk Analysis
Analysis Dates: Jul 31, 2006 - Jul 31, 2021

RISK SELECTION	
Select	1.00Yr Tsy

	Annualized Total Return	Annualized Price Return	Annualized Income Return	Annualized Std Dev Total Return	Annualized Std Dev Price Return	Annualized Std Dev Income Return	Avg Yield to Worst	Avg Eff Dur	TR Sharpe Ratio	Yld Sharpe Ratio	Income Return Ratio	Price Return Ratio	Main Street Ratio	Yield/Edur % of 30Yr	TR/Std Dev % of 30Yr	Weighted Rank
3Mo Tsy	1.055%	1.055%		0.454%	0.454%	0.000%	0.946%	0.235						28.6% / 1.2%	15.2% / 3.1%	
6Mo Tsy	1.355%	1.355%		0.539%	0.539%	0.000%	1.040%	0.484	0.556	0.065		0.556	0.193	31.5% / 2.5%	19.5% / 3.6%	9
9Mo Tsy	1.466%	0.684%	0.783%	0.629%	0.533%	0.211%	1.101%	0.735	0.641	0.110	0.355	0.278	0.206	33.3% / 3.8%	21.1% / 4.2%	3
1.00Yr Tsy	1.576%	0.013%	1.566%	0.719%	0.528%	0.422%	1.162%	0.986	0.725	0.155	0.711		0.219	35.2% / 5.1%	22.7% / 4.9%	1
1.25Yr Tsy	1.718%	0.217%	1.539%	0.873%	0.701%	0.411%	1.193%	1.225	0.747	0.182	0.608	0.000	0.208	36.1% / 6.3%	24.7% / 5.9%	2
1.50Yr Tsy	1.860%	0.422%	1.512%	1.028%	0.874%	0.400%	1.225%	1.463	0.770	0.210	0.506	0.000	0.197	37.1% / 7.5%	26.8% / 6.9%	7
1.75Yr Tsy	2.002%	0.626%	1.486%	1.183%	1.047%	0.389%	1.256%	1.701	0.792	0.238	0.404	0.000	0.187	38.0% / 8.7%	28.8% / 8.0%	13
2.00Yr Tsy	2.144%	0.830%	1.459%	1.338%	1.221%	0.377%	1.287%	1.939	0.814	0.265	0.302		0.176	39.0% / 10.0%	30.9% / 9.0%	20
2.25Yr Tsy	2.305%	0.910%	1.565%	1.515%	1.400%	0.384%	1.334%	2.171	0.822	0.308	0.328	0.012	0.178	40.4% / 11.1%	33.2% / 10.2%	19
2.50Yr Tsy	2.466%	0.990%	1.672%	1.691%	1.580%	0.391%	1.381%	2.403	0.831	0.351	0.354	0.023	0.180	41.8% / 12.3%	35.5% / 11.4%	18
2.75Yr Tsy	2.626%	1.070%	1.778%	1.867%	1.760%	0.397%	1.427%	2.635	0.839	0.394	0.380	0.035	0.182	43.2% / 13.5%	37.8% / 12.6%	17
3.00Yr Tsy	2.787%	1.151%	1.884%	2.044%	1.940%	0.404%	1.474%	2.866	0.847	0.437	0.406	0.047	0.184	44.6% / 14.7%	40.1% / 13.8%	16
3.25Yr Tsy	2.929%	1.251%	1.959%	2.258%	2.158%	0.394%	1.528%	3.101	0.837	0.491	0.402	0.071	0.186	46.3% / 15.9%	42.2% / 15.3%	14
3.50Yr Tsy	3.071%	1.351%	2.034%	2.473%	2.377%	0.384%	1.582%	3.336	0.826	0.544	0.399	0.095	0.189	47.9% / 17.1%	44.2% / 16.7%	12
3.75Yr Tsy	3.213%	1.452%	2.108%	2.687%	2.595%	0.374%	1.636%	3.570	0.816	0.598	0.396	0.119	0.191	49.5% / 18.3%	46.3% / 18.2%	11
4.00Yr Tsy	3.355%	1.552%	2.183%	2.902%	2.814%	0.364%	1.690%	3.805	0.805	0.652	0.393	0.143	0.193	51.2% / 19.5%	48.3% / 19.6%	10
4.25Yr Tsy	3.497%	1.652%	2.258%	3.117%	3.033%	0.354%	1.744%	4.040	0.794	0.705	0.389	0.167	0.196	52.8% / 20.7%	50.4% / 21.1%	8
4.50Yr Tsy	3.639%	1.753%	2.332%	3.331%	3.251%	0.344%	1.798%	4.274	0.784	0.759	0.386	0.191	0.198	54.4% / 21.9%	52.4% / 22.5%	6
4.75Yr Tsy	3.781%	1.853%	2.407%	3.546%	3.470%	0.334%	1.852%	4.509	0.773	0.813	0.383	0.215	0.200	56.1% / 23.1%	54.4% / 24.0%	5
5.00Yr Tsy	3.923%	1.954%	2.482%	3.760%	3.689%	0.324%	1.906%	4.744	0.763	0.867	0.379	0.239	0.202	57.7% / 24.4%	56.5% / 25.4%	4
10.00Yr Tsy	4.761%	2.090%	3.375%	7.020%	6.968%	0.293%	2.594%	8.846	0.528	1.623	0.330	0.147	0.186	78.5% / 45.4%	68.6% / 47.4%	15
30.00Yr Tsy	6.945%	3.482%	4.960%	14.802%	14.766%	0.265%	3.303%	19.478	0.398	2.514	0.264	0.164	0.121			21

INDEX DATES	
Start Date	7/31/06
End Date	7/31/21

RISK/REWARD WEIGHTING	
TR Sharpe Ratio	0.00%
Yld Sharpe Ratio	0.00%
Income Return Ratio	0.00%
Price Return Ratio	0.00%
Main Street Ratio	100.00%

CDIAC

Market Based Approach

Single or Multiple Curve Analysis

- Uses simple methodology by utilizing a single or multiple curves that are easily accessible.
- Risk/Reward is measured through principles like the Sharpe Ratio or a duration modified Sharpe Ratio and are relatively simple calculations.
- Does not capture true portfolio exposure (single curve used to measure duration, but portfolio is allocated across different sectors).
- Multiple curve approach requires sector allocation desires before duration established (chicken vs. egg).
- Mean-Variance Analysis possible, but requires sophistication and still optimizes market-based volatility to expected returns.
- **Does not** account for liabilities or cash flow needs of portfolio.

Approaches for Determining Portfolio Duration

Market Based – Index Sets

- Manager uses a set of indices and measures risk/reward profiles accordingly (ICE/BAML, Lehman/Bloomberg, etc..).
- Like multiple curves, the manager could weight their preference of sectors and structures and determine the optimal blended duration for the portfolio.

Approaches for Determining Portfolio Duration

Market Based Approach

Single or Multiple Index Analysis

0 – 1Yr Agy Composite = .53
1 – 3Yr A-AAA Corporate = 1.93
Blended 50/50 Duration= 1.23

MAXQ Analytics
POWERED BY QUANTRIX

Static Index Stats
Analysis Dates: Nov 30, 2007 - Nov 30, 2019

INDEX DATES	
Start Date	11/30/07
End Date	11/30/19

INDEX STATS 0-1	Annualized Total Return	Annualized Price Return	Annualized Income Return	Annualized Std Dev Total Return	Avg Yield to Worst	Std Dev Yld	Avg Eff Dur	TR Sharpe Ratio	Yld Sharpe Ratio	Main Street Ratio	Weighted Rank
0-1 Treasury	0.925%	(1.137%)	1.843%	0.375%	0.767%	0.844%	0.515	0.644	0.180	0.296	4.0
0-1 Agy Composite	1.105%	(1.385%)	2.178%	0.469%	0.915%	0.965%	0.530	0.899	0.310	0.565	3.0
0-1 Supranational	1.395%	(1.565%)	2.553%	0.413%	1.315%	0.941%	0.539	1.724	0.743	1.298	2.0
0-1 A-AAA Corp	1.848%	(2.162%)	3.300%	0.841%	1.782%	1.508%	0.525	1.385	0.773	2.221	1.0

INDEX STATS 1-3	Annualized Total Return	Annualized Price Return	Annualized Income Return	Annualized Std Dev Total Return	Avg Yield to Worst	Std Dev Yld	Avg Eff Dur	TR Sharpe Ratio	Yld Sharpe Ratio	Main Street Ratio	Weighted Rank
1-3 Treasury	1.629%	(0.396%)	1.948%	1.125%	1.051%	0.784%	1.865	0.841	0.556	0.234	6.0
1-3 Agency Blt	1.993%	(0.587%)	2.440%	1.251%	1.233%	0.886%	1.835	1.047	0.697	0.337	4.0
1-3 Agency Clb	1.515%	0.052%	1.471%	0.662%	1.279%	0.895%	1.169	1.257	0.742	0.568	2.0
1-3 Municipal	1.902%	(2.674%)	3.614%	1.115%	1.159%	0.649%	1.805	1.093	0.838	0.301	5.0
1-3 Supranational	2.329%	(0.411%)	2.636%	1.166%	1.576%	0.801%	1.935	1.412	1.200	0.497	3.0
1-3 A-AAA Corp	2.682%	(1.089%)	3.419%	2.570%	2.318%	1.592%	1.930	0.778	1.070	0.882	1.0

