

# Texas Municipal Retirement System

2019 ASSET LIABILITY STUDY



August 15, 2019

Board of Trustees  
Texas Municipal Retirement System  
Austin, Texas

Dear Members of the Board:

**Subject: Results of the 2019 Asset Liability Study**

We are pleased to present our report of the 2019 Asset and Liability Study for the Texas Municipal Retirement System (TMRS). Our report includes a discussion to assist the Board of Trustees in understanding the unique nature of TMRS, to provide a framework to evaluate the Board's risk tolerance, and ultimately provide quantitative analysis in order to optimize the combination of strategies employed to pay the benefits to members and beneficiaries.

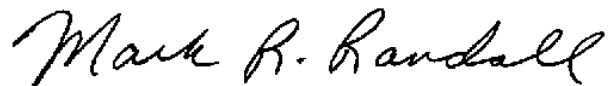
This study was conducted in accordance with generally accepted actuarial principles and practices, and with the Actuarial Standards of Practice issued by the Actuarial Standards Board. The undersigned meet all of the Qualification Standards of the American Academy of Actuaries. In addition, all of the undersigned have extensive experience as retained public sector actuaries for several large, statewide public retirement systems.

We wish to thank Ms. Leslee Hardy, ASA, EA, FCA, MAAA, Director of Actuarial Services, in particular, and the entire TMRS staff for their assistance in this project.

Sincerely,



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## **SECTION I**

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### **INTRODUCTION**

# Introduction

## Why Conduct an Asset and Liability Study?

The purpose of an Asset and Liability Study, sometimes referred to as Asset Liability Modeling, for a retirement system is to understand the unique nature of the specific system, to provide a framework for the Board of Trustees to evaluate their risk tolerance, and ultimately provide quantitative analysis in order to optimize the combination of strategies employed to pay the benefits to members and beneficiaries.

To accomplish these objectives, this study evaluates the interaction of the three key policies, as described below, which govern a defined benefit pension plan with the goal of establishing the best combination of policies by providing the following:

- 1) Analysis of current and projected future states of the plan, including review of the funding requirements, funded status, and the economic cost of the plan
- 2) Major risk sources are market, inflation and demographic risks. Together with benefit and funding policies they produce the experienced cash flow and contribution risks
- 3) Tools for TMRS to assess its risk tolerance, including discussion of the need to take risk in order to achieve the ultimate objectives

### **Investment Policy**

How will the assets supporting the benefits be invested?

What risk/return objectives?

How to manage cash flows?

### **Funding Policy**

How will the benefits be funded?

What is the assumed investment return?

How will actuarial losses be financed?

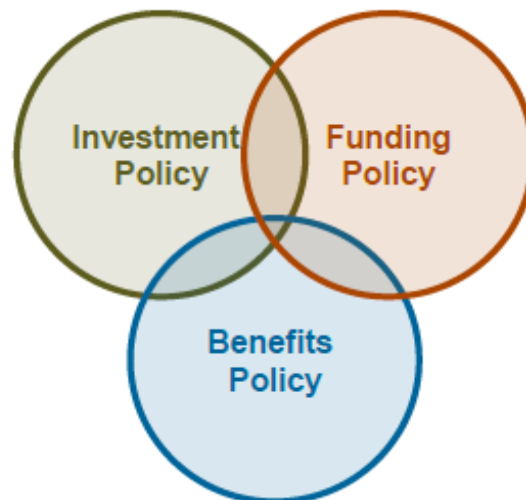
What actuarial methodologies are applied to dampen contribution volatility?

### **Benefits Policy**

What kind/type of benefits?

What level of benefit?

When and to whom are they payable?



In order to assist TMRS Trustees in quantifying their risk tolerance, the analysis will need to accomplish the following:

- 1) Show how expected advantages and risks of different investment policy choices depend on the interaction of Investment, Funding and Benefits Policies with each other and economic, capital market and demographic risks.
- 2) The expected return on assets should be sufficient to support the desired level of funding, understanding that lower returns will require higher funding over the longer term
- 3) The level of risk should be high enough to support the desired level of expected return, but controlled in order to avoid intolerable levels of downside risk and undesirable outcomes

When comparing peer systems, the following characteristics can impact the appropriate risk tolerance and portfolio construction:

- Size of the Plan
- Current funded status
- Expected funding requirements
- Plan status (open to new participants; existing members still accrue benefits)
- Time horizon
- Liquidity needs: Benefit payment less contributions
- Liability growth rates
- Sensitivity to size of contribution
- Sensitivity to contribution volatility
- Financial ability to take risk

Our analysis attempts to explore TMRS using these above characteristics as a guide and providing metrics that can be used to compare alternative strategies.

## **SECTION II**

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### **EXECUTIVE SUMMARY OF FINDINGS**

# Executive Summary

This Executive Summary provides a high level discussion of the findings from this analysis. For each section, more detail is provided later in the report.

## Current Situation

TMRS is an agent-multiple employer retirement system. As such, TMRS is made up of several hundred independent plans with respect to their own individual funded status and contribution requirements. However, the investment program is the same across all plans. Our analysis assesses most of the metrics from the perspective of TMRS, as a whole, but also for many of the metrics (such as contribution volatility) from the perspective of the individual units, as well.

As a whole, the System's current annual funding rate is 13.58% of annual covered payroll. Based on the December 31, 2018 actuarial valuation results, this was the amount that was needed to fully fund the pension plan over the long-term, based on the investment return assumption of 6.75%, among other assumptions.

The present value of all future benefits payable by the System is \$41.2 billion. The value of System assets, plus the present value of future expected contributions, is also \$41.2 billion. This is based on assumed annual returns of 6.75%. This balance is created by a funding policy that adjusts the contribution levels over time to make up any unfunded actuarial accrued liability (UAAL) that either exists today or is created in the future.

However, a significant factor in that balance is the assumed 6.75% annual return. If the returns do not achieve the 6.75% prospectively, then contributions will have to increase accordingly. It is the probability of achieving the 6.75%, and how much and how fast the contributions may have to adapt in possible future outcomes where the 6.75% is not achieved, that is the emphasis of our analysis.

## TMRS Objectives

TMRS is committed to fully funding the pension obligation over the long-term. The primary objective is to ensure that all long-term pension obligations are covered by pension assets, which will be made up of a mix of contributions and investment returns. In this way, the funding and investment strategies are linked. Lower investment returns would lead to higher required funding, and vice versa.

TMRS will need to take risk to achieve investment returns sufficient to support the current level of annual pension funding, as a certain degree of investment risk must be taken in order to satisfy the 6.75% expected return on plan assets. However, TMRS must exercise caution to not take more risk than necessary in order to achieve the desired investment results.

Finally, TMRS should invest and set its funding policies in a manner appropriate for the characteristics of its liability. In a risk/reward context, we have compared the expected contributions to the potential amount of contributions in adverse investment environments. This exercise attempts to give the risk some context (impact on contribution levels). We have also utilized downside risk and contribution volatility as risk factors for this purpose.



## Major Risk Factors to the Plan

Risk refers to the degree of uncertainty and/or potential financial loss. The potential major risk factors to a retirement system include capital market risk, return underperformance risk, inflation risk, cash flow risk, demographic risks, and contribution risks.

Sometimes referred to as investment risk, capital market risk is a term that refers to one of the risks associated with investing. Capital markets such as the stock, bond, foreign currency and derivatives markets are considered “risky” because of the constantly changing prices of the securities that are traded. In other words, security prices are volatile. Security prices are not influenced just by their fundamentals, but also by broader market influences such as economic news, political developments, currency movements, or even “black-swan” unexpected events such as a massive earthquake, tsunami or general market panic. While debatable, some consider price volatility to be a proxy for risk. The risk of financial loss associated with either choosing to or being forced to sell a security when prices have declined is what is meant by capital market risk.

In the context of a retirement system with a long time horizon, a discount rate not tied to short-term market fluctuations, and smoothing techniques for determining funding requirements, investment risk primarily consists of the level of uncertainty of achieving the returns as per the expectations of the system, or underperformance risk. For TMRS, this is the risk of falling short of the actuarial assumed rate of return assumption, currently 6.75%.

Inflation risk is the risk to the plan caused by potentially higher inflation rates (price or wage). Cash balance plans have significantly less inflation risk than other plan structures, but a substantial portion of TMRS retirees do have benefits that are indexed with inflation.

Cash flow risk is the risk that the monthly benefit payouts exceed the monthly contributions by amounts large enough to impact the portfolio composition and potentially the generation of lower investment earnings over time due to illiquidity concerns. It is also the risk that capital calls (on committed capital for private investment funds) exceeds available liquidity and results in forced sales of other investments. Liquidity can be managed from several angles, including plan design, funding policy, and selecting the investment return assumption and portfolio structure. TMRS has very strong cash flow characteristics and low potential for changes in cash flow over a shorter period of time.

Demographic risks include longevity risk, retirement pattern risk, and other risks. These involve demographic experience which may be different than the actuarial assumptions. For example, plan participants who live longer than expected will collect benefit payments longer than expected, resulting in a greater obligation than is currently expected. Rates of retirement which are different than expected might also result in a higher pension obligation than currently expected. The cash balance plan design and agent-multiple employer structure of TMRS dampens much of the potential system-wide risk from demographic sources. Mortality is unquestionably a risk for retirees, but having the annuity purchase rates generationally adapt over time to changing longevity lowers this exposure for TMRS as well.

All of the above risks could eventually lead to higher funding requirements than are currently expected, which represents contribution risk. As such, it is important to be aware of these risks, and to continually measure and monitor these risk exposures on an ongoing basis in order to optimally manage them. In general, TMRS' risk characteristics are favorable when compared to its peers, with a much less mature population, very manageable cash flow risks, a cash balance plan design, a growing population, a lower

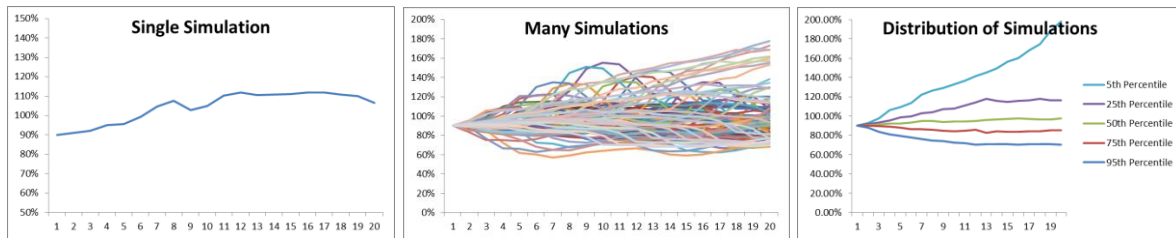
investment return assumption, and employers having no discretion on the minimum amount of contributions.

## Asset-Liability Projection Results

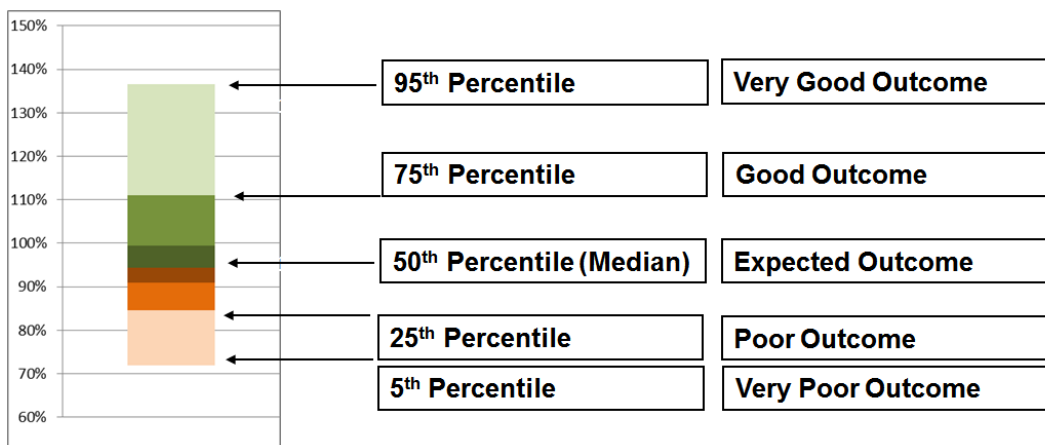
Stochastic projections help illustrate the effect of future possible economic conditions on selected valuation results by varying multiple parameters in the model. This can help isolate reward vs risk alongside with benefit vs cost. Since inflation, and the extent liability and revenue growth is associated with it, can be varied along with investment returns, the model may show dampened risks to some strategies and amplified risks to others, that a single variable model would not produce.

This analysis produced 5,000 30 year trials for each asset class, price inflation, and wage inflation. Then, 30 year projections were performed for each trial based on the portfolio and funding policy selected. Specific metrics were collected for each trial and then the results are aggregated into summaries to be able to compare to other options.

Clearly, thousands of simulations on one graph or in one table would be impossible to interpret. Instead, the simulations are ranked at each point in time, which produces a distribution of outcomes illustrating the possible range over the projected period.



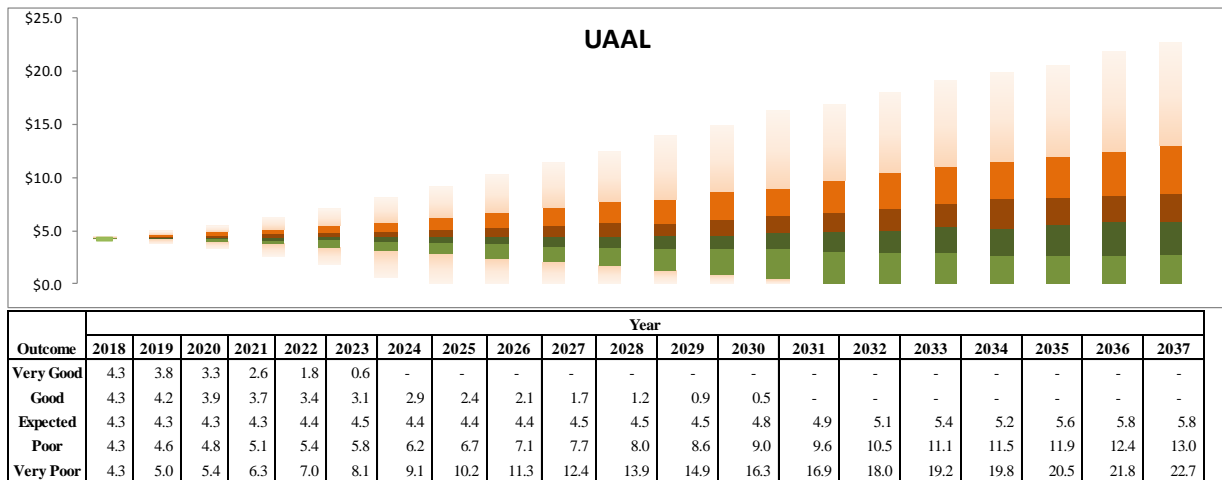
Then, to communicate the results, the distributions are described in percentiles. For example, the 25th percentile means that 25% of the results are lower than this point. We find that the percentiles can be from the top or bottom, and thus find it possibly easier to use other terminology. Since risk is focused on downside outcomes, we may refer to the 25th and 5th percentile undesirable outcome as the 1 in 4 or 1 in 20 outcome. Also, we are going to rename the percentiles with more descriptive names as shown below:



As part of this study, we reviewed the projected results for the funded status and the associated economic cost of TMRS. We have defined the economic cost in two ways: the total employer contributions over the

next 20 years plus the financing of any UAAL that remains at the end of year 20 (all discounted for inflation), and the “Effective Contribution Rate”. The Effective Contribution Rate is the contribution as a percentage of payroll that would need to be collected over the specified time horizon (in this case 20 years) to fully amortize the UAAL created by that scenario, meaning all 5,000 scenarios have a unique Effective Contribution Rate determined based on the result of that actual trial that would produce a UAAL of \$0 at the end of the 20 years. This metric can take on several meanings, but the simplest understanding would be the rate that the actual contribution rate would trend towards as the experience unfolds. Any difference in this rate and the current actual rate would be an economic cost that is pushed into a future generation.

Based on the current forward looking capital market assumptions provided by RVK, the current portfolio is expected to produce a median (geometric) expected return of 6.30% over the next 10 years. Since this is less than the 6.75% investment return assumption, the stochastic modeling does not anticipate the UAAL will be fully amortized (reduced to zero) at the median outcome. The following is the distribution of UAAL in billions of dollars.



The System’s funded ratio is expected to increase from today’s 87.0% funding level. However, under today’s investment strategy with the expectations used in this study, the funded ratio is expected to trend towards 100%, but is not expected to achieve 100% funding. Under some of the alternative investment strategies, the funded ratio is expected to become fully funded (i.e., 100% or more) over the next 30 years, with less risk of lower funded ratios.

Under the current funding policy and investment strategy, the projected, inflation adjusted, total future employer contributions over the next 20-years (plus any shortfall at year 20) are \$18.3b for units that have repeating COLAs. This group was used because it represents 76% of TMRS liabilities and have the most volatile set of benefit provisions, thus any combination of strategies for this group would also be appropriate for other units. However, in the 1 in 4 outcome (Poor Outcome), this would increase to about \$25.2b. The 1 in 4 outcome indicates that of the 5,000 trials from the model, 25% of the trials would produce contributions lower than this amount, and since 25% is half way between 0% and 50%, the 1 in 4 Outcome could be representative of the average, adverse outcome.

Using the 1 in 20 outcome (Very Poor), or values that approximate worst case scenarios, the total projected employer contributions increases to \$33.4b. A majority of this amount would not actually be contributed over the next 20 years, but would remain as an UAAL at time 20.

Using the Effective Contribution Rate instead to attempt to put those dollar amounts in context, the median expected Effective Contribution Rate over the 20 year period is 16.4% for the current investment strategy

and funding policy. This compares to a current contribution rate for this COLA group of 14.9%. This means that at the median expectation, as the investment portfolio is slightly underperforming the 6.75% return assumption, the contribution rate would drift upwards toward 16.4% over the 20 year period.

This analysis is not examining the reasonability of the current 6.75% investment return assumption. That assumption will be addressed in the Experience Study to follow. A significant difference could be allowance for time horizon, investment alpha, or not wanting to be overly precise with short term capital market expectations as the 6.30% is a ten year estimate and has no allowance for active management. However, to explicitly address this difference would require tightening the amortization strategy, lowering the return assumption, generating alpha, and/or modifying the portfolio in a way to increase the expected return.

## **Cash Flow Projections and Liquidity Assessment**

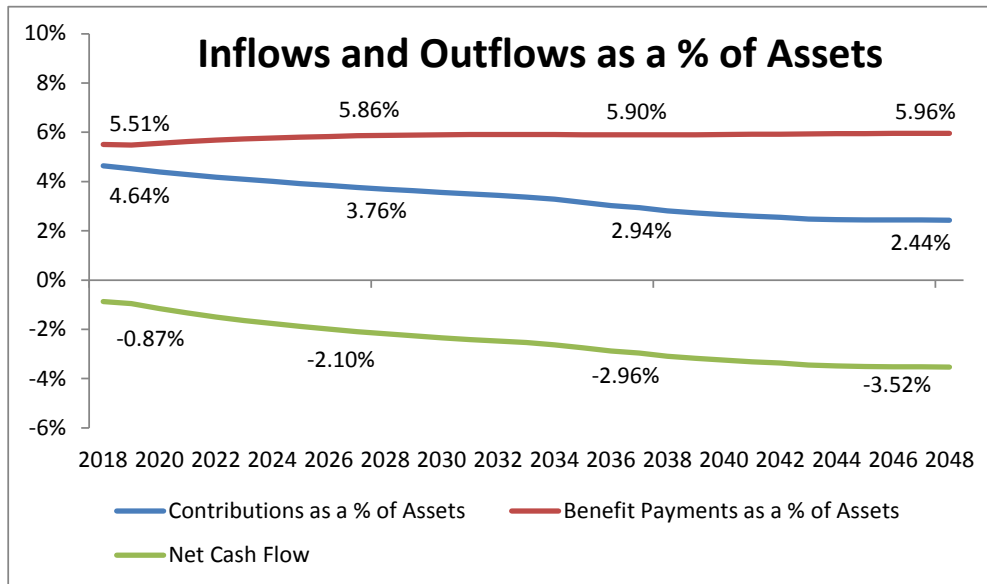
A pension plan is a series of cash flows. Every month there are contributions made into the trust and benefit payments made from the trust. Any amount paid out from the trust in excess of the amount contributed into the trust must be made up from the corpus of the trust assets.

Managing how much of the corpus must be used to meet that difference is one of the main functions of the investment staff and must be considered when selecting investment strategies. A system does not want to be in a position where they have to sell assets every month to meet obligations, as there will be times that selling those assets would be unfavorable.

The difference between the amount paid out and the amount collected is the net cash flow. Typically this is shown as a percent of assets, meaning what percent of the corpus is needed to meet cash flow throughout the year. Net cash flow requirements in the negative 3-4% range is typically seen as manageable as interest, dividends, and the general churning of assets will meet liquidity needs in that range.

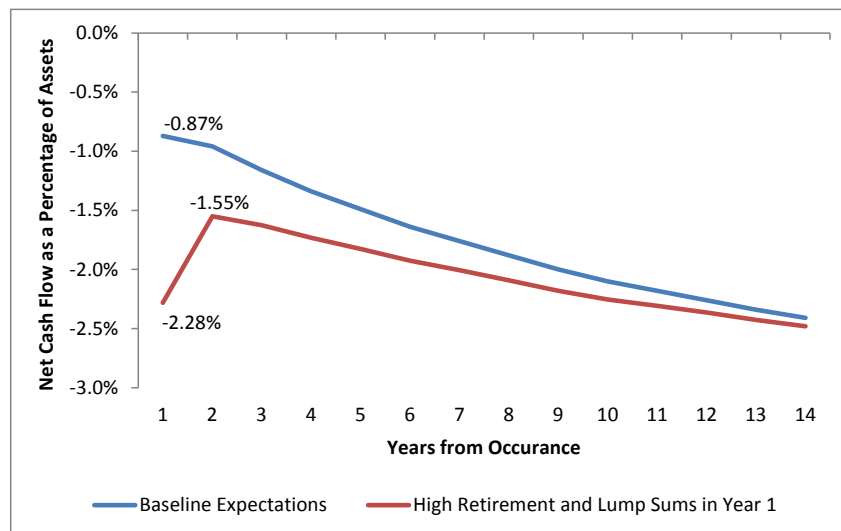
TMRS currently has negative cash flow as a percent of trust assets of less than 1%, meaning the cash flow requirements are very favorable in comparison to peers. The main reason the amount is low is because generally TMRS is still a less mature plan, having experienced substantial active population growth in the 1980's into the 1990's, and continued active population growth since of 1-2% per year, and thus not having a large retiree liability in comparison to the active payroll.

The following graph shows the projected inflows and outflows as a percent of trust assets, and includes the projection of negative cash flow.



Notice the benefit payments stay rather constant as a percentage of assets and it is actually the contribution declining as a percentage of trust assets that is producing the expansion in the amount of negative cash flow. This is the purpose of the trust fund, to generate investment earnings and help pay the benefits over time. The negative cash flow is anticipated to expand to approximately 3-4% over the longer term, but should not exceed 3% for at least two decades.

Many pension plans also have to deal with the potential for a large swing in the cash flow in a given year. Either the members could choose to take a lump sum of the value of their projected annuity and there is a spike in retirements, or the employer could elect to take a contribution holiday and crash the contribution level. Contribution holidays are not allowed at TMRS, so there is no risk from the contribution side, but to test the potential from the outflows we created a scenario that assumes twice the number of people as expected (historical patterns) retire in a given year and proportionately 50% more members choose PLSO and refund options than expected. The net outflows in year one would be approximately \$400m larger than expected. As shown, the payouts increase, but still within manageable levels, even in this very unlikely scenario given TMRS is a multiple employer plan, meaning it would be difficult for a single event to impact retirement behavior to that extreme a level.



Based on this analysis, TMRS has minimal liquidity concerns.