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Approaches for Determining Portfolio Duration

Market Based Approach

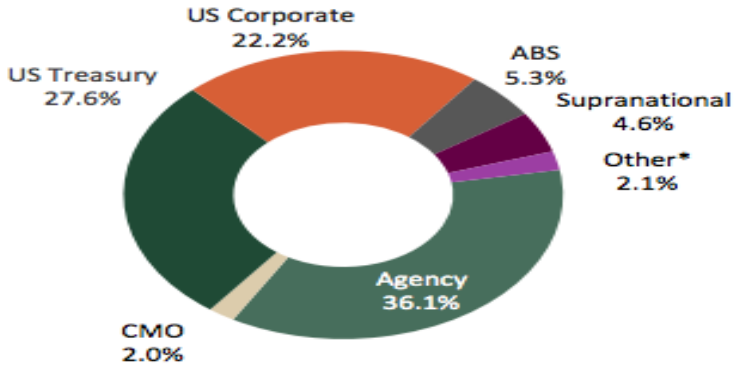
Single or Multiple Index Analysis

Treasuries represent 97.0% of this index as of Dec 31, 2022

CHARACTERISTICS	[redacted]	ICE BAML 1-5 Year US Treasury & Agency Index
Average Maturity	2.53	2.67
Average Duration	2.31	2.54
Yield-to-Maturity	2.71%	2.52%
Average Quality*	AA	AAA
Average Coupon	1.99%	2.18%

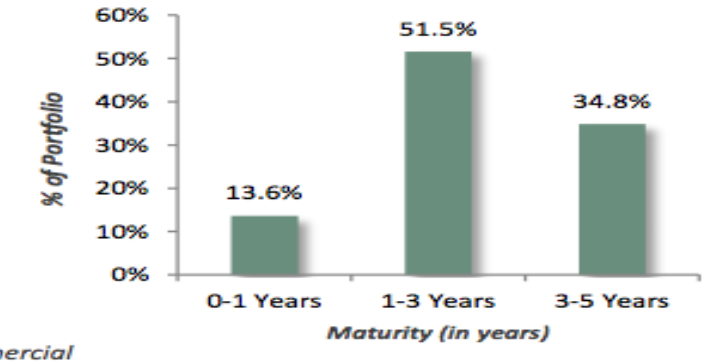
*Composite quality based on S&P ratings. Index quality reflects S&P equivalent of composite/average of S&P, Moody's and Fitch ratings. Composite characteristics are supplemental information under GIPS and supplement the composite presentation herein.

ASSET ALLOCATION



*Other includes Cash, Commercial Paper, Foreign Corporate, Municipal Bonds and Negotiable CD.

MATURITY BREAKDOWN



Market Based Approach

Single or Multiple Index Analysis

- Again uses simple methodology by utilizing a single or multiple indices that are easily accessible.
- Risk/Reward is measured through principles like the Sharpe Ratio or a duration modified Sharpe Ratio and are relatively simple calculations.
- Single Indices like the ICE BofAML 1-5 Tsy / Agy can be heavily weighted in one sector.
- Does not capture liquidity needs or actual allocation exposure of your portfolio (unless several indices are used with actual exposure weights).
- Multiple index approach requires sector allocation desires before duration established (chicken vs. egg)
- **Does** not account for liabilities or cash flow needs of portfolio.

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Approaches for Determining Portfolio Duration

Cash Flow Based - ALM

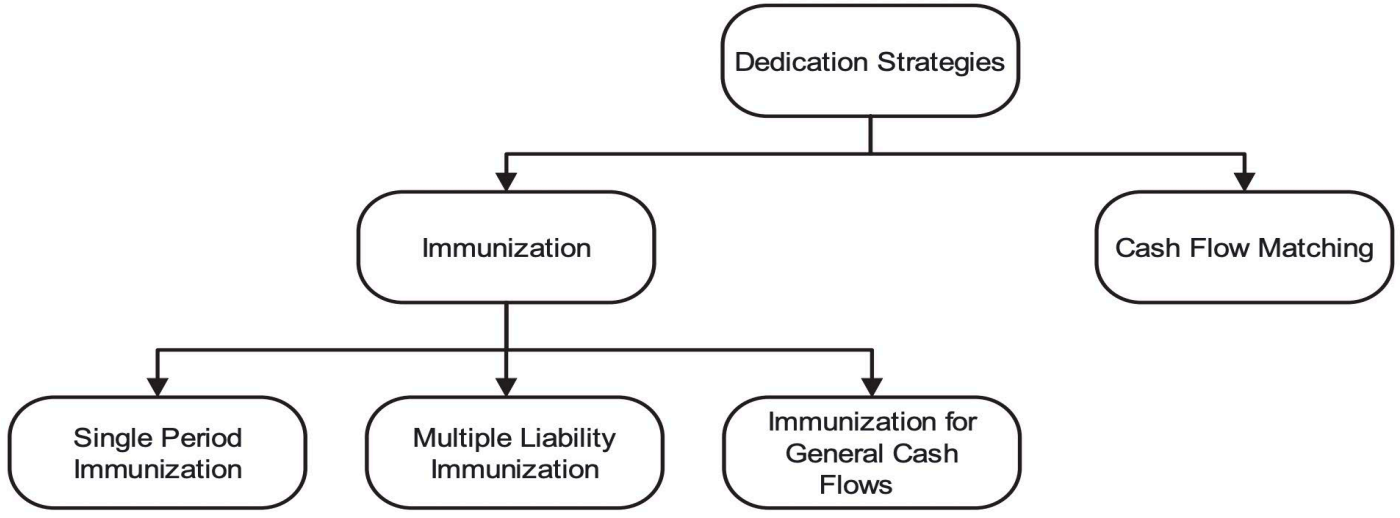
- Utilizes cash flow analysis to measure the timing and magnitude of liabilities.
- Uses immunization techniques utilized in the insurance and pension world to measure individual liability streams.
- These liability streams are combined and weighted to derive a total portfolio duration that will suffice to match the liability needs.

Cash Flow Based Approach

ALM Analysis

Dedication Strategy: Specialized fixed-income strategy designed to accommodate specific funding needs of the investor. They generally are classified as passive in nature, although it is possible to add some active management elements to them.

Exhibit 6 **Dedication Strategies**



**CFA Instititute, Fixed-Income Analysis 3rd Edition*

Cash Flow Based Approach

ALM Analysis

Immunization: Aims to construct a portfolio that, over a specified horizon, will earn a predetermined return regardless of interest rate changes (duration focused). An increase in rates and the corresponding drop in investment value partially offset by an increase in re-investment rates (and vice-versa).

Cash Flow Matching: Provides the future funding of a liability stream from the coupon and matured principal payments of the portfolio (not duration focused). A simple accumulation of the coupon, reinvestment return and value at horizon will offset liability in full.

Neither strategy perfectly fits public treasury as public entities must focus on Duration as a primary risk metric and typically spend coupons as anticipated by their budget.

**CFA Instititute, Fixed-Income Analysis 3rd Edition*

Cash Flow Based Approach

ALM Analysis

Combination Matching (also called horizon matching): Popular variation of multiple immunization and cash flow matching to fund liabilities by combining the two strategies. A portfolio is created that is duration-matched with the added constraint that it be cash flow-matched in the first few years, usually the first five years.

Since most public entities are policy constrained to five years and in, we can combine the strategies for the entire legal timeframe of the portfolio.

**CFA Instititute, Fixed-Income Analysis 3rd Edition*

Approaches for Determining Portfolio Duration

Cash Flow Based Approach

ALM Analysis

Step 1 – Liquidity Profile

Enter Receipts and Disbursements for 36 months (or desired length) to calculate Net Cash Flow per month over the last three years.

If data is difficult to obtain, a portfolio proxy can be used by utilizing the month over month change in book value of the portfolio as the net cash flow.