## Alternative Investment Portfolios

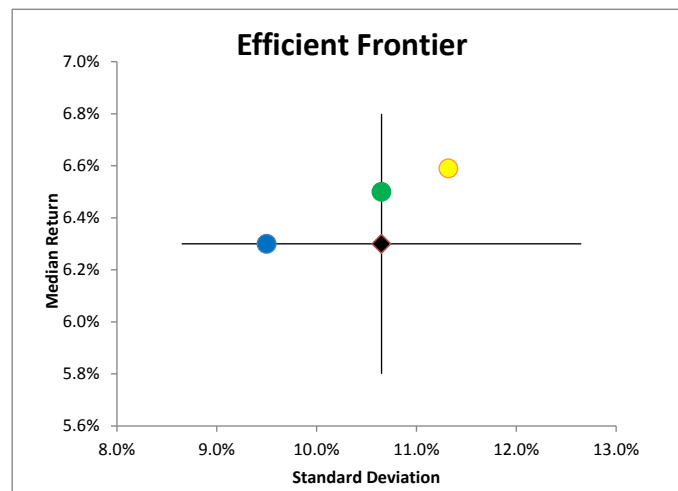
We chose some alternative portfolios to illustrate the impact of various risk and reward choices. For example, we chose the following portfolios from the efficient frontier:

- One that achieves the same expected return as the current portfolio, but with less standard deviation
- One that achieves more expected return, with the same standard deviation
- One that achieves even more expected return, but has to increase the standard deviation to do so

The following is a summary of the characteristics of the illustrated portfolios.

	Current	Same Return, Less Std Dev	More Return, Same Std Dev	Extra Return, More Std Dev
	◆	●	●	●
Median Return	6.3%	6.3%	6.5%	6.6%
Standard Deviation	10.7%	9.5%	10.7%	11.3%
Probability of a Negative Return	27.1%	24.1%	26.4%	27.4%
Probability of -10% Return	4.3%	2.3%	4.1%	5.1%
1/100 Worst Annual Return	-14.9%	-12.3%	-14.7%	-15.9%
Probability of Achieving 6.75% over 10 Years	43.7%	43.0%	46.0%	47.2%
Probability of Achieving 6.75% over 20 Years	42.5%	41.5%	45.8%	47.2%

Using the traditional efficient frontier, the portfolios would plot in this fashion:



Thus, clearly the portfolio with the same return with less standard deviation appears preferable to the current, and likewise the one with more return and the same standard deviation. However, how does the last portfolio, which must take on more “risk” to achieve more return, relate to the current portfolio? Is the additional 0.3% expected return enough to warrant the additional 0.6% in standard deviation?

For this analysis we have used other metrics to try to put the additional amount of risk into the context of having an obligation to pay benefits to retirees. The amount of the annuity payable to a retiree is independent of the amount of earnings generated. Thus, even though the standard deviation of the portfolio might be higher, does that lead to higher contributions, higher probabilities of declining funded

ratios, or higher contribution volatility? These tend to be the financial risks that stakeholders of pension plans focus on.

So, revisiting the economic cost variables discussed previously, we calculated the total projected employer contributions based on the three alternative portfolios at the median, the 1 in 4 outcome, and the 1 in 20 outcome. We also did this for the Effective Contribution Rate. The results are in the following table:

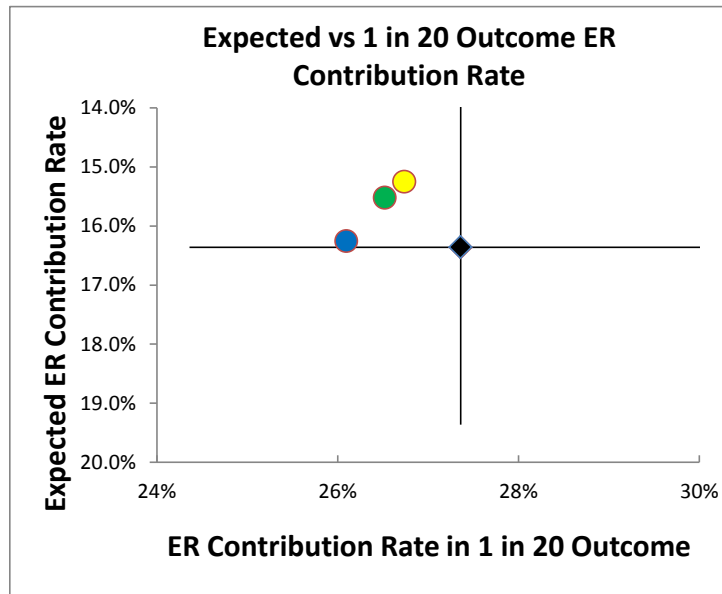
20 Year Time Horizon			Total Contributions			Effective Contribution Rate		
			Expected	Poor	Very Poor	Expected	Poor	Very Poor
Expected	SD	Expected	Outcome	Outcome	Expected	Outcome	Outcome	
Current	6.3%	10.7%	\$ 18.3	\$ 25.2	\$ 33.4	16.4%	21.3%	27.4%
Same Return, Less Std Dev	6.3%	9.5%	18.2	24.6	31.8	16.3%	20.8%	26.1%
More Return, Same Std Dev	6.5%	10.7%	17.1	24.1	32.3	15.5%	20.4%	26.5%
Extra Return, More Std Dev	6.6%	11.3%	16.7	23.8	32.7	15.2%	20.3%	26.7%

In the Expected outcome, all three alternative portfolios produce lower employer contributions than the Current (although the Lower Std Dev is basically the same). This makes sense as they are expected to generate more investment earnings, and thus if the benefits are the same, the contributions would be less.

In the adverse outcomes, when comparing the three options to each other, the pattern looks as anticipated. The riskier portfolio has a lower expected contribution due to the higher expected earnings, but as the outcomes become more adverse, begins to slightly underperform the other two.

However, it should be noted that at the Poor Outcome, the higher standard deviation portfolio still produces less contributions. In fact, the additional contributions in the Very Poor Outcome from alternative 2 to 3 is approximately \$0.4b, which is the same amount of savings expected at the Expected Outcome between these two alternatives, meaning the absolute value of risk and reward between those two options is equivalent.

Comparing the third portfolio back to the current, the higher expected earning portfolio produces less contribution across the entire spectrum of outcomes. The same pattern is presented in the Effective Contribution Rate. The following is an efficient frontier, but mapping the Effective Contribution Rate in the expected outcome against the Very Poor Outcome, and notice that all three alternative portfolios are up and to the left of the current one. Note that contribution rates on the y-axis have been plotted in reverse order to make a higher dot (i.e. lower contribution rate) the desired outcome just like a typical efficient frontier.



Thus, given a 20 year time frame (and giving this model full credibility) this analysis would suggest all three alternative portfolios are “less risky” in the context of the amount of contributions as the potential adverse outcome is actually smaller.

What about funded status and contribution rate volatility? Stochastic modeling also allows these metrics to be analyzed. The following provides some data points.

	Expected Return	SD	Probability of Contribution Increase Greater Than		Probability Less than 80% Funded in 2040	Prob, >100% funded anytime before 2040
			0.50%	1.00%		
Current	6.3%	10.7%	19%	7.0%	31%	45%
Same Return, Less Std Dev	6.3%	9.5%	17%	5.2%	28%	42%
More Return, Same Std Dev	6.5%	10.7%	18%	6.2%	26%	49%
Extra Return, More Std Dev	6.6%	11.3%	18%	6.8%	26%	52%

The two middle columns show the probability the contribution rate increases by more than 0.5% or 1% in any given year. This group has a current contribution level of 14.9%, so that would be equivalent to increasing to a 15.4% or 15.9% rate in one valuation cycle. As shown, the third alternative is slightly more volatile than the other two alternatives, but slightly less so than the Current. That is because the current is not expected to generate 6.75% and is thus generating actuarial losses, which produces a bias to create increases in cost.

All three alternatives also show quite lower probability of being less than 80% funded in 2040, and the two which have a higher expected return have a much higher probability of achieving full funding in the next 20 years.

Thus, advantages of all three potential investment strategies relative to the current investment strategy include:

- Higher expected return per unit of asset risk (return divided by standard deviation)



- Higher expected return per unit of liability risk (expected contributions divided by adverse contributions)
- Lower expected economic cost
- Higher expected ending funded status
- Lower contribution volatility

The purpose of this exercise was to provide more context and other methods of assessing the riskiness of a given portfolio choice. The standard deviation, capital market risk (short term), and the other risk metrics shown on page 11 should also be considered.

Likewise, and just as importantly, other non-financial risks should be considered, although these are not in the purview of this analysis. Stakeholders should understand all three of the illustrated portfolios have higher allocations to a more diverse set of asset classes, many of which require much more oversight, managing liquidity, active management, due diligence, fees, etc. Essentially, it takes more than a simple mathematical optimization model to differentiate between the risks and rewards of these classes. Thus, in the upcoming asset allocation study, one of the first main decisions is what limits to put on these diversifying “Alternative” strategies, and then move on to other decisions.

### Impact from Funding Policy

The values in the above analysis are all based on the current funding policy. We also used the model to test various funding policies, and their associated parameters, against each other to put their risk rewards into context, as well. For this analysis, we used the portfolio that expects a 6.6% return from the above section. We are in no way recommending that as a choice, or presuming that would be the portfolio chosen by the Board, but used it because it produces outcomes closer to the current 6.75% return assumption and the lower median return of the current portfolio actually produces a bias when examining funding strategies.

The current policy is based on 10 year asset smoothing and 25 year layered amortization of any UAAL and actuarial losses. The current layered methodology is the most commonly used policy in the industry, although there are several others. We also employ offsetting techniques that are “non-traditional” to attempt to dampen the year to year volatility in the contribution rate. These techniques are used both in the amortization and asset smoothing process and will offset any experience in one direction, whether a gain or a loss, against previous experience in the opposite direction before continuing with the layered recognition. The following compares TMRS’ current 25 and 10 layered/smoothing approach to a more traditional application of the layered approach with the same parameters.

	Probability of Contribution Increase Greater Than	Probability Less than 80% Funded
	0.50%	In 2050 (MVA)
Traditional 25/10	31%	25%
TMRS 25/10	18%	25%

As shown, the offsetting techniques in the amortization and asset smoothing methods decrease the volatility quite a lot, without giving up downside protection. Thus, we will continue to utilize these techniques going forward.

As is the case with any liability, the UAAL accrues interest. When using an increasing amortization policy, naturally the payments made earlier in the pattern are lower than the payments made later in the pattern. With a long period, this can produce payments at the beginning that are quite low and can even be below the amount of interest being accrued. This is called “negative amortization”. The result is an increase in the UAAL from one year to the next, even if the actuarially determined contribution is met. In most cases, this issue arises when the remaining amortization period gets beyond 20 years.

The topic of negative amortization has recently become a focus of particular attention in the public sector actuarial industry, and the public sector community, as a whole. While there are no regulatory or prescribed statutes that would keep a pension system from using a funding policy that uses negative amortization, the actuarial standards of practice and relative industry practice notes strongly recommend systems use policies that do not incorporate negative amortization.

The most notable and comprehensive document available for guidance on funding policy is “Actuarial Funding Policies and Practices for Public Pension Plans” by the Public Plans Community of the Conference of Consulting Actuaries. While not authoritative, this comprehensive document provides commentary and does approximate the general thoughts of the actuarial industry on this subject.

The paper categorizes separate model practices into acceptable, acceptable with conditions, and unacceptable. The 10 year smoothing period, with the 15% corridor, is found to be an acceptable practice. The 25 year layered amortization process is also defined as an acceptable practice, but with conditions.

However, the paper does not directly address the combination of specific parameters. The combination of 25 and 10 yields a 35 year period from when a significant event would occur to when it would eventually be fully amortized. Given the lengthy write up against negative amortization in the paper, and the paper categorizing the 25 year layered as acceptable with conditions, the 35 year combined period would not be considered a current industry best practice.

Thus, we are recommending that one of the two parameters be shortened by 5 years. These parameters impact the contribution volatility and the protection against downside events, so the following exhibits provides those metrics based on the current 25/10, as well as 25/5 and 20/10.

	Probability Contribution Rate Changes	Probability of Contribution Increase Greater Than			Probability Less than 80% Funded		Prob, >100% Funded
		0.00%	0.50%	1.00%	In 2050 (MVA)	Anytime before 2040 (AVA)	Anytime before 2040 (AVA)
		25/10 Layered	99%	50%	18%	7%	25%
25/5 Layered	99%	51%	28%	12%	23%	43%	59%
20/10 Layered	99%	50%	22%	9%	20%	26%	53%

As shown, all three recalculate the rate each year, so the probability of some type of change is fully 99%. Both of the two alternatives provide more downside protection than the current approach, which is why they are more standard in the industry, but both also increase contribution rate volatility, with the 5 year smoothing doing so by quite a large margin. The reader may have noticed the change to compare funded ratios in 2050 versus 2040 from the previous section. With 10 year smoothing and 2040 only being 20

years from now, more time was needed to see the true difference in the methodologies beginning to manifest.