MAXQ Analytics
POWERED BY QUANTRIX

Cash Flow Entry
Sample City

Update Data

	Date	Receipts	Expenditures	Net Flow
1	08/31/2018	$24,471,632.81	$26,953,467.16	($2,481,834.35)
2	09/30/2018	$23,559,974.56	$25,279,925.18	($1,719,950.62)
3	10/31/2018	$30,230,063.91	$32,487,689.44	($2,257,625.53)
4	11/30/2018	$51,936,945.68	$29,593,564.84	$22,343,380.84
5	12/31/2018	$24,127,233.19	$36,589,847.89	($12,462,614.70)
6	01/31/2019	$24,918,896.36	$38,186,973.19	($13,268,076.83)
7	02/28/2019	$25,734,823.79	$29,043,844.20	($3,309,020.41)
8	03/31/2019	$16,548,385.34	$27,337,583.28	($10,789,197.94)
9	04/30/2019	$20,508,348.59	$29,534,947.01	($9,026,598.42)
10	05/31/2019	$89,102,085.61	$36,728,474.91	$52,373,610.70
11	06/30/2019	$45,733,196.26	$41,057,162.97	$4,676,033.29
12	07/31/2019	$28,962,367.65	$32,115,824.92	($3,153,457.27)
13	08/31/2019	$27,149,309.89	$30,267,442.20	($3,118,132.31)
14	09/30/2019	$20,715,835.31	$26,719,598.11	($6,003,762.80)
15	10/31/2019	$26,003,560.74	$32,235,031.27	($6,231,470.53)
16	11/30/2019	$62,252,076.52	$37,799,795.37	$24,452,281.15
17	12/31/2019	$29,319,020.67	$40,322,210.03	($11,003,189.36)
18	01/31/2020	$28,241,721.32	$43,668,419.60	($15,426,698.28)
19	02/29/2020	$31,291,231.95	$34,078,791.63	($2,787,559.68)
20	03/31/2020	$19,500,350.84	$37,131,753.46	($17,631,402.62)
21	04/30/2020	$16,677,064.70	$26,304,041.58	($9,626,976.88)
22	05/31/2020	$88,324,955.64	$48,333,158.15	$39,991,797.49
23	06/30/2020	$52,111,610.18	$46,363,012.78	$5,748,597.40
24	07/31/2020	$33,638,613.02	$34,979,405.09	($1,340,792.07)
25	08/31/2020	$28,346,100.41	$31,194,182.34	($2,848,081.93)
26	09/30/2020	$22,215,127.23	$32,450,056.41	($10,234,929.18)
27	10/31/2020	$20,081,784.50	$35,741,768.07	($15,659,983.57)
28	11/30/2020	$62,542,916.58	$36,943,063.72	$25,599,852.86
29	12/31/2020	$30,429,996.34	$42,419,717.79	($11,989,721.45)
30	01/31/2021	$30,074,891.47	$43,632,363.40	($13,557,471.93)
31	02/28/2021	$31,592,189.05	$34,700,203.72	($3,108,014.67)
32	03/31/2021	$20,648,902.89	$34,525,669.42	($13,876,766.53)
33	04/30/2021	$30,150,467.58	$37,415,760.79	($7,265,293.21)
34	05/31/2021	$99,478,439.49	$48,720,733.83	$50,757,705.66
35	06/30/2021	$44,395,717.46	$43,679,333.78	$716,383.68
36	07/31/2021	$37,275,538.69	$34,980,269.97	$2,295,268.72

CDIAC

Approaches for Determining Portfolio Duration

Cash Flow Based Approach

ALM Analysis

Step 1 – Liquidity Profile

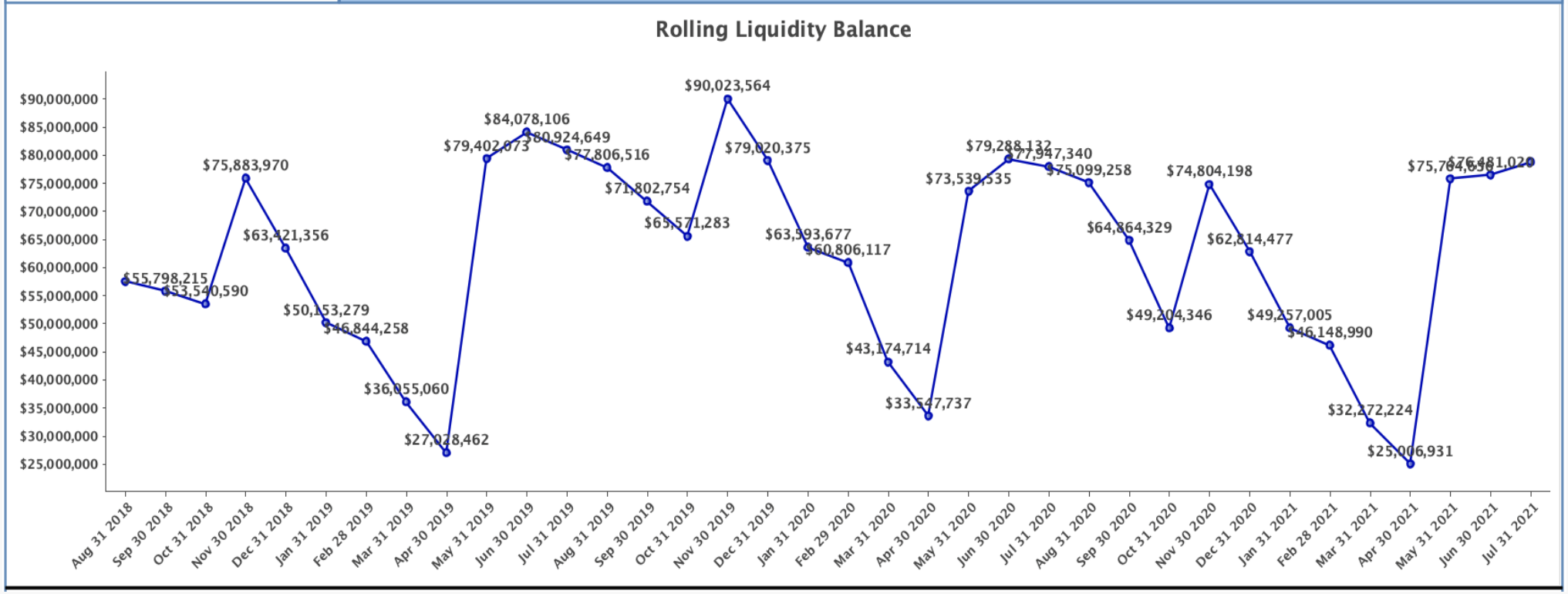
Institution Name	Sample City
Portfolio Balance	$300,000,000.00
Primary Liquidity	$60,000,000.00
Analysis Date	07/31/2021

MAXQ Analytics
POWERED BY QUANTRIX

Liquidity Graph
Sample City
Analysis Date: Jul 31, 2021

MONTHS REVIEWED	
Months	36

BALANCE DATA	
Min Balance	$25,006,931
Max Balance	$90,023,564
Max Drawdown	$34,993,069



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Cash Flow Based Approach

ALM Analysis

Step 1 – Liquidity Profile

Liquidity Buffer	1.50
Liquidity %	17.50%

Rolling Liquidity Evaluation	36	
	Value	**Date**
Minimum Balance	$25,006,930.66	
Maximum Balance	$90,023,564.27	
Maximum Drawdown	($34,993,069.34)	4/30/21
Required Liquidity		***Multiplier***
Strategic Primary Liquidity	**$34,993,069.34**	**1.00x / 11.7%**
Strategic Book Liquidity	**$34,993,069.34**	**1.00x / 11.7%**
Strategic Total Liquidity	**$69,986,138.68**	**2.00x / 23.3%**
Actual Liquidity		***Multiplier***
Actual Primary Liquidity	$60,000,000.00	1.71x / 20.0%
Actual Book Liquidity	$0.00	0.00x / 0.0%
Actual Total Liquidity	$60,000,000.00	1.71x / 20.0%
Investable Liquidity		***% Change***
Investable Primary Liquidity	$25,006,930.66	41.68%
Investable Book Liquidity	($34,993,069.34)	N/A
Total Investable Liquidity	($9,986,138.68)	N/A

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Approaches for Determining Portfolio Duration

Cash Flow Based Approach

ALM Analysis

Step 2 – Projected Cash Flows

Using your own assumptions or average/worst case cash flow projections, we can establish a liability ladder to measure against.

These projections are the net inflow and outflow expectations laddered over the policy limited timeframe of the portfolio.

Projected Net Cash Flows by Year		Worst Outflow	Average Outflow	User Outflow
1	August	($3,118,132.31)	($2,816,016.20)	
	September	($10,234,929.18)	($5,986,214.20)	
	October	($15,659,983.57)	($8,049,693.21)	
	November	$22,343,380.84	$24,131,838.28	
	December	($12,462,614.70)	($11,818,508.50)	
	January	($15,426,698.28)	($14,084,082.35)	
	February	($3,309,020.41)	($3,068,198.25)	
	March	($17,631,402.62)	($14,099,122.36)	
	April	($9,626,976.88)	($8,639,622.84)	
	May	$39,991,797.49	$47,707,704.62	
	June	$716,383.68	$3,713,671.46	
	July	($3,153,457.27)	($732,993.54)	
2	August	($3,118,132.31)	($2,816,016.20)	
	September	($10,234,929.18)	($5,986,214.20)	
	October	($15,659,983.57)	($8,049,693.21)	
	November	$22,343,380.84	$24,131,838.28	
	December	($12,462,614.70)	($11,818,508.50)	
	January	($15,426,698.28)	($14,084,082.35)	
	February	($3,309,020.41)	($3,068,198.25)	
	March	($17,631,402.62)	($14,099,122.36)	
	April	($9,626,976.88)	($8,639,622.84)	
	May	$39,991,797.49	$47,707,704.62	
	June	$716,383.68	$3,713,671.46	
	July	($3,153,457.27)	($732,993.54)	
3	August	($3,118,132.31)	($2,816,016.20)	
	September	($10,234,929.18)	($5,986,214.20)	
	October	($15,659,983.57)	($8,049,693.21)	
	November	$22,343,380.84	$24,131,838.28	
	December	($12,462,614.70)	($11,818,508.50)	
	January	($15,426,698.28)	($14,084,082.35)	
	February	($3,309,020.41)	($3,068,198.25)	
	March	($17,631,402.62)	($14,099,122.36)	
	April	($9,626,976.88)	($8,639,622.84)	
	May	$39,991,797.49	$47,707,704.62	
	June	$716,383.68	$3,713,671.46	
	July	($3,153,457.27)	($732,993.54)	

Approaches for Determining Portfolio Duration

Cash Flow Based Approach

ALM Analysis

Step 3 – DCF/Duration Analysis of Cash Flows

Year 1 Modified Monthly Duration = 5.815/(1+(Wtd Avg Tsy yield/12))=5.810
Year 1 Annualized Modified Duration = 5.810/12 = .484

Duration Optimization Calcs		NetFlow	NegNetFlow	Hedge Security	PV Rate	Period	PV NegFlow	PV Factor	Weight	PeriodWt
1	August	($2,816,016.20)	($2,816,016.20)	3Mo Tsy	0.946%	1	$2,813,797.84	0.999	4.08%	0.041
	September	($5,986,214.20)	($5,986,214.20)	3Mo Tsy	0.946%	2	$5,976,786.48	0.998	8.67%	0.173
	October	($8,049,693.21)	($8,049,693.21)	3Mo Tsy	0.946%	3	$8,030,684.44	0.998	11.65%	0.349
	November	$24,131,838.28								
	December	($11,818,508.50)	($11,818,508.50)	6Mo Tsy	1.040%	5	$11,767,443.55	0.996	17.07%	0.853
	January	($14,084,082.35)	($14,084,082.35)	6Mo Tsy	1.040%	6	$14,011,089.19	0.995	20.32%	1.219
	February	($3,068,198.25)	($3,068,198.25)	9Mo Tsy	1.101%	7	$3,048,568.85	0.994	4.42%	0.310
	March	($14,099,122.36)	($14,099,122.36)	9Mo Tsy	1.101%	8	$13,996,081.63	0.993	20.30%	1.624
	April	($8,639,622.84)	($8,639,622.84)	9Mo Tsy	1.101%	9	$8,568,621.70	0.992	12.43%	1.119
	May	$47,707,704.62								
	June	$3,713,671.46								
	July	($732,993.54)	($732,993.54)	1.00Yr Tsy	1.162%	12	$724,530.44	0.988	1.05%	0.126
2	August	($2,816,016.20)	($2,816,016.20)	1.25Yr Tsy	1.193%	13	$2,779,866.49	0.987	4.09%	0.531
	September	($5,986,214.20)	($5,986,214.20)	1.25Yr Tsy	1.193%	14	$5,903,497.88	0.986	8.68%	1.215
	October	($8,049,693.21)	($8,049,693.21)	1.25Yr Tsy	1.193%	15	$7,930,578.28	0.985	11.66%	1.748
	November	$24,131,838.28								
	December	($11,818,508.50)	($11,818,508.50)	1.50Yr Tsy	1.225%	17	$11,615,346.67	0.983	17.07%	2.902
	January	($14,084,082.35)	($14,084,082.35)	1.50Yr Tsy	1.225%	18	$13,827,863.69	0.982	20.32%	3.658
	February	($3,068,198.25)	($3,068,198.25)	1.75Yr Tsy	1.256%	19	$3,007,817.97	0.980	4.42%	0.840
	March	($14,099,122.36)	($14,099,122.36)	1.75Yr Tsy	1.256%	20	$13,807,209.12	0.979	20.29%	4.059
	April	($8,639,622.84)	($8,639,622.84)	1.75Yr Tsy	1.256%	21	$8,451,898.98	0.978	12.42%	2.609
	May	$47,707,704.62								
	June	$3,713,671.46								
	July	($732,993.54)	($732,993.54)	2.00Yr Tsy	1.287%	24	$714,372.32	0.975	1.05%	0.252

Macaulay Dur = Sum PeriodWt = 5.815

Macaulay Dur = Sum PeriodWt = 17.814

Year 2 Modified Monthly Duration = 17.814/(1+(Wtd Avg Tsy yield/12))=17.795
Year 2 Annualized Mod Duration = 17.795/12 = 1.483

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Cash Flow Based Approach

ALM Analysis

Step 3 – DCF/Duration Analysis of Cash Flows

Once the annualized duration's are calculated, we now weight each year based on our preference of coverage of each year's total liabilities.

Duration Optimization Values by Year		
1	*Annualized Duration*	*0.484*
2	*Annualized Duration*	*1.483*
3	*Annualized Duration*	*2.481*
4	*Annualized Duration*	*3.480*
5	*Annualized Duration*	*4.477*

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Approaches for Determining Portfolio Duration

Cash Flow Based Approach

ALM Analysis

Step 3 – DCF/Duration Analysis of Cash Flows

Portfolio Size	$300,000,000.00
Immunized Portfolio	$299,992,155.11
Percent Immunized	100.00%

Immunization Weight	
Year 1	90.00%
Year 2	70.50%
Year 3	70.00%
Year 4	70.00%
Year 5	70.00%

The total immunization weights for each year should create a portfolio that is 100% immunized relative to the portfolio size.

Duration Optimization Values by Year		
1	Sum Present Value of Outflows	$68,937,604.13
	Sum of Asset Matched Present Values	$62,043,843.72
	Asset Matched Weight in Portfolio	20.681%
	Annual Total Liquidity Coverage Required	$6,893,760.41
	Annualized Duration	*0.484*
	Weighted Duration	*0.100*
2	Sum Present Value of Outflows	$68,038,451.40
	Sum of Asset Matched Present Values	$47,967,108.24
	Asset Matched Weight in Portfolio	15.989%
	Annual Total Liquidity Coverage Required	$20,071,343.16
	Annualized Duration	*1.483*
	Weighted Duration	*0.237*
3	Sum Present Value of Outflows	$66,942,361.12
	Sum of Asset Matched Present Values	$46,859,652.79
	Asset Matched Weight in Portfolio	15.620%
	Annual Total Liquidity Coverage Required	$20,082,708.34
	Annualized Duration	*2.481*
	Weighted Duration	*0.388*

Approaches for Determining Portfolio Duration

Cash Flow Based Approach

ALM Analysis

Step 3 – DCF/Duration Analysis of Cash Flows

Duration Estimation and Allocation Bucket Approximation	
Starting Liquidity	$52,500,000.00
1Yr Min Liquidity	$47,360,819.51
Weighted Average Cash Flow Duration	1.92
Cash (Liquidity Profile)	17.50%
0-1Yr	20.68%
1-3Yr	31.61%
3-5Yr	30.21%

Sum of Weighted Durations (4 & 5 Year Not Shown)

Duration Optimization Values by Year		
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Approaches for Determining Portfolio Duration

Cash Flow Based Approach

ALM Analysis

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3-5Yr	30.21%

Sum of Asset Matched Weights (4 & 5 Year Not Shown)

Duration Optimization Values by Year		
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Approaches for Determining Portfolio Duration

Cash Flow Based Approach

ALM Analysis

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Duration Optimization Values by Year		
1	Sum of Asset Matched Present Values	$62,043,843.72
	Weighted Duration	*0.100*
2	Sum of Asset Matched Present Values	$47,967,108.24
	Weighted Duration	*0.237*
3	Sum of Asset Matched Present Values	$46,859,652.79
	Weighted Duration	*0.388*
4	Sum of Asset Matched Present Values	$45,889,528.29
	Weighted Duration	*0.532*
5	Sum of Asset Matched Present Values	$44,732,022.07
	Weighted Duration	*0.668*

Cash Flow Based Approach

ALM Analysis

		NetFlow	PV NegFlow	Assets Needed	1Yr Liquidity Change	1Yr Liquidity Rolling Balance
1	August	($2,816,016.20)	$2,813,797.84	$2,532,418	($281,380)	$52,218,620
	September	($5,986,214.20)	$5,976,786.48	$5,379,108	($597,679)	$51,620,942
	October	($8,049,693.21)	$8,030,684.44	$7,227,616	($803,068)	$50,817,873
	November	$24,131,838.28			$1,682,127	$52,500,000
	December	($11,818,508.50)	$11,767,443.55	$10,590,699	($1,176,744)	$51,323,256
	January	($14,084,082.35)	$14,011,089.19	$12,609,980	($1,401,109)	$49,922,147
	February	($3,068,198.25)	$3,048,568.85	$2,743,712	($304,857)	$49,617,290
	March	($14,099,122.36)	$13,996,081.63	$12,596,473	($1,399,608)	$48,217,682
	April	($8,639,622.84)	$8,568,621.70	$7,711,760	($856,862)	$47,360,820
	May	$47,707,704.62			$5,139,180	$52,500,000
	June	$3,713,671.46				$52,500,000
	July	($732,993.54)	$724,530.44	$652,077	($72,453)	$52,427,547
2	August	($2,816,016.20)	$2,779,866.49	$1,959,806		
	September	($5,986,214.20)	$5,903,497.88	$4,161,966		
	October	($8,049,693.21)	$7,930,578.28	$5,591,058		
	November	$24,131,838.28				
	December	($11,818,508.50)	$11,615,346.67	$8,188,819		
	January	($14,084,082.35)	$13,827,863.69	$9,748,644		
	February	($3,068,198.25)	$3,007,817.97	$2,120,512		
	March	($14,099,122.36)	$13,807,209.12	$9,734,082		
	April	($8,639,622.84)	$8,451,898.98	$5,958,589		
	May	$47,707,704.62				
	June	$3,713,671.46				
	July	($732,993.54)	$714,372.32	$503,632		
3	August	($2,816,016.20)	$2,738,872.78	$1,917,211		
	September	($5,986,214.20)	$5,815,759.42	$4,071,032		
	October	($8,049,693.21)	$7,811,797.51	$5,468,258		
	November	$24,131,838.28				
	December	($11,818,508.50)	$11,430,879.00	$8,001,615		
	January	($14,084,082.35)	$13,606,489.65	$9,524,543		
	February	($3,068,198.25)	$2,957,182.76	$2,070,028		
	March	($14,099,122.36)	$13,572,833.72	$9,500,984		
	April	($8,639,622.84)	$8,307,243.38	$5,815,070		
	May	$47,707,704.62				
	June	$3,713,671.46				
	July	($732,993.54)	$701,302.90	$490,912		