We find the 20/10 combination preferable to both the 25/10 and the 25/5. It is slightly more volatile than the current, but decreases the probability of going below 80% funded by 20%, from 25% to 20%. It also removes negative amortization from TMRS policies.

## Possible Other Funding Policies

The information above assumes the funding policy remains as is, with different parameters. With the non-traditional techniques applied in the formula to offset experience, the 20/10 layered numbers above are the most optimized combination under the “layered” structure. As shown, there is an approximate 22% probability of having a 0.5% increase in contribution rate in a given year. If stakeholders believe this contribution rate volatility is “too high”, then the only options will be utilizing a different structure all together, or utilizing some form of “direct rate” smoothing.

A direct rate smoothing mechanism would use the rate that comes out of the set formula, and then apply another round of smoothing. The most common, and most defensible, approaches work from above by holding the rate steady when the underlying formula would suggest the rate could be reduced, waiting for experience to bring the rate back up in future years.

There are two forms that would be easiest to transition to given TMRS’ current policies:

1. Keep the layered approach, but don’t let the contribution rate decrease until UAAL is fully amortized. We will define this as the “Disciplined” approach. This approach is used by some peer systems, including TCDRS in an elective manner.
2. Keep the current contribution rate until one of the following two triggers occur: 1.) UAAL is fully amortized or 2.) The 20 year Actuarially Determined Contribution (ADC) exceeds the current rate. If the 20 year ADC exceeds the current rate, the current rate is reset upwards to meet the requirement. We will define this as the “Floating” approach. This approach is used by some peer systems as well, including Utah and South Carolina. In fact, this approach was singled out in a positive manner in the recent stress testing paper by the Pew Foundation as showing a strong ability to manage contribution rate volatility.

The Disciplined approach is going to be rather path dependent. Since the model is built on the layered approach, if the beginning years have some adverse experience or a significant adverse event occurs, the contribution would likely increase quite a bit. This approach would depend on positive experience occurring first to generate a “cushion” between the formula rate and the actual contribution rate. The Floating approach would be a different emphasis all together. This approach is emphasizing stable contribution rates and deemphasizing reaching 100% funded by a specific date. If an adverse event occurs, including population decline, this approach would try to extend the period out before trying to extend the rate up.

For example, assume a significant new loss occurs when a TMRS City’s UAAL is expected to be fully amortized in 8 years based on the current rate. The Layered approach, and the Disciplined approach, to the extent there has been no cushion created, will add a new layer on top for the new loss. The current UAAL would remain on the 8 year path. Thus, the contribution rate would increase materially.

The Floating approach, however, would try to extend the 8 years out to the extent that it could. So, if extending the 8 year period out to a 15 year period is enough to not have to increase the rate, the rate

will not change. *This manipulation of the period reduces volatility substantially.* However, this approach is only appropriate when the maximum period does not entail negative amortization. The following exhibit provides the same metrics as the analysis above.

	Probability Contribution Rate Changes	Probability of Contribution Increase Greater Than			Probability Less than 80% Funded		Prob, >100% Funded
		0.00%	0.50%	1.00%	In 2050 (MVA)	Anytime before 2040 (AVA)	Anytime before 2040 (AVA)
25/10 Layered	99%	50%	18%	7%	25%	31%	52%
20/10 Layered	99%	50%	22%	9%	20%	26%	53%
20/10 Disciplined	43%	38%	18%	8%	18%	25%	62%
20/10 Float	25%	20%	10%	5%	23%	29%	56%

As shown, the Disciplined approach basically brings the volatility back in line with the current approach and parameters. However, the downside protection is very good. If the Board wishes to emphasize downside protection over contribution volatility, the Disciplined approach is optimal.

The Floating approach reduces volatility in half but gives back some of the downside protection, although still better than the current. Thus, if the Board wishes to emphasize stable contribution rates while still remaining in best practices, the Floating approach would be optimal.

## Combinations of Strategies

Ultimately, TMRS will have one set of strategies to deploy, so it is important to consider what this “package” would look like. For illustrative purposes, we have compared the expectations of:

- 1) The current portfolio with the current 25/10 layered funding policy, to the
- 2) 6.6%/11.3% portfolio with a 20 year Floating approach.

As shown below, the metrics appear better across the entire spectrum: higher projected funding ratios, lower projected contributions, and lower contribution volatility.

	Expected Return		20 Year Contribution Dollars			20 Year Effective Contribution Rate			Probability of Contribution Increase Greater		Probability Less than 80% Funded		Prob, >100% Funded
	Return	SD	Expected	Poor Outcome	Very Poor Outcome	Expected	Poor Outcome	Very Poor Outcome	0.50%	1.00%	In 2050 (MVA)	Anytime before 2040 (AVA)	Anytime before 2040 (AVA)
	Current Portfolio	6.3%	10.7%	\$ 18.3	\$ 25.2	\$ 33.4	16.4%	21.3%	27.4%	19%	7%	31%	34%
25/10 Layered Extra Return, More Risk	6.6%	11.3%	\$ 16.7	\$ 23.9	\$ 32.9	15.2%	20.3%	26.5%	10%	5%	23%	29%	56%
20/10 Floating													

As with any changes to the portfolio, there is no specific timeframe for implementing any of these policies. In fact, a change to one of the alternative funding policies would likely need at least another year to fully vet the many different circumstances that could arise from having 880 potentially different circumstances. This analysis provides the Board more detail on various options and any combination could be investigated further if desired.

## Key Takeaways

- TMRS' primary objective is to ensure that all long-term pension obligations are covered by pension assets, which will be made up of a mix of contributions and investment returns. In this way, the funding and investment strategies are linked. Lower investment returns would lead to higher required funding, and vice versa.
- In the context of a retirement system with a long time horizon, investment risk primarily consists of the level of uncertainty of achieving the returns as per the expectations of the system, or underperformance risk. For TMRS, this is the risk of falling short of the actuarial assumed rate of return assumption, currently 6.75%.
- Based on the current forward looking capital market assumptions provided by RVK, the current portfolio is expected to produce a median (geometric) expected return of 6.30% over the next 10 years. Since this is less than the 6.75% investment return assumption, the stochastic modeling does not anticipate the UAAL will be fully amortized (reduced to zero) at the median outcome.
- To explicitly address this difference would require tightening the amortization strategy, lowering the return assumption, generating alpha, including an allowance for timeframe, and/or modifying the portfolio in a way to increase the expected return.
- The 35 year combined asset smoothing and amortization period would not be considered industry best practices. The 20/10 combination appears to be optimal compared to the 25/5 option.
- There are combinations of portfolios and funding policies that can create better metrics across the entire spectrum: higher projected funding ratios, lower projected contributions, and lower contribution volatility.
- However, there are other non-financial risks which should be considered which may limit the actual portfolios that can be implemented.
- All three of the alternative portfolios have higher allocations to a more diverse set of asset classes, many of which require more active management, are illiquid, and typically have higher fees. The Board must consider this complexity when assessing the appropriateness of those portfolios.
- This study is not making any recommendations on portfolio choice. The upcoming asset allocation study will dive into the details of individual classes and produce recommendations. This analysis attempts to provide a broader quantitative framework for the Board to assess the risks and rewards of the portfolios recommended in the asset allocation study.

## **SECTION III**

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### **DEFINING THE MODEL AND BASELINE PROJECTION RESULTS**

# Model and Baseline Projection Results

## Regular Actuarial Valuations

Due to the desire to reduce a series of complicated situations to a small set of data points, along with a tradeoff between costs, complexity, and value; pension liabilities are regularly defined in the pension world as a one dimensional value. Meaning, liabilities are reduced down to a single, discounted value: “our actuarial accrued liability is \$34b”. This is appropriate for and efficient to track experience over time and make adjustments to contribution requirements based on a pre-determined set of formulaic policies. However, it can cover up several risk factors and potential changes to contributions in the future.

So the normal valuation process:

- Quantifies commitments with present value liability calculations
- Contains an implied plan for meeting cash flows
- Does not specify variances in the future commitments of the plan very well
- Does not allow enough context to make choice between policies that will have risk and reward characteristics that contend over multiple timeframes.

## Deterministic Projections

The actual obligation is to pay monthly annuities to retirees, or to meet cash flows over time. So, the actual “liability” is the payments made over time.

- Example: \$1.7b in 2019, \$1.7b in 2020, \$1.8b in 2021, etc.

A projection quantifies commitments by projecting year by year cash flows:

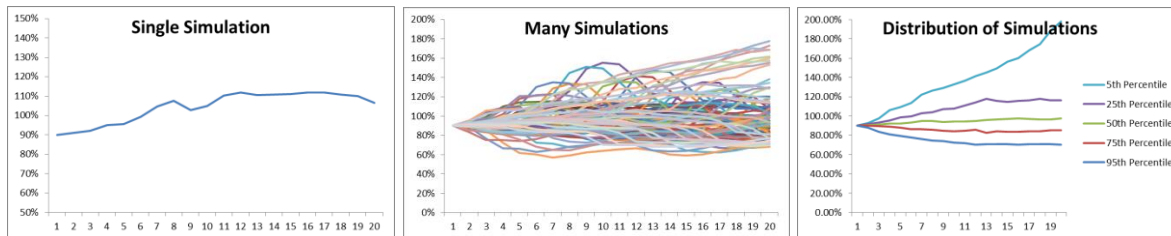
- Demonstrates how the plan for meeting cash flows is expected to work
- Discloses emerging patterns
- Can provide more information for comparing risks and rewards between choices, but usually can only change one experience variable at a time and short term valuation metrics are typically still over-emphasized
- Do not incorporate the reality that, while hopefully offsetting over time, significant year-to-year market gains and losses will occur and thus risk vs reward is typically simplified to a cost now versus cost later, compounding interest exercise

## Stochastic Projections

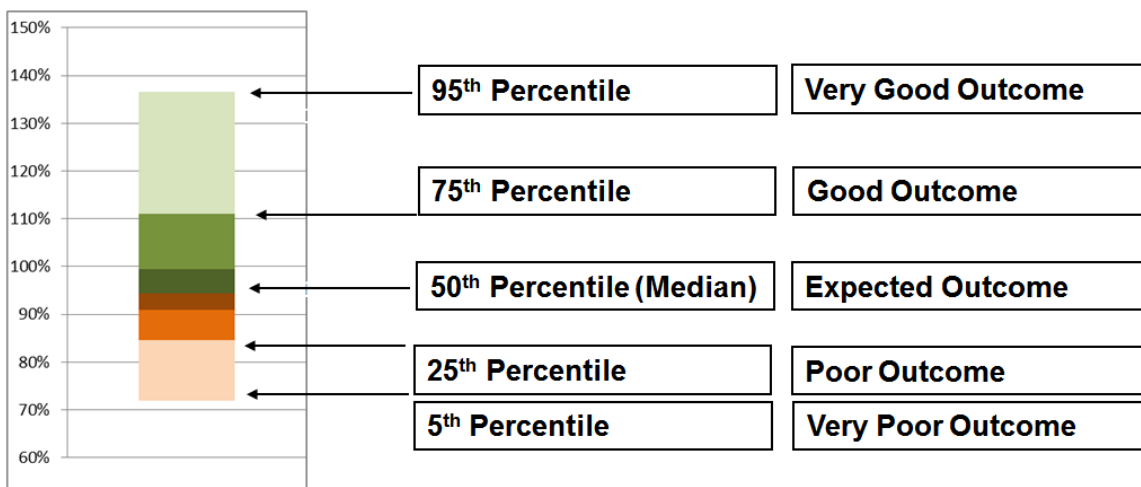
Stochastic projections help illustrate the effect of future possible economic conditions on selected valuation results by varying multiple parameters in the model. This can help isolate reward vs risk alongside benefit vs cost. Since inflation, and the extent liability and revenue growth is associated with it, can be varied along with investment returns, the model may show dampened risks to some strategies and amplified risks to others, that a single variable model would not produce.

Monte Carlo simulations sample from a probability distribution for each variable to produce thousands of possible outcomes. The results are analyzed to get probabilities of different outcomes occurring. For example, this analysis produced 5,000 30-year trials for each asset class, price inflation, and wage inflation. Then, 30-year projections were performed for each trial based on the portfolio and funding policy selected. Specific metrics were collected for each trial and then the results are aggregated into summaries to be able to compare to other options.