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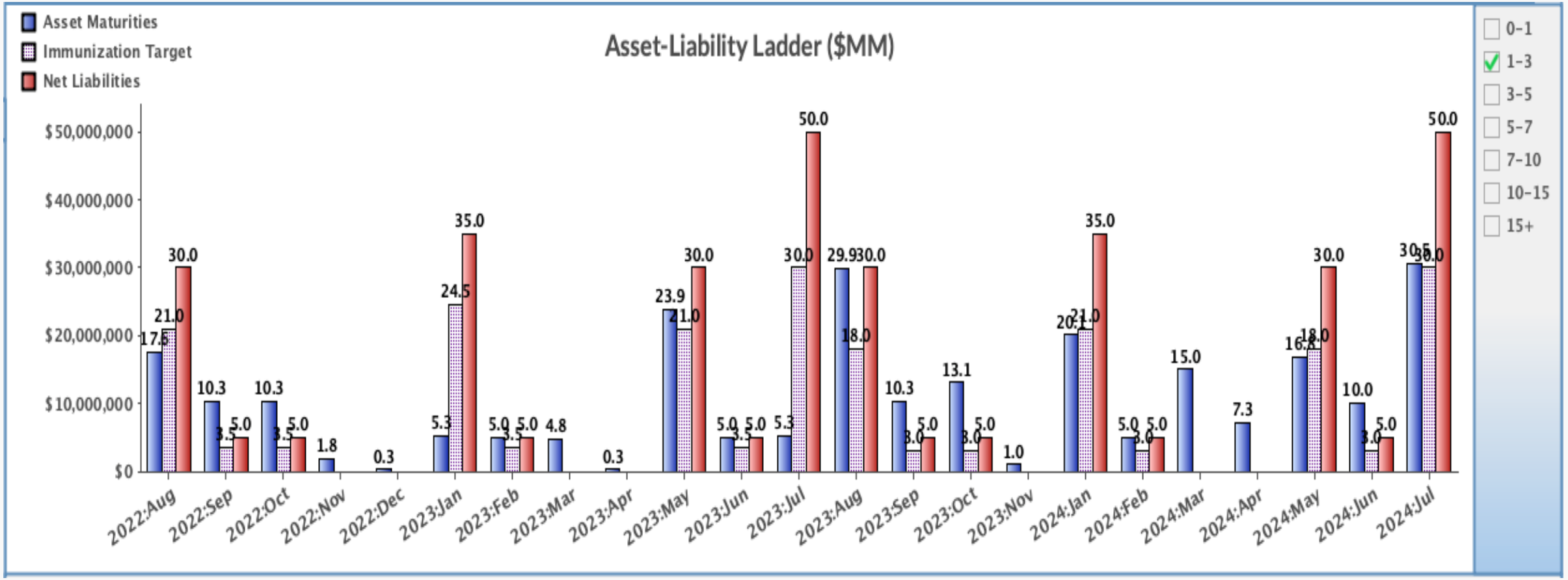
Cash Flow Based Approach

ALM Analysis



Case Study: City and County of San Francisco

CCSF Investment Pool

- CCSF Investment Pool currently is $14.7 billion
- Many different participants both discretionary and non-discretionary with 13 major participants
- Monthly apportionment to each participant
- Consists of operating reserves and bond issuance proceeds

Investment Strategy

- Focus is on Safety of Principal and Liquidity – return is considered after the first two mandates are satisfied
- Emphasis on Asset/Liability Management – matching asset maturities with cash outflows
- Maintaining a consistent average maturity consistent with cashflow profile – not market timing
- Income generation is key – not total return