Clearly, thousands of simulations on one graph or in one table would be impossible to interpret. Instead, the simulations are ranked at each point in time, which produces a distribution of outcomes illustrating the possible range over the projected period.



Then, to communicate the results, the distributions are described in percentiles. For example, the 25<sup>th</sup> percentile means that 25% of the results are lower than this point. We find that the percentiles can be from the top or bottom, and thus find it possibly easier to use other terminology. Since risk is focused on downside outcomes, we may refer to the 25<sup>th</sup> and 5<sup>th</sup> percentile undesirable outcome as the 1 in 4 or 1 in 20 outcome. Also, we are going to rename the percentiles with more descriptive names as shown below:



Typical versions of this model assume each year’s outcome is independent from the one before and after it. Thus, Monte Carlo simulations often ignore everything that is not built into the price movement (macro trends, political impacts, hype, cyclical factors, etc.). For financial forecasts, these simulations tend to give a good distribution of short term returns, and a broad range of possible outcomes, but likely too wide a distribution for longer term scenarios. Thus for this analysis, metrics focused on short to medium term cash flows used the full standard deviation for each asset class, while metrics focused on longer term financial



risks used 70% of the annual standard deviation for each asset class to produce a more reasonable range of longer term outcomes.

## Limitations and Reliability

It is important to remember this is a model, which is built on a set of assumptions, presumptions, and an overly-simplistic version of reality. The reality will most certainly be different, and much more complicated and nuanced, than any of the scenarios modeled. *It is impossible to predict the future.*

As such, a different set of assumptions, or even a different modeling procedure, will produce different results for a specific option. Thus, don't over emphasize the specific result for a given choice. However, the relationship between choices will be more reliable across different models and is useful for decision making. For example, if using the probability of being less than 80% funded as a metric and an option shows a 20% probability of being less than 80% funded, be hesitant with that as a nominal value because a different model could produce a 10% probability or a 30% probability.

However, if Option A shows a 20% probability and Option B shows a 10% probability, that relationship is more reliable as Option B will likely have a smaller probability than Option A in most models, and significantly so. It just may not be 20/10, might be 10/5 or 30/15, etc.

## Capital Market Assumptions

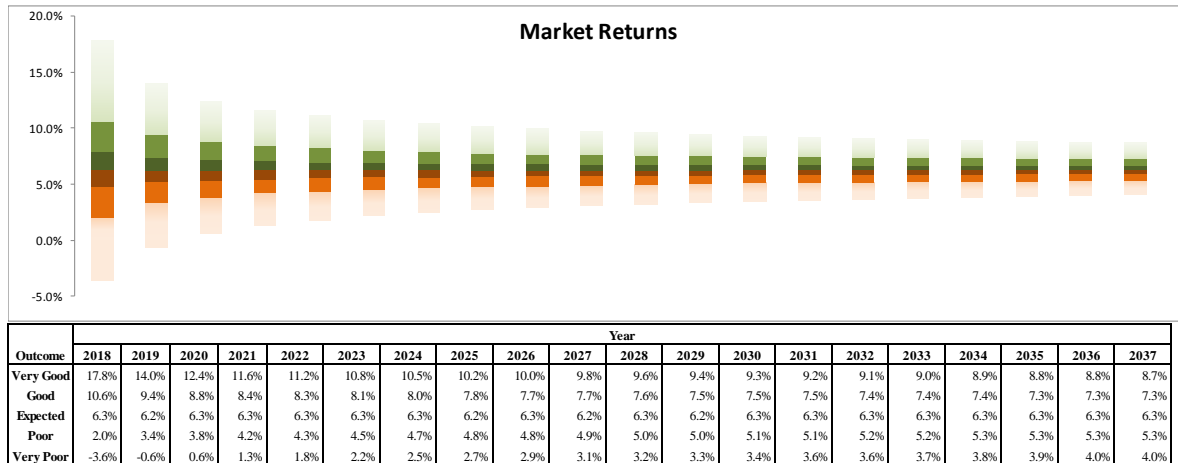
In order to perform a stochastic analysis and create asset allocation alternatives, it is necessary to estimate, for each asset class, its probable return and risk. For this analysis, GRS received capital market assumptions from RVK, the investment consultant for TMRS. The expected returns are their best estimates of the average annual percentage increases in values of each asset class over a prospective long period of time. The risk of an asset class is measured by its standard deviation, or volatility. For this analysis, we assumed all returns were lognormally distributed. The risk and return assumptions used in this study, along with the correlations between asset classes, are outlined in the below table:

	Geometric Return	Standard Deviation	Global Equity	Fixed Income	Non-Core Fixed Income	Real Return	Real Estate	Absolute Return	Private Equity	CPI	GWI
Global Equity	6.3%	18.4%	1.00								
Fixed Income	3.6%	6.0%	-0.02	1.00							
Non-Core Fixed Income	6.0%	11.3%	0.76	0.17	1.00						
Real Return	6.0%	9.1%	0.52	0.22	0.70	1.00					
Real Estate	5.6%	13.9%	0.10	-0.15	-0.09	0.11	1.00				
Absolute Return	5.6%	9.0%	0.81	0.11	0.78	0.61	-0.05	1.00			
Private Equity	8.3%	21.3%	0.75	-0.26	0.50	0.53	0.27	0.72	1.00		
CPI	2.5%	1.5%	0.06	-0.11	-0.01	0.07	0.15	0.15	0.12	1.00	
GWI	3.0%	2.0%	0.29	-0.02	-0.01	0.07	0.30	0.15	0.29	0.40	1.00

## Current Asset Classes and Portfolio Expectations

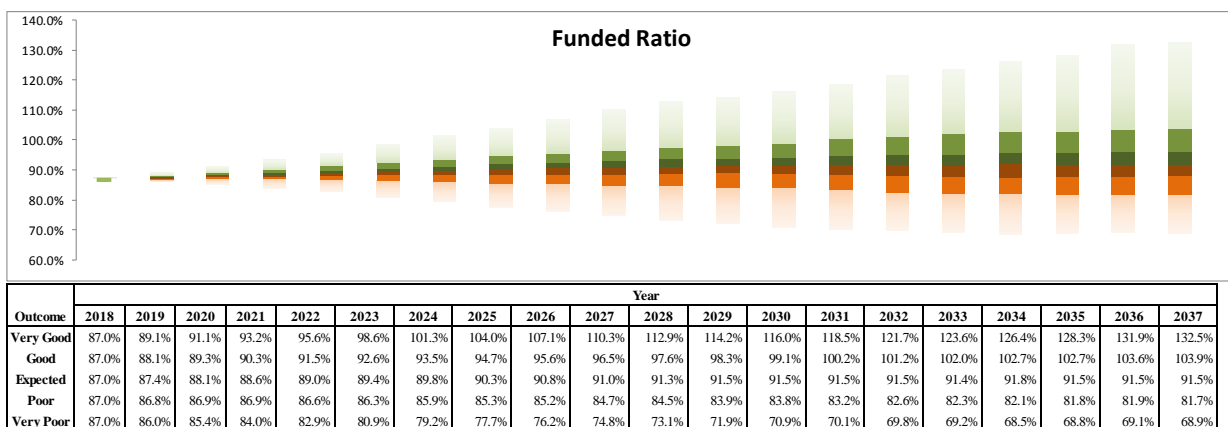
Using the expectations above and TMRS' current target asset allocation, the model produces an expected median return (50% outcome) of 6.30%, with a standard deviation for the entire portfolio of 10.7%. To validate these as reasonable, we compared this to GRS' 2019 capital market survey, which includes 14 sources of investment professionals. This survey produces an expected return of 6.29%, thus we believe the expectations are reasonable for decision making.

As this is lower than the currently assumed 6.75% in the actuarial valuation, the model shows a bias of underperformance at the median outcome. This will become apparent in the results to follow. Over a 20 year period, this produces a 25<sup>th</sup> to 75<sup>th</sup> percentile range of 5.3% to 7.3%



## Stochastic Results

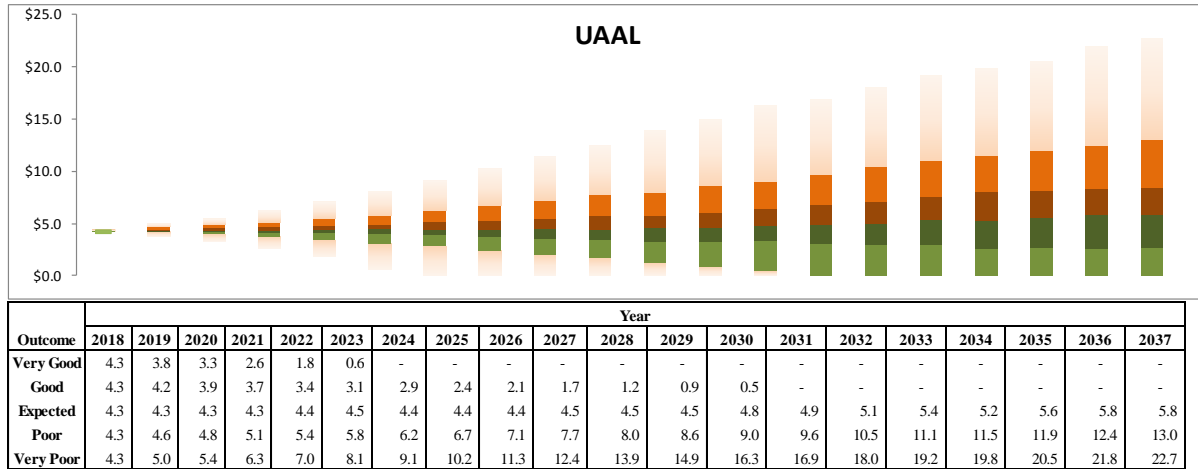
Using the current benefit provisions, funding polices, actuarial assumptions, and the model as previously described, we produce the following distributions of outcomes for TMRS as a whole:



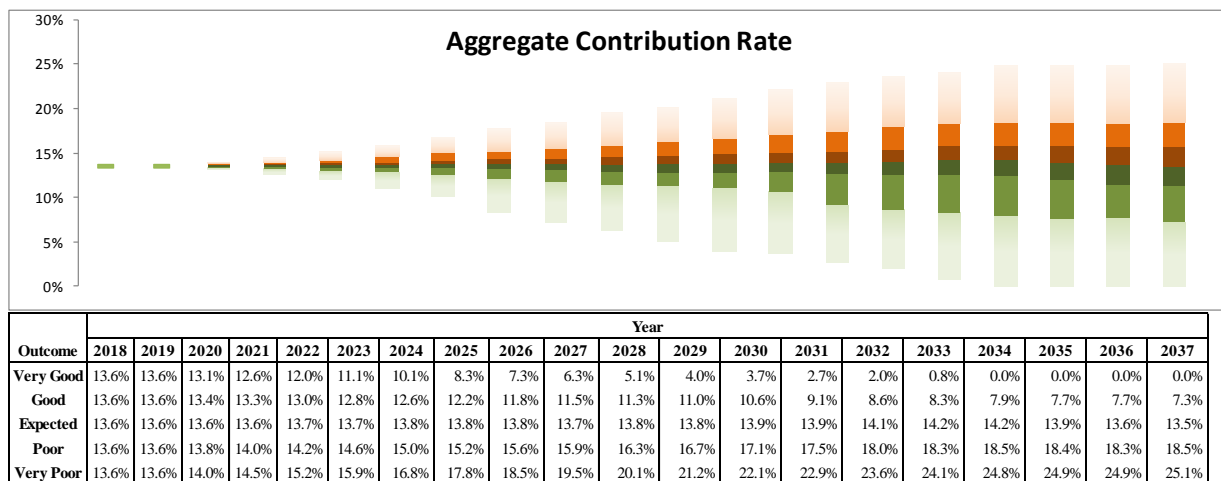
As shown, the 6.3% earnings over time do not increase the funded ratio to 100% over the 20 year period, but it is increasing throughout the period and would continue to do so slowly as the funding policy would amortize off losses. By 2047 the funded ratio would have increased further to 93.4%.

In addition, the funded ratio in the Poor Outcome solidifies around the 82% funded level. This is a metric we use routinely in our communications and decision making as it represents the average adverse scenario (half way between 0% and 50%). In this model, this is a scenario producing 5.3% annual returns. By 2047, this value remains 82%, so this is a long term consistent value based on the current combination of portfolio and funding strategy.

Taking volatility into account, the model produces a 34% probability of being less than 80% funded *at some point* before 2040. This is different than the distributed outcomes above as any of them could have spiked down and then recovered. Likewise, even though the median outcome does not expect to achieve 100% funding by 2040, the model does produce a 42% probability of being 100% funded at some point before 2040.



However, the gap in earnings at the median is large enough so that the UAAL would not be expected to decline in dollar amount, growing from \$4.3b to \$5.8b (and eventually \$6.3b by 2047). Clearly, this is not a desirable outcome. To explicitly address this would require tightening the amortization strategy, lowering the return assumption, generating alpha and/or modifying the portfolio in a way to increase the expected return.



Although the median is not generating 6.75% returns, the current policy includes a large amortization base for most cities that is distributed across the next 10-25 year time horizon. Because of this base being fully amortized, and thus the amortization payment falling out of the annual contributions, the contribution rate at the median does not increase materially above current levels and eventually begins to slowly decline.

At the Poor level, to hold that 82% funded level discussed above, the rate has slowly increased to 18.5%.

## **SECTION IV**

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### **ASSESSMENT OF TMRS RISK CHARACTERISTICS**

# Assessment of TMRS Risk Characteristics

When assessing risk tolerance and comparing peer systems, the following characteristics can impact the appropriate portfolio construction, funding policy, and ultimately all decision making:

- Plan status (open to new participants; existing members still accrue benefits)
- Size of the Plan
- Current funded status
- Maturity level
  - Number of actives to retirees
  - Growth in active population
  - Growth of underlying plan sponsor
- Benefit policy
  - Liability growth rates
  - Sensitivity to Inflation
- Expected funding requirements
  - Discretion of Plan Sponsor on Amount
- Time horizon
- Liquidity needs: Benefit payment less contributions expected
- Liquidity needs: Potential shock
- Sensitivity to size of contribution
- Sensitivity to contribution volatility
- Financial ability to take risk

The analysis attempts to explore TMRS using these characteristics as a guide and providing metrics that can be used to compare the appropriateness alternative strategies.

## Basic Cash Flow Statistics

A pension plan is a series of cash flows. Every month there are contributions made into the trust and benefit payments made from the trust. Any amount paid out from the trust in excess of the amount contributed into the trust must be made up from the corpus of the trust assets.

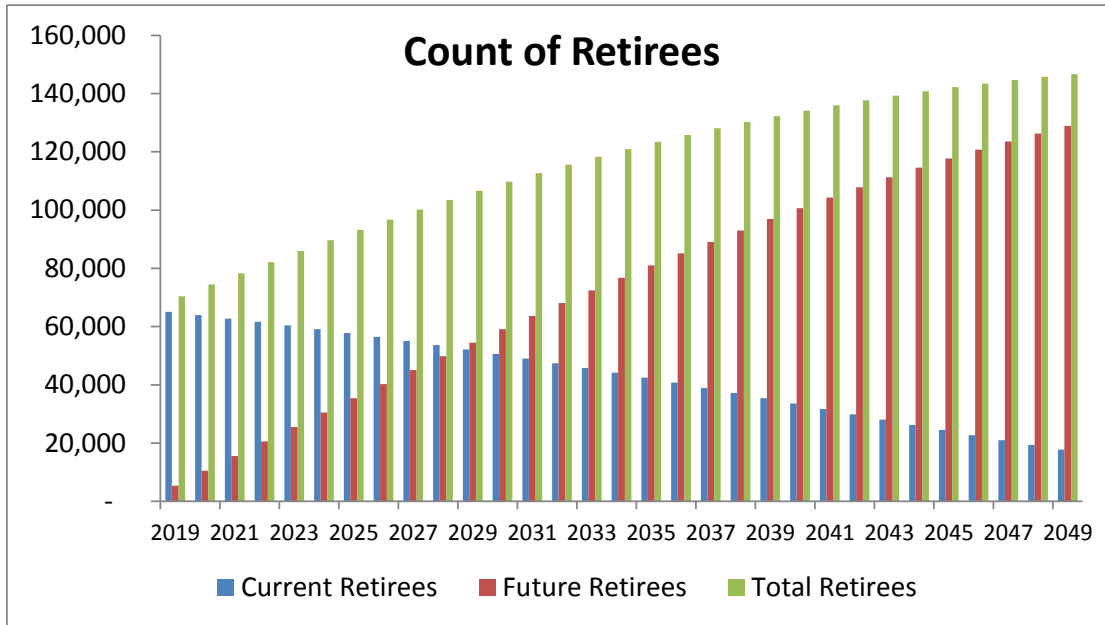
Managing how much of the corpus must be used to meet that difference is one of the main functions of the investment staff and must be considered when selecting investment strategies. A system does not want to be in a position where they have to sell assets every month to meet obligations, as there will be times that selling those assets would be unfavorable.

The difference between the amount paid out and the amount collected is the net cash flow. Typically this is shown as a percent of assets, meaning what percent of the corpus is needed to meet cash flow throughout the year. Net cash flow requirements in the negative 3-4% range is typically seen as manageable as interest, dividends, and the general churning of assets will meet liquidity needs in that range.

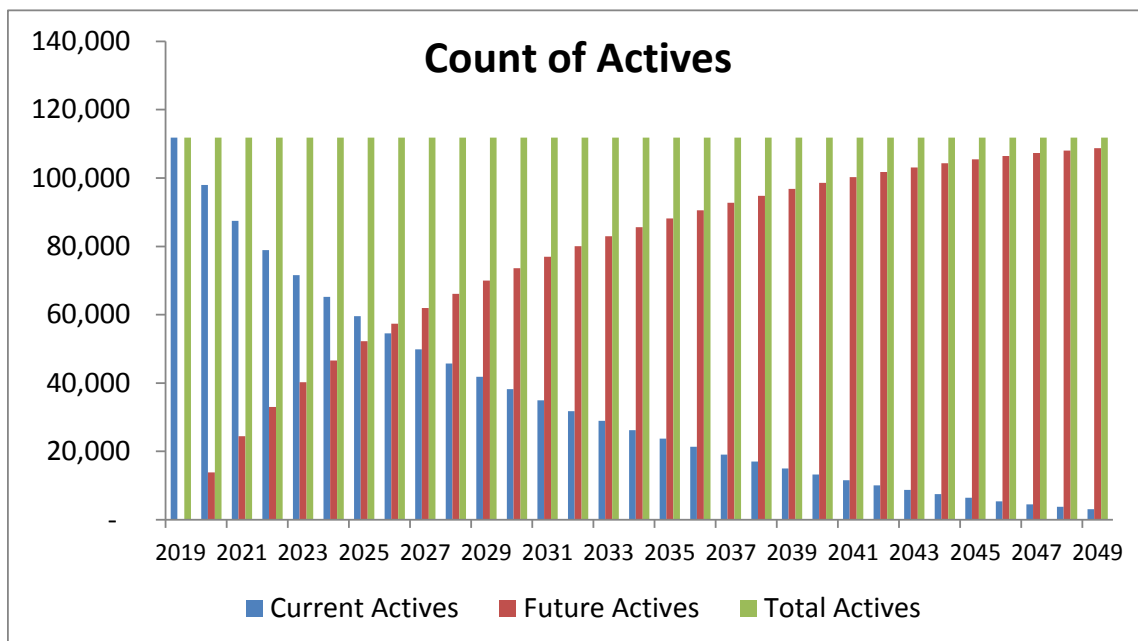
TMRS currently has negative cash flow as a percent of trust assets of less than 1%, meaning the cash flow requirements are very favorable in comparison to peers. The main reason the amount is low is because generally TMRS is still a less mature plan, having experienced substantial active population growth in the

1980's into the 1990's, and continued active population growth since of 1-2% per year, and thus not having a large retiree liability in comparison to the active payroll.

The following is a graph of the projected retiree population over the next 30 years. The number of retirees is expected to double within the next 20 years as half of the current active population is expected to retire within the next decade. Any administrative support that is proportionate to the number of members collecting annuities would likely increase as well.

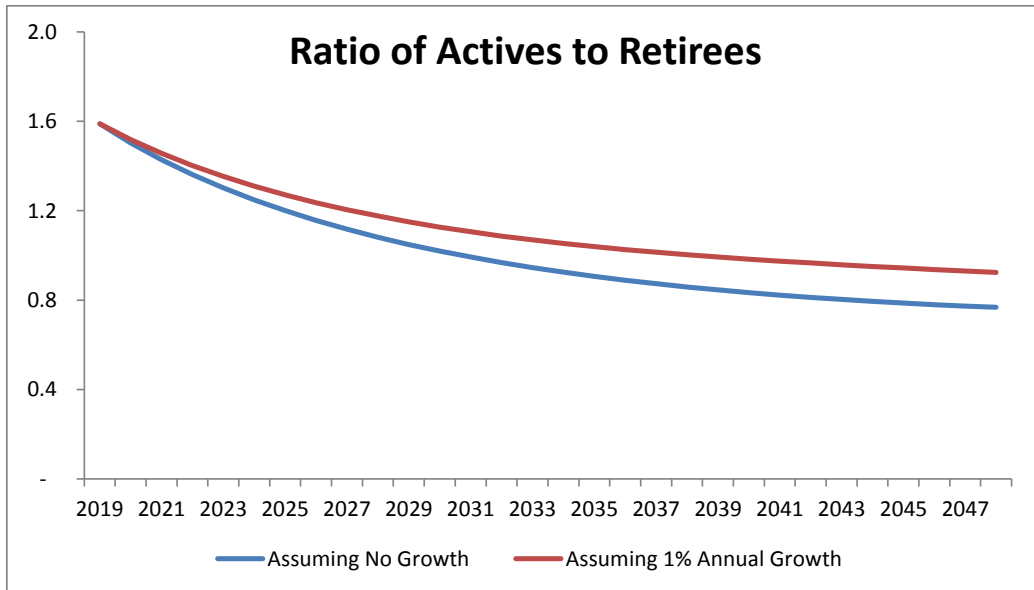


The projections in this analysis assume active membership remains constant. The following is a projection of the active headcount, separated between current membership and replacement active employees.

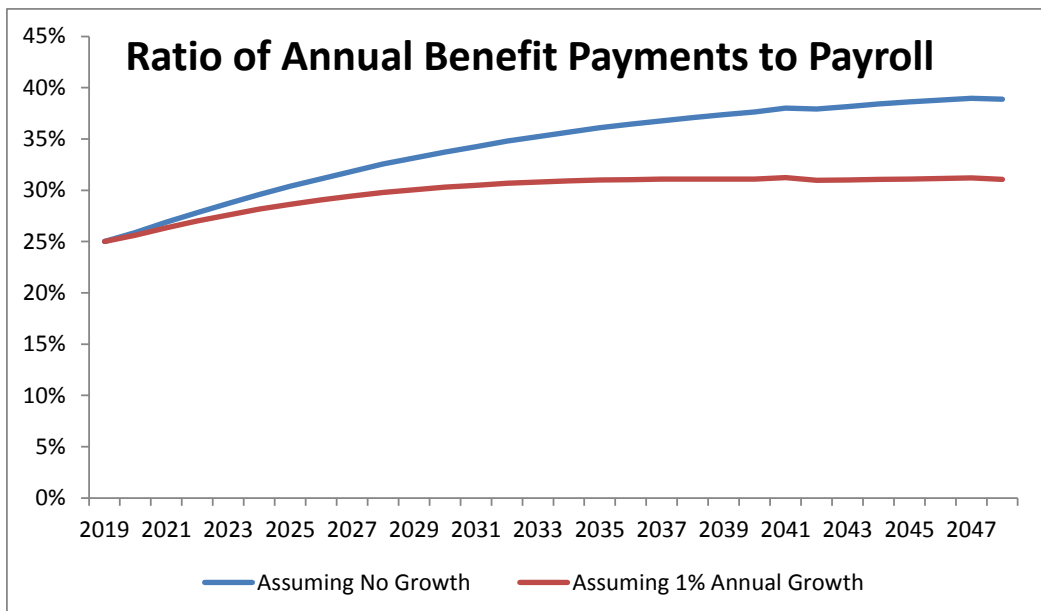


The comparison of these two groups is commonly referred to as the active to retiree ratio. This is a sign of the maturity of the plan. TMRS currently has a ratio of approximately 1.7, meaning there are 1.7

actives to every retiree. The ratio is expected to decline to the range of 0.8 to 1.0, depending on active population growth. This is a reasonable ratio given TMRS' retirement eligibilities. In a pre-funded plan, the declining ratio of active to retired is not expected to change the funding requirements, but it will increase leverage (volatility).