CDIAC

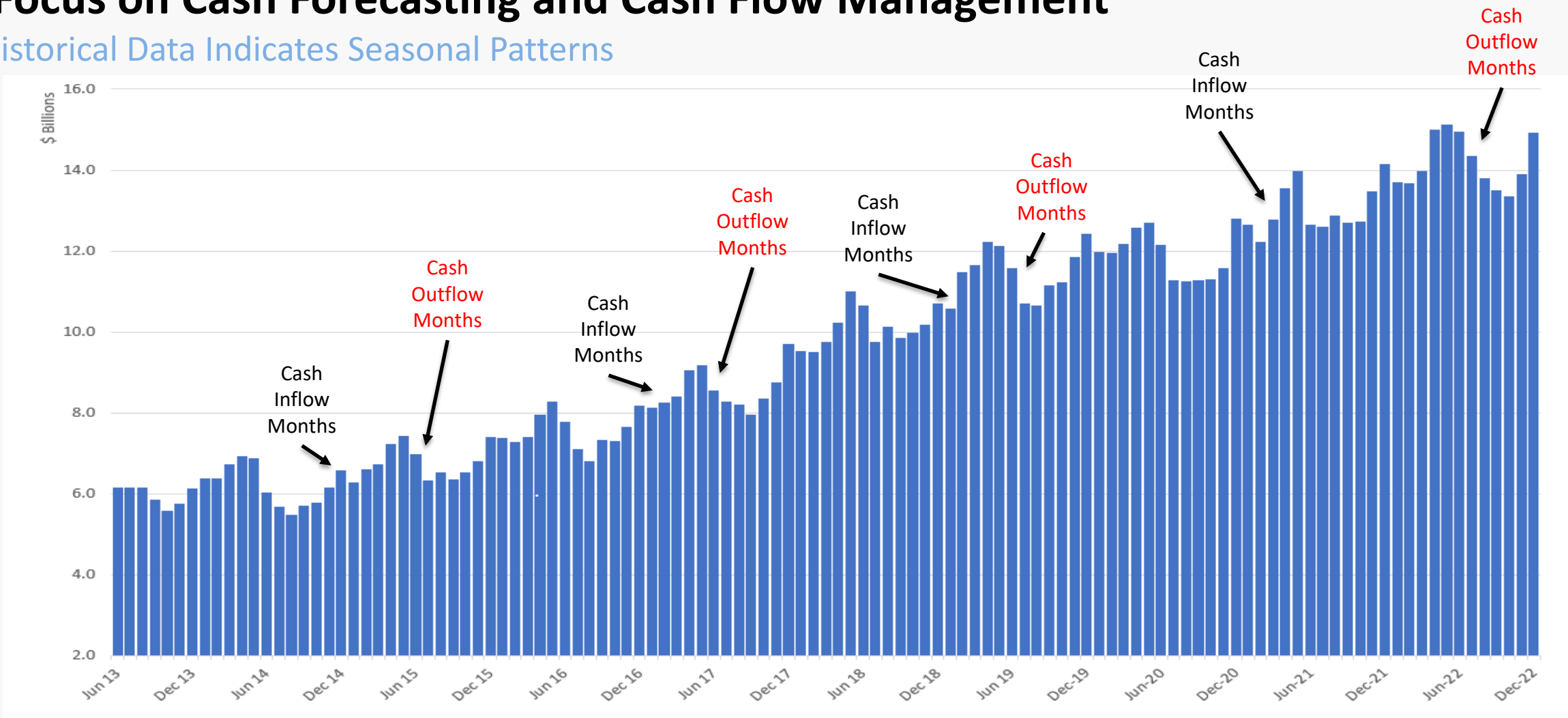
CA Government Code 53600.5

Objectives

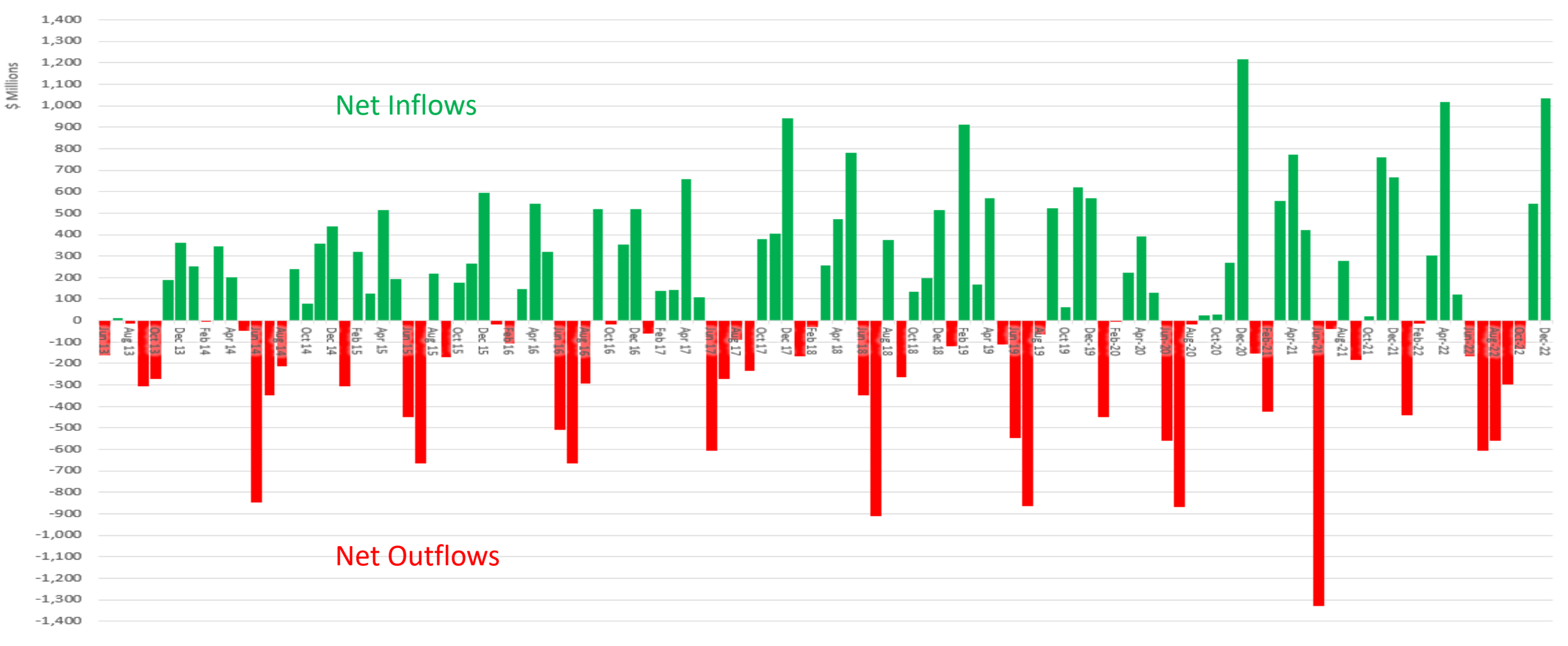
When investing, reinvesting, purchasing, acquiring, exchanging, selling, or managing public funds, the primary objective of a trustee shall be to safeguard the principal of the funds under its control. The secondary objective shall be to meet the liquidity needs of the depositor. The third objective shall be to achieve a return on the funds under its control.

Focus on Cash Forecasting and Cash Flow Management

Historical Data Indicates Seasonal Patterns



Historic Monthly Net Cash Flows



Historic Monthly Net Cash Flows By Year

Flow Selection Type

Historical Net Cash Flow by Year	2020	2021	2022
January	($448,647,971.30)	($152,567,793.13)	($439,872,611.00)
February	($7,539,007.66)	($424,131,996.20)	($16,209,979.34)
March	$224,362,201.75	$558,057,207.64	$302,531,367.33
April	$391,223,723.90	$772,652,422.72	$1,016,711,651.48
May	$130,361,300.30	$420,298,800.07	$120,346,417.41
June	($559,741,656.00)	($478,948,512.72)	($167,005,356.90)
July	($869,500,897.70)	($888,436,677.20)	($605,180,069.90)
August	($20,319,151.31)	$279,306,180.50	($558,558,396.91)
September	$24,735,030.05	($183,099,387.80)	($299,599,809.30)
October	$25,990,625.74	$17,904,953.55	($134,221,025.12)
November	$270,025,553.90	$760,418,717.00	$543,970,916.97
December	$1,215,365,138.10	$664,570,791.80	$1,032,680,667.38

Projected Cash Flows

Projected Net Cash Flows by Year		Worst Outflow	Average Outflow	User Outflow
1	January	($448,647,971.30)	($347,029,458.48)	
	February	($424,131,996.20)	($149,293,661.07)	
	March	$224,362,201.75	$361,650,258.91	
	April	$391,223,723.90	$726,862,599.37	
	May	$120,346,417.41	$223,668,839.26	
	June	($559,741,656.00)	($401,898,508.54)	
	July	($888,436,677.20)	($787,705,881.60)	
	August	($558,558,396.91)	($99,857,122.57)	
	September	($299,599,809.30)	($152,654,722.35)	
	October	($134,221,025.12)	($30,108,481.94)	
	November	$270,025,553.90	$524,805,062.62	
	December	$664,570,791.80	$970,872,199.09	
2	January	($448,647,971.30)	($347,029,458.48)	
	February	($424,131,996.20)	($149,293,661.07)	
	March	$224,362,201.75	$361,650,258.91	
	April	$391,223,723.90	$726,862,599.37	
	May	$120,346,417.41	$223,668,839.26	
	June	($559,741,656.00)	($401,898,508.54)	
	July	($888,436,677.20)	($787,705,881.60)	
	August	($558,558,396.91)	($99,857,122.57)	
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	September	($299,599,809.30)	($152,654,722.35)	
	October	($134,221,025.12)	($30,108,481.94)	
	November	$270,025,553.90	$524,805,062.62	
	December	$664,570,791.80	$970,872,199.09	

Projected Net Cash Flows by Year		Worst Outflow	Average Outflow	User Outflow
4	January	($448,647,971.30)	($347,029,458.48)	
	February	($424,131,996.20)	($149,293,661.07)	
	March	$224,362,201.75	$361,650,258.91	
	April	$391,223,723.90	$726,862,599.37	
	May	$120,346,417.41	$223,668,839.26	
	June	($559,741,656.00)	($401,898,508.54)	
	July	($888,436,677.20)	($787,705,881.60)	
	August	($558,558,396.91)	($99,857,122.57)	
	September	($299,599,809.30)	($152,654,722.35)	
	October	($134,221,025.12)	($30,108,481.94)	
	November	$270,025,553.90	$524,805,062.62	
	December	$664,570,791.80	$970,872,199.09	
5	January	($448,647,971.30)	($347,029,458.48)	
	February	($424,131,996.20)	($149,293,661.07)	
	March	$224,362,201.75	$361,650,258.91	
	April	$391,223,723.90	$726,862,599.37	
	May	$120,346,417.41	$223,668,839.26	
	June	($559,741,656.00)	($401,898,508.54)	
	July	($888,436,677.20)	($787,705,881.60)	
	August	($558,558,396.91)	($99,857,122.57)	
	September	($299,599,809.30)	($152,654,722.35)	
	October	($134,221,025.12)	($30,108,481.94)	
	November	$270,025,553.90	$524,805,062.62	
	December	$664,570,791.80	$970,872,199.09	

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Average Outflow Scenario

Duration Optimization

Duration Estimation and Allocation Bucket Approximation

Portfolio Size	$14,937,401,021.16
Immunized Portfolio	$14,937,266,745.05
Percent Immunized	100.00%
Starting Liquidity	$1,194,992,081.69
1Yr Min Liquidity	$1,194,992,081.69
Weighted Average Cash Flow Duration	2.12
Cash (Liquidity Profile)	8.00%
0-1Yr	22.57%
1-3Yr	36.31%
3-5Yr	33.12%

3Mo Tsy	0.228
6Mo Tsy	0.474
9Mo Tsy	0.723
1.00Yr Tsy	0.972
1.25Yr Tsy	1.202
1.50Yr Tsy	1.431
1.75Yr Tsy	1.661
2.00Yr Tsy	1.891
2.25Yr Tsy	2.103
2.50Yr Tsy	2.315
2.75Yr Tsy	2.527
3.00Yr Tsy	2.739
3.25Yr Tsy	2.951

INDEX DATES

Start Date	11/30/22
End Date	12/31/22

Outflow Selection

OutFlow Selection	Average Outflow
Maximum Maturity (Yrs)	5.00

Immunization Weight

Year 1	175.00%
Year 2	150.00%
Year 3	150.00%
Year 4	150.00%
Year 5	144.20%

Average Outflow Scenario

Duration Optimization Values by Year					
1	Sum Present Value of Outflows	$1,926,462,807.38	4	Sum Present Value of Outflows	$1,710,172,792.44
	Sum of Asset Matched Present Values	$3,371,309,912.92		Sum of Asset Matched Present Values	$2,565,259,188.67
	Asset Matched Weight in Portfolio	22.570%		Asset Matched Weight in Portfolio	17.173%
	Annual Total Liquidity Coverage Required	($1,444,847,105.54)		Annual Total Liquidity Coverage Required	($855,086,396.22)
	Annualized Duration	*0.463*		*Annualized Duration*	*3.454*
	Weighted Duration	*0.105*		*Weighted Duration*	*0.593*
2	Sum Present Value of Outflows	$1,842,237,143.79	5	Sum Present Value of Outflows	$1,651,944,767.24
	Sum of Asset Matched Present Values	$2,763,355,715.69		Sum of Asset Matched Present Values	$2,382,104,354.35
	Asset Matched Weight in Portfolio	18.500%		Asset Matched Weight in Portfolio	15.947%
	Annual Total Liquidity Coverage Required	($921,118,571.90)		Annual Total Liquidity Coverage Required	($730,159,587.12)
	Annualized Duration	*1.460*		*Annualized Duration*	*4.451*
	Weighted Duration	*0.270*		*Weighted Duration*	*0.710*
3	Sum Present Value of Outflows	$1,773,496,994.48			
	Sum of Asset Matched Present Values	$2,660,245,491.72			
	Asset Matched Weight in Portfolio	17.809%			
	Annual Total Liquidity Coverage Required	($886,748,497.24)			
	Annualized Duration	*2.457*			
	Weighted Duration	*0.438*			