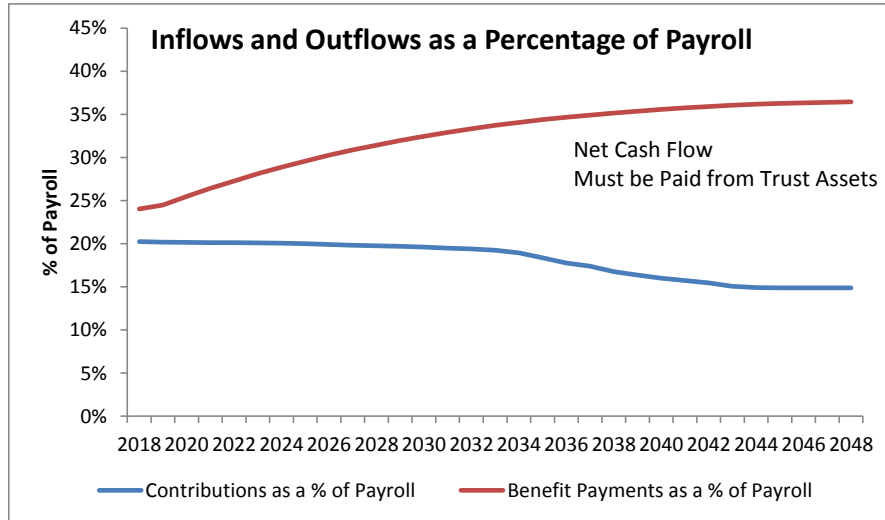
We believe a better metric is the benefit payments to payroll. The active to retiree ratio counts all individuals the same, regardless of the liability and thus the active to retiree ratio for a city with the 5% 1 to 1 benefit package could be the same as a city with 7% 2 to 1 with colas, and clearly they would have substantially different volatility. The benefit payments to payroll reflects these differences in benefit structure. However, the message is the same, leverage should increase over the next 20 years.



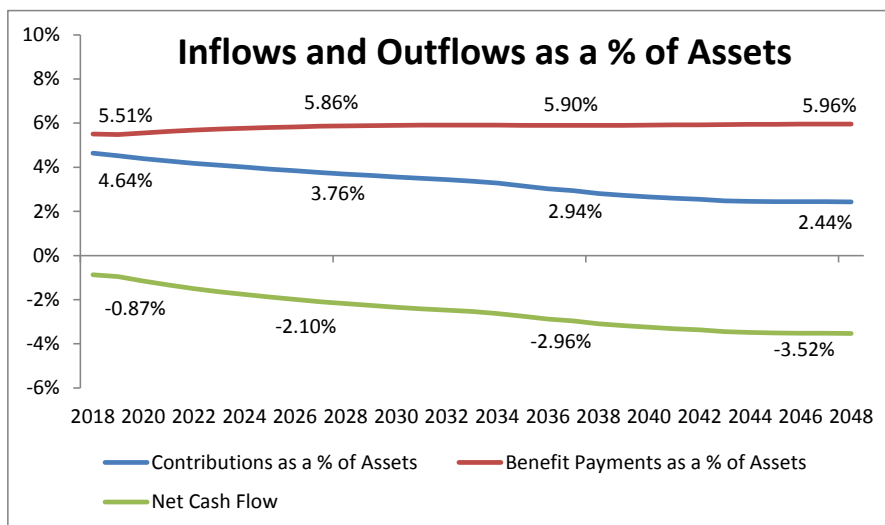
The increase in these maturity metrics also translates into higher levels of negative cash flow. The following graph shows the projected contributions and benefit payments as a percentage of covered payroll. Notice the benefit payments increase while the contributions are actually anticipated to slowly



decline. This is because cities should be reaching the end of their amortization of the 2007 PUC bases and contributions should be declining to the normal cost.

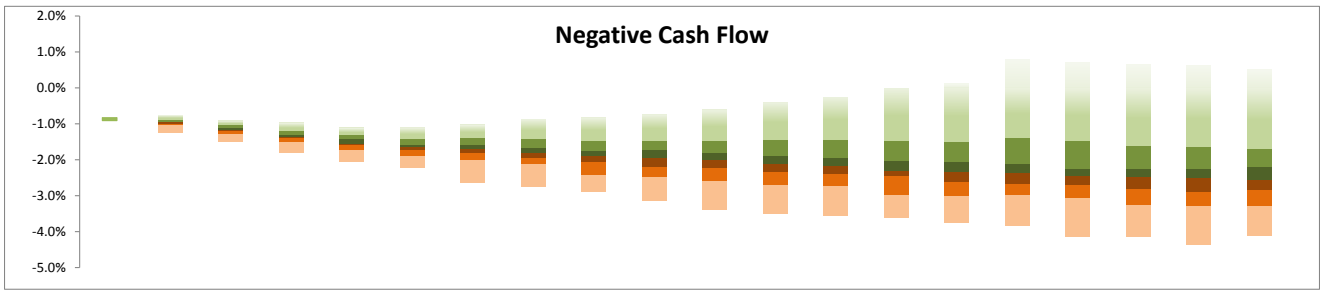


The next graph shows similar information, but as a percent of trust assets, and includes the projection of negative cash flow.



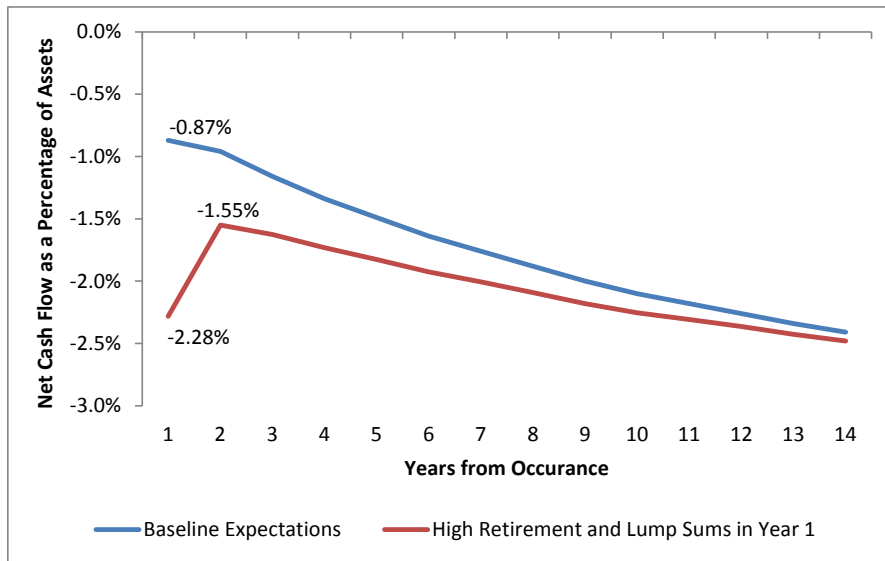
Notice the benefit payments stay rather constant as a percentage of assets and it is actually the contribution declining as a percentage of trust assets that is producing the expansion in the amount of negative cash flow. This is the purpose of the trust fund, to generate investment earnings and help pay the benefits over time. The negative cash flow is anticipated to expand to approximately 3-4% over the longer term, but should not exceed 3% for at least two decades.

As with all of the metrics in this analysis, there is a potential range of outcomes in the negative cash flow. However, the negative cash flow is inversely related to the investment experience. Meaning, favorable investment experience would push contributions down faster, expanding negative cash flow sooner. For example, to reach a level of -3.5% in 2030 requires a scenario with a funded ratio well over 100%.



## Potential Cash Flow Shock

Many pension plans have to deal with the potential for a large swing in the cash flow in a given year. Either the members could choose to take a lump sum of the value of their projected annuity and there is a spike in retirements, or the employer could elect to take a contribution holiday and crash the contribution level. Contribution holidays are not allowed at TMRS, so there is no risk from the contribution side, but to test the potential from the outflows we created a scenario that assumes twice the number of people as expected (historical patterns) retire in a given year and proportionately 50% more members choose PLSO and refund options than expected. The net outflows in year one would be approximately \$400m larger than expected. As shown, the payouts increase, but still within manageable levels, even in this very unlikely scenario given TMRS is a multiple employer plan, meaning it would be difficult for a single event to impact retirement behavior to that extreme a level.

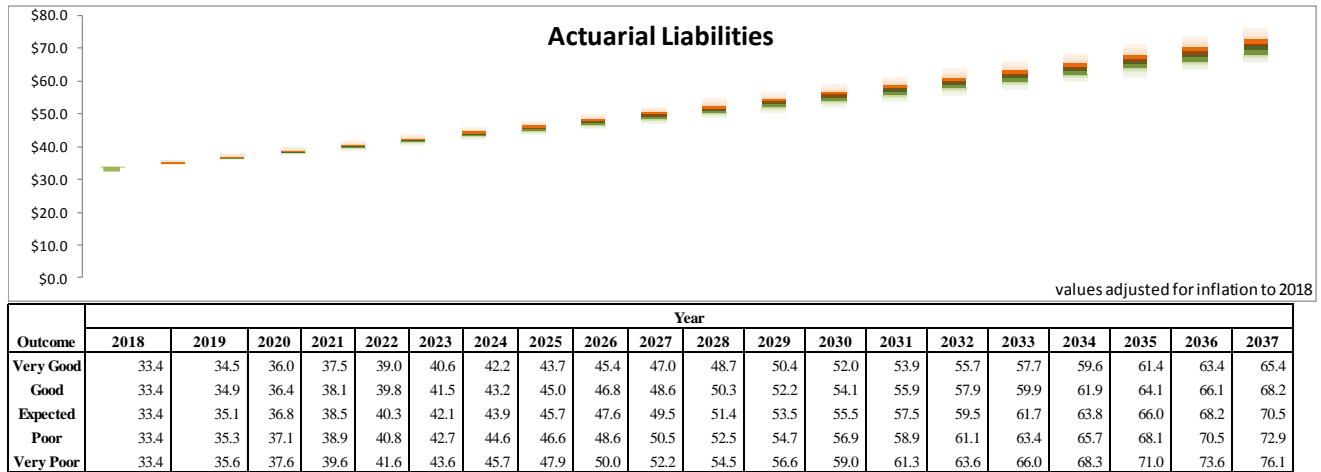


## Liability Growth and Uncertainty

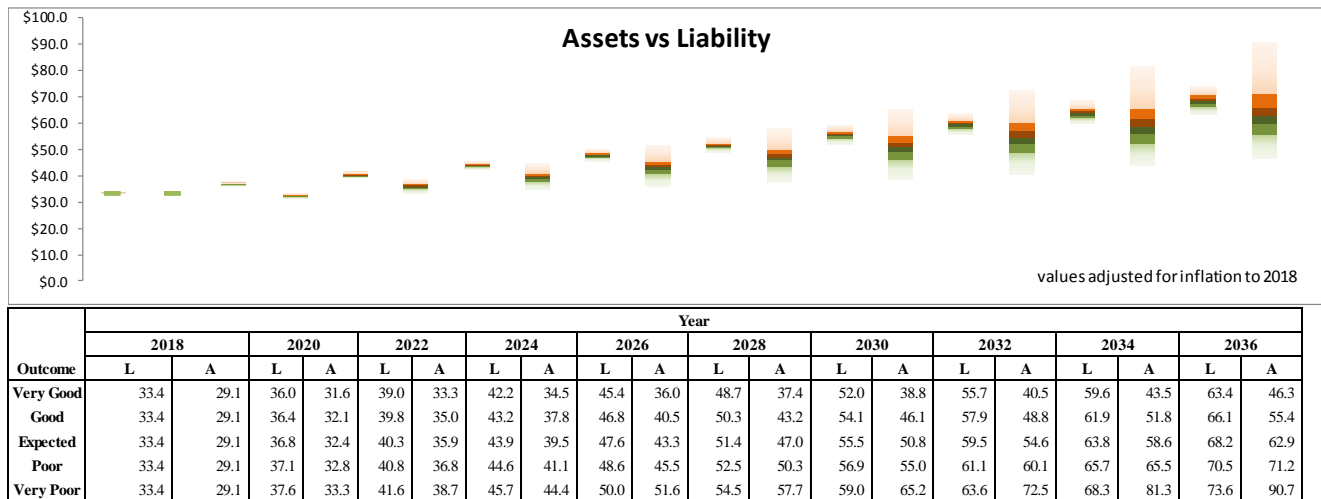
The actuarial accrued liability is a value that represents the present value of all future benefits that are anticipated to be paid in the future, but that have been accrued on past service. In a funding valuation, it more explicitly resembles the target amount of assets the funding policy wants to have in the trust at that point in time. Using either definition, this amount is expected to grow over time as members accrue new benefits and inflation increases the nominal value of those benefits from one generation to the next.

There are multiple sources for potential deviation from the expected growth, but in general the main two for TMRS are price inflation for those with a COLA and wage inflation for those with repeating USC. The

following is a 20 year projection for TMRS as a whole, with the potential variance in the amount from this analysis:



As shown, while there is potential for variation in this amount, it is rather muted. Compared to the range of possible outcomes of the assets, it is almost immaterial. The following compares the distribution of the potential asset values to the potential liability values over time.



Because of this, focus is rightfully put onto investment risk. Especially in the more controlled inflation environment we are currently in, the liabilities are much more predictable.

Liabilities are expected to grow nominally at about 4% per year prospectively while the assets approximately 4.3% per year. The assets are growing faster and are expected to catch the liability and amortize the UAAL.

### Shorter Term Contribution Sensitivity to Inflation

Higher price and wage inflation would both increase contributions in dollar amounts. While correlated, the two forms of inflation are not as correlated as commonly suggested as there are many real life scenarios where they are disconnected.

The cash balance nature of the benefit structure and the less than 100% CPI COLA help limit the exposure to both of these items. In addition, focusing on contribution rates, plans with higher funded status will not be as sensitive to payroll growth compared to peers.

The following exhibit shows the sensitivity of the contribution rates and the contribution dollar amounts to changes in the two forms of inflation over one and five year periods for an example TMRS city. The first column is the baseline result from a 2.5% price and 3.0% wage inflation scenario. The next four columns assume price and wage inflation are precisely correlated and show the impact of inflation being 1% or 3% more than assumed. The last two columns show the impact of price inflation being higher than assumed, but wage inflation being as expected.

Duration	Contributions						
	0%	1 Year +1%	1 Year +3%	5 Years +1%	5 Years +3%	1 Year +3%	5 Years +3%
CPI	0%	+1%	+3%	+1%	+3%	+3%	+3%
GWI	0%	+1%	+3%	+1%	+3%	0%	0%
Billions of Dollars							
2018	1.35	1.35	1.35	1.35	1.35	1.35	1.35
2019	1.39	1.40	1.40	1.43	1.43	1.39	1.39
2020	1.42	1.45	1.46	1.50	1.54	1.44	1.44
2021	1.46	1.49	1.53	1.54	1.66	1.48	1.50
2022	1.51	1.53	1.60	1.58	1.80	1.53	1.57
2023	1.55	1.58	1.67	1.63	1.94	1.57	1.63
2024	1.60	1.62	1.74	1.68	2.03	1.62	1.71
Rates of Payroll							
2018	13.56%	13.56%	13.56%	13.56%	13.56%	13.56%	13.56%
2019	13.53%	13.53%	13.53%	13.53%	13.53%	13.53%	13.53%
2020	13.50%	13.64%	13.91%	13.64%	13.91%	13.73%	13.73%
2021	13.48%	13.62%	13.91%	13.76%	14.31%	13.73%	13.98%
2022	13.47%	13.61%	13.89%	13.90%	14.70%	13.72%	14.25%
2023	13.44%	13.58%	13.85%	14.02%	15.07%	13.69%	14.53%
2024	13.43%	13.57%	13.83%	14.15%	15.43%	13.68%	14.83%

As shown, up to 1% higher inflation, even over a 5 year period would not be substantially different than the expected scenario. However, very high inflation would have a substantial impact on both the contribution rate and especially the contribution dollar amounts.

## Time Horizon

Pension plans are long term financing arrangements, but the question is how long is appropriate for decision making? One series of items to consider is the political reality over the short term to market fluctuations and the impact negative cash flow has on the distribution of outcomes. However, after those, what is the most appropriate time horizon for making investment decisions and for setting investment return assumptions?

The investment return assumption is used to discount the future cash flows, and especially the future benefit payments, into present values as of today. The future benefit payments are discounted to become the actuarial accrued liability, which is a component on the balance sheet of participating employers. Benefit payments that occur one year into the future have only one year to invest, one that occur in two years have two years, and so on. The average discounted weighted benefit payment for current TMRS members is approximately 17 years from now. This is likely the most appropriate choice for selecting the investment return assumption.

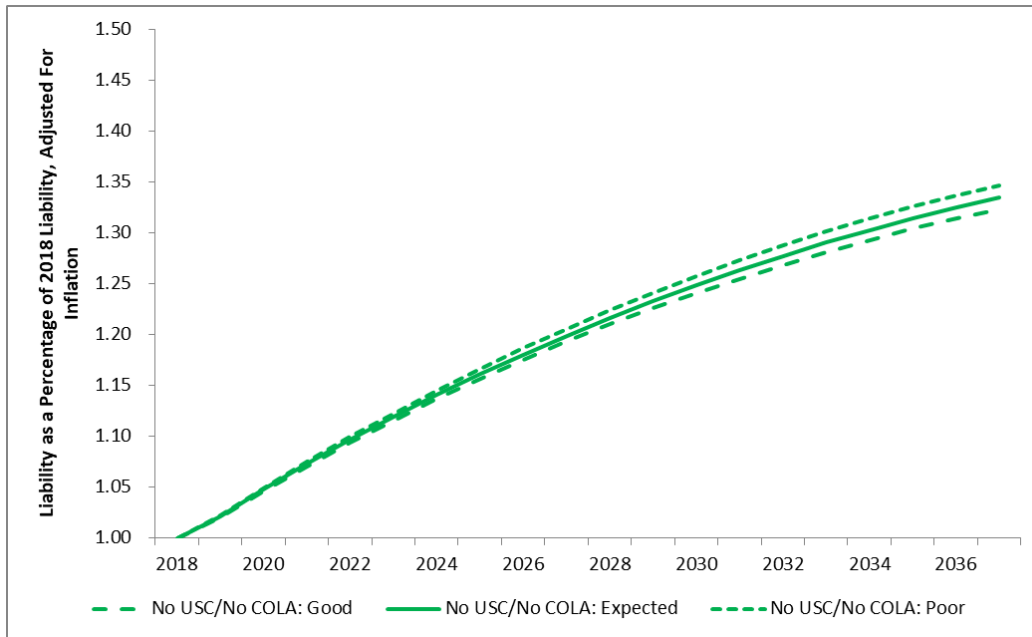
However, as discussed in the cash flow section, much of the annual benefit payments are paid from contribution inflows and thus the trust is responsible for only the portion of the payment in excess of that amount, which is currently very small. The average discounted weighted net cash flow occurs

approximately 21 years from now for current TMRS members, but 32 years from now for TMRS as an open system.

Combining these metrics produces a time horizon of 17 to 32 years for investment decisions, while also having an eye on shorter term risks as the system will have to exist through any short term adverse time period.

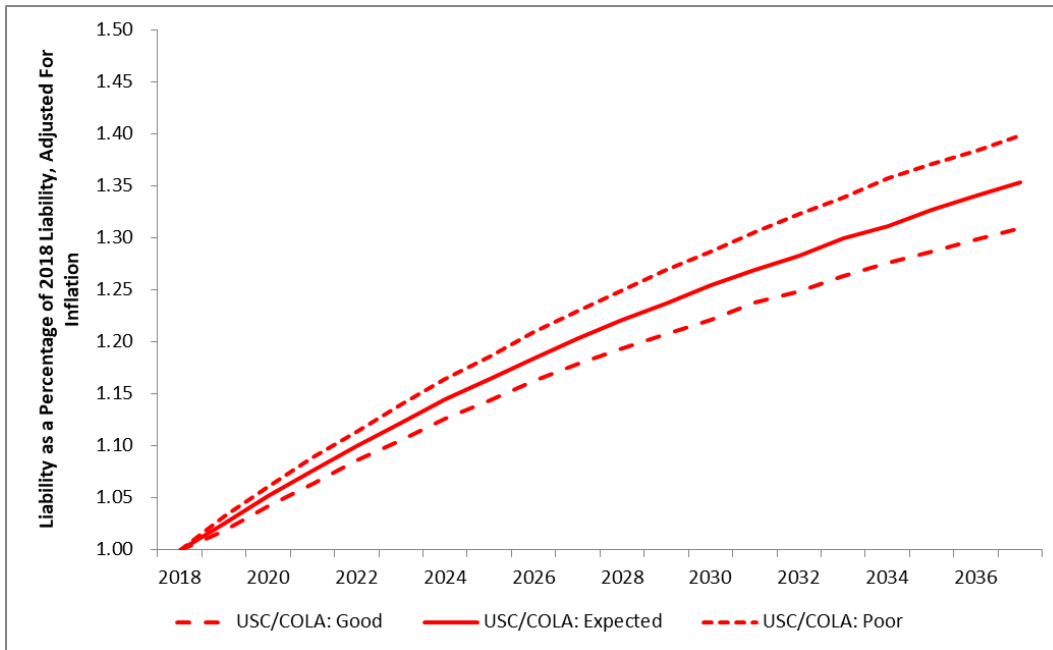
### Impact from Benefit Structure

The various benefit levels provided through TMRS have various levels of projected liability growth and distributions of potential outcomes. In general a traditional cash balance plan with a fixed interest credit has very low distribution of projected outcomes as all liabilities from the past grow at 5% each year. The following is the projected liability as a ratio of today's accrued liability for all units with no repeating USC and no repeating COLA, just the baseline cash balance design.



As shown, this is a very predictable pattern. The most probable outcomes after 20 years are within 1% of the median.

The USC provision adds sensitivity to wage inflation, and a repeating COLA provision adds additional sensitivity to price inflation. The following is the same liability ratio but for units with both repeating COLAs and USC.



The distribution is 4 times wider with these provisions. Thus, this group will have more volatility and has the potential for the actual contributions to be measurably different than currently expected.

However, there are a group of cities providing COLAs annually but financing them on an ad hoc basis. Each time a new COLA is granted, the additional liability is amortized over a 15 year period using a level dollar basis. As most of the cities using this provision are doing it each year, they are stacking layers on top of layers.

To assess the appropriateness of this financing approach, we have compared the projection for the repeating COLA group to this ad hoc COLA group.

The group with repeating COLAs is currently 86% funded and are projected to be 96% funded 20 years from now. The contribution rate is projected to decline from 14.9% to 12.6%. Rates would then slowly continue to decline to about 9.0%.

The group with ad hoc COLAs is currently 87% funded (assuming no future COLAs) and are projected to be 88% funded 20 years from now, modeling that they grant COLAs each year. The contribution rate would be projected to increase from 11.1% to 15.2%. They are never expected to be more than 90% funded, and the rate will remain high perpetually.

There are also the following observations

- The cities providing ad hoc COLAs have just as wide a potential outcome as the cities providing repeating.
- However, their contribution rates have an upward bias over time, so their volatility changes from expecting 0% change with +/- 0.20% per year to an +0.15% expectation with the same +/- 0.20% per year, for a total range each from -0.05% to 0.35%.
- There is real risk that retirees in these groups will not receive COLAs longer term.
- The funded status for cities providing ad hoc colas is not expected to improve.
- The additional liability from COLAs is expected to offset the amortization of the current UAAL from the financing policy.
- Due to lower contributions over the short term, the assets for this group will not grow as fast as the assets for the repeating COLA group, even though they ultimately have the same liabilities.
- Assuming the ad hoc COLAs continue to be provided, the contribution rate will eventually be higher for this group.
- May need to reduce the amortization period for ad hoc colas to improve the sustainability for these units.

## **SECTION V**

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### **APPROACHES TO RISK ASSESSMENT**



## Approaches to Risk Assessment

A risk assessment attempts to analyze what can go wrong, how likely it is to happen, what the potential consequences are, and how tolerable the identified risk is. In everyday life, and maybe even at the stakeholder level of discussion, “risk” is a general term usually used in almost an abstract context: *we can’t make a given decision because it is too “risky”*. A risk assessment should attempt to explicitly define “risk” and what would be deemed to be “too risky”, naming the given risk and by how much it could go wrong, and what those potential consequences are.

For example, the term investment risk is used often and usually means underperformance risk, but it is often analyzed using volatility risk. Both risks are important, and both should be considered, but they are different. There are several more levels