Worst Outflow Scenario

Duration Optimization

Duration Estimation and Allocation Bucket Approximation

Portfolio Size	$14,937,401,021.16
Immunized Portfolio	$14,937,132,909.84
Percent Immunized	100.00%
Starting Liquidity	$1,194,992,081.69
1Yr Min Liquidity	$1,194,992,081.69
Weighted Average Cash Flow Duration	2.07
Cash (Liquidity Profile)	8.00%
0-1Yr	21.69%
1-3Yr	40.71%
3-5Yr	29.60%

3Mo Tsy	0.228
6Mo Tsy	0.474
9Mo Tsy	0.723
1.00Yr Tsy	0.972
1.25Yr Tsy	1.202
1.50Yr Tsy	1.431
1.75Yr Tsy	1.661
2.00Yr Tsy	1.891
2.25Yr Tsy	2.103
2.50Yr Tsy	2.315
2.75Yr Tsy	2.527
3.00Yr Tsy	2.739
3.25Yr Tsy	2.951

INDEX DATES

Start Date	11/30/22
End Date	12/31/22

Outflow Selection

OutFlow Selection	Worst Outflow
Maximum Maturity (Yrs)	5.00

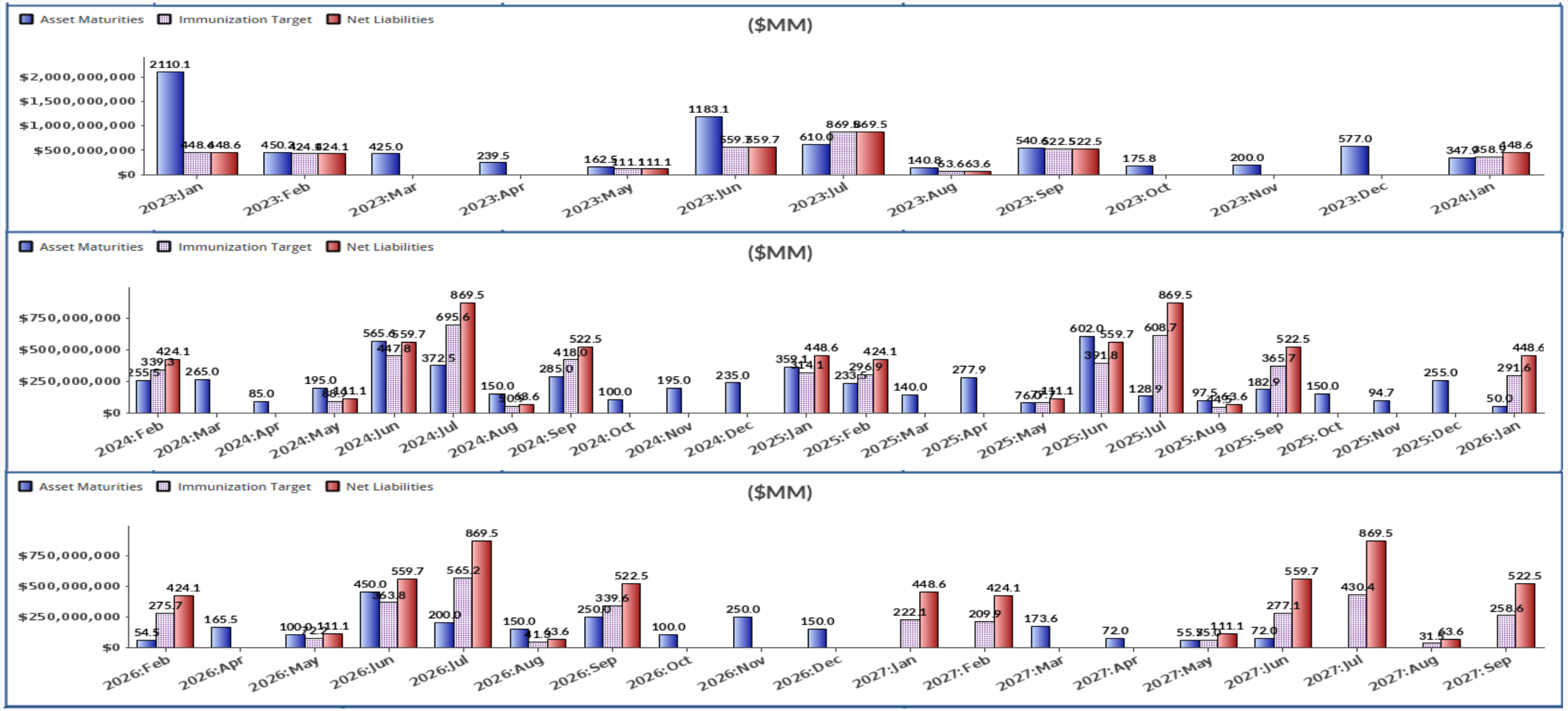
Immunization Weight

Year 1	100.00%
Year 2	100.00%
Year 3	100.00%
Year 4	85.00%
Year 5	71.15%

Worst Outflow Scenario

Duration Optimization Values by Year					
1	Sum Present Value of Outflows	$3,239,481,723.32	4	Sum Present Value of Outflows	$2,876,289,956.04
	Sum of Asset Matched Present Values	$3,239,481,723.32		Sum of Asset Matched Present Values	$2,444,846,462.63
	Asset Matched Weight in Portfolio	21.687%		Asset Matched Weight in Portfolio	16.367%
	Annualized Duration	*0.483*		Annual Total Liquidity Coverage Required	$431,443,493.41
	Weighted Duration	*0.105*		*Annualized Duration*	*3.474*
2	Sum Present Value of Outflows	$3,098,198,627.66		*Weighted Duration*	*0.569*
	Sum of Asset Matched Present Values	$3,098,198,627.66	5	Sum Present Value of Outflows	$2,778,465,498.52
	Asset Matched Weight in Portfolio	20.741%		Sum of Asset Matched Present Values	$1,976,878,202.19
	Annualized Duration	*1.480*		Asset Matched Weight in Portfolio	13.234%
	Weighted Duration	*0.307*		Annual Total Liquidity Coverage Required	$801,587,296.32
3	Sum Present Value of Outflows	$2,982,735,812.34		*Annualized Duration*	*4.471*
	Sum of Asset Matched Present Values	$2,982,735,812.34		*Weighted Duration*	*0.592*
	Asset Matched Weight in Portfolio	19.968%			
	Annualized Duration	*2.477*			
	Weighted Duration	*0.495*			

Asset-Liability Ladder ($MM)



Case Study: City and County of San Francisco

Cash Flow Schedule

Cash Flow Schedules By Day

Projected EOD Bank Balance	($37,450,879.94)
EC Bank Balance Target	$30,000,000.00
Net Bank Balance Available	($67,450,879.94)
Portfolio MMKT Holdings	$1,690,006,035.01
Intra-Day MMKT Transactions	
Target Liquidity	$1,000,000,000.00
Spendable Cash Non-Immunized	$622,555,155.07

CF Start Date	1/6/2023
CF End Date	1/31/2028

☑ Include MMKT Holdings

☑ Include Target Liquidity

Portfolio MMKT Holdings	$1,690,006,035.01
MMKT Holdings Immunized	$0.00
Portfolio MMKT Actual	$1,690,006,035.01
Intra-Day MMKT Transactions	
Target Liquidity	$1,000,000,000.00
Spendable Cash Immunized	$622,555,155.07

Min Liquidity	($21,262,676,505.98)
Max Liquidity	$700,322,804.07
Avg Liquidity	($8,185,525,434.54)
Immun Min Liquidity	($21,312,676,505.98)
Immun Max Liquidity	$635,139,105.07
Immun Avg Liquidity	($8,242,168,291.68)
Negative Net Outflow Filter Amount	($10,000,000.00)

☑ Activate Filter

Cash Flow By Day

		Total CF	Adjusted Liquidity
01/13/2023	Payroll Transfer to Bank	($102,000,000.00)	
	3133EN6A3 : FFCB 01/13/2026-57567	($29,977,200.00)	
	3133EN6A3 : FFCB 01/13/2026-57568	($19,982,400.00)	
	06367CTW7 : BMOCHG 01/13/2023-47344	$50,000,000.00	
	89114WU94 : TDNY 01/13/2023-47345	$50,000,000.00	
	Total Cash Flow	($51,959,600.00)	$570,595,555.07
01/18/2023	CCSF Payroll Tax 1	($41,000,000.00)	
	06367CUZ8 : BMOCHG 01/18/2023-47370	$50,000,000.00	
	Total Cash Flow	$9,000,000.00	$579,595,555.07
01/19/2023	3133EMWK4 : FFCB 01/19/2023-47053	$60,000,000.00	
	Total Cash Flow	$60,000,000.00	$639,595,555.07
01/20/2023	CCSF Payroll Tax 2	($10,000,000.00)	
	OCII Debt Service	($18,291,991.00)	
	Total Cash Flow	($28,291,991.00)	$611,303,564.07
01/23/2023	3133ELJH8 : FFCB 01/23/2023-46472	$10,140,000.00	
	Total Cash Flow	$10,140,000.00	$621,443,564.07
01/24/2023	SFO Debt Service ACH	($36,961,583.00)	
	89114WWX9 : TDNY 01/24/2023-47363	$50,000,000.00	
	Total Cash Flow	$13,038,417.00	$634,481,981.07
01/27/2023	OCII Debt Service	($73,006,867.00)	
	78012U5C5 : RY 01/27/2023-47357	$50,000,000.00	
	Total Cash Flow	($23,006,867.00)	$611,475,114.07
01/30/2023	Payroll Transfer to Bank	($102,000,000.00)	
	89114WQL2 : TDNY 01/30/2023-47282	$50,000,000.00	
	06367CSR9 : BMOCHG 01/30/2023-47304	$50,000,000.00	
	Total Cash Flow	($2,000,000.00)	$609,475,114.07
01/31/2023	Retiree Pension Payment	($115,000,000.00)	
	SFO Projected Capital Expenditures	($25,452,310.00)	
	Pension Payment Northern Trust Pmt	$115,000,000.00	
	Total Cash Flow	($25,452,310.00)	$584,022,804.07

Immunized Cash Flow By Day

		Total CF	Adjusted Liquidity
01/13/2023	Payroll Transfer to Bank	($102,000,000.00)	
	3133EN6A3 : FFCB 01/13/2026-57567	($29,977,200.00)	
	3133EN6A3 : FFCB 01/13/2026-57568	($19,982,400.00)	
	06367CTW7 : BMOCHG 01/13/2023-47344	$50,000,000.00	
	89114WU94 : TDNY 01/13/2023-47345	$50,000,000.00	
	Total Cash Flow	($51,959,600.00)	$570,595,555.07
01/31/2023	Retiree Pension Payment	($115,000,000.00)	
	SFO Projected Capital Expenditures	($25,452,310.00)	
	Pension Payment Northern Trust Pmt	$115,000,000.00	
	3133EMWK4 : FFCB 01/19/2023-47053	$15,000,000.00	
	Total Cash Flow	($10,452,310.00)	$584,022,804.07
02/01/2023	CCSF Payroll Tax 1	($41,000,000.00)	
	313384BH : FHLBDN 02/01/2023-57570	$10,400,000.00	
	Total Cash Flow	($30,600,000.00)	$553,422,804.07
03/06/2023	Kaiser Health Premium	($40,000,000.00)	
	Total Cash Flow	($40,000,000.00)	$585,139,105.07
03/16/2023	CCSF COP 2017B Moscone Debt Service	($19,557,856.25)	
	CCSF COP 2010A Debt Service	($1,785,300.00)	
	CCSF COP 2009A Debt Service	($10,458,715.00)	
	Total Cash Flow	($31,801,871.25)	$560,337,233.82
03/29/2023	CCSF Payroll Tax 1	($41,000,000.00)	
	Total Cash Flow	($41,000,000.00)	$509,236,424.82
03/31/2023	CCSF Payroll Tax 2	($10,000,000.00)	
	Retiree Pension Payment	($115,000,000.00)	
	SFO Projected Capital Expenditures	($28,369,090.00)	
	Pension Payment Northern Trust Pmt	$115,000,000.00	
	Total Cash Flow	($38,369,090.00)	$470,867,334.82
04/10/2023	Payroll Transfer to Bank	($102,000,000.00)	

Cash Flow Based Approach

ALM Analysis

Step 4 – Sector/Maturity Allocation

INDEX STATS	Annualized Total Return	Annualized Price Return	Annualized Income Return	Annualized Std Dev Total Return	Avg Yield to Worst	Std Dev Yld	Avg Eff Dur	TR Sharpe Ratio	Yld Sharpe Ratio	Main Stree Ratio	Weighted Rank
1-3 A-AAA Corp	3.010%	(0.769%)	3.476%	2.427%	2.415%	1.750%	1.914	0.805	0.840	0.768	1.0
1-3 Agency Clb	1.827%	0.148%	1.711%	0.715%	1.537%	1.399%	1.143	1.080	0.423	0.517	2.0
1-3 Supranational	2.762%	(0.119%)	2.842%	1.213%	1.774%	1.276%	1.921	1.408	0.649	0.431	3.0
1-3 Agency Blt	2.418%	(0.253%)	2.593%	1.277%	1.468%	1.376%	1.832	1.067	0.379	0.285	4.0
1-3 Municipal	2.103%	(2.500%)	3.529%	1.111%	1.310%	0.962%	1.811	0.943	0.379	0.201	5.0
1-3 Treasury	2.133%	(0.061%)	2.178%	1.240%	1.291%	1.291%	1.856	0.869	0.267	0.186	6.0
3-5 A-AAA Corp	4.280%	0.312%	4.100%	3.698%	2.948%	1.515%	3.665	0.872	1.321	0.546	1.0
3-5 Agency Clb	2.361%	0.099%	2.289%	1.406%	1.932%	1.315%	2.048	0.929	0.750	0.482	2.0
3-5 Supranational	4.323%	0.999%	3.706%	2.495%	2.397%	1.191%	3.712	1.310	1.218	0.391	3.0
3-5 Agency Blt	3.983%	0.816%	3.466%	2.676%	1.936%	1.245%	3.685	1.094	0.795	0.269	4.0
3-5 Municipal	3.228%	(1.204%)	3.906%	2.388%	1.717%	0.905%	3.416	0.910	0.852	0.226	5.0
3-5 Treasury	3.602%	0.980%	2.933%	2.918%	1.714%	1.146%	3.793	0.873	0.670	0.203	6.0

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Cash Flow Based Approach

ALM Analysis

Step 4 – Sector/Maturity Allocation

MODEL WEIGHTING		Target Allocation	Agy and Credit	Agency Portfolio	Treasury Portfolio
L0US	OVERNIGHT CASH	17.50%	17.50%	17.50%	17.50%
G0QA	Treasury 0-1Yr				20.68%
H541	Agy Composite 0-1Yr	10.68%	10.68%	20.68%	
C01A	US Corp A-AAA 0-1Yr	10.00%	10.00%		
G1O2	Treasury 1-3Yr				31.61%
G1PB	Agy Bullet 1-3Yr	11.61%	21.61%	31.61%	
G1PC	Agy Callable 1-3Yr	10.00%			
C110	US Corp A-AAA 1-3Yr	10.00%	10.00%		
G2O2	Treasury 3-5Yr				30.21%
G2PB	Agy Bullet 3-5Yr	15.21%	25.21%	30.21%	
G2PC	Agy Callable 3-5Yr	10.00%			
C210	US Corp A-AAA 3-5Yr	5.00%	5.00%		

Duration Estimation and Allocation Bucket Approximation	
Starting Liquidity	$52,500,000.00
1Yr Min Liquidity	$47,360,819.51
Weighted Average Cash Flow Duration	1.92
Cash (Liquidity Profile)	17.50%
0-1Yr	20.68%
1-3Yr	31.61%
3-5Yr	30.21%

MODEL STATS	Annualized Total Return	Annualized Price Return	Annualized Income Return	Annualized Std Dev Total Return	Avg Yield to Worst	Std Dev Yld	Avg Eff Dur	TR Sharpe Ratio	Yld Sharpe Ratio	Main Street Ratio	*Weighted Rank*
Target Allocation	2.372%	(0.252%)	2.548%	1.091%	1.719%	1.417%	1.576	1.207	0.545	0.490	1
Agy and Credit	2.594%	(0.219%)	2.743%	1.275%	1.712%	1.410%	1.809	1.207	0.543	0.424	2
Agency Portfolio	2.452%	(0.076%)	2.506%	1.284%	1.491%	1.387%	1.802	1.087	0.393	0.302	3
Treasury Portfolio	2.218%	0.090%	2.151%	1.350%	1.337%	1.306%	1.839	0.861	0.300	0.213	4

**ICE/BAML Index Data - July 2006 to July 2021*

Cash Flow Based Approach

ALM Analysis

- Uses institution's actual cash flow data to measure future liabilities and derive duration needs
- Eliminates bias and idiosyncratic problems that public entities can have with market based approaches (liquidity, sector and structure differences).
- Ensures each institution's duration is unique and not peer or market related.
- Places emphasis on timing and magnitude of investments relative to liabilities versus market based optimizations for the masses.
- Does require more data and effort to establish the projected liability stream and involves calculations that may not be familiar.
- There are opportunity costs associated by limiting the investment universe to any particular timeframe, however it can be argued that maintaining a stable duration and limiting cash balances can more than offset any costs associated with security selection constraints (without this process, cash balances tend to be higher and more conservative securities are purchased due to uncertainty).

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Thank You!

If you have any questions or comments please reach out and we would be happy to discuss.

Thank you for attending!

Disclosure

This presentation is for informational purposes only. All information is assumed to be correct, but the accuracy has not been confirmed and therefore is not guaranteed to be correct. Information is obtained from third party sources that may or may not be verified. The information presented should not be used in making any investment decisions and is not a recommendation to buy, sell, implement, or change any securities or investment strategy, function, or process.

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All calculations and results presented are for discussion purposes only and should not be used for making calculations and/or decisions. The data in this presentation is unaudited.

Many factors affect performance including changes in market conditions and interest rates and in response to other economic, political, or financial developments. Investment involves risk including the possible loss of principal. No assurance can be given that the performance objectives of a given strategy will be achieved. Past performance is not an indicator of future performance or results. Any financial and/or investment decision may incur losses.

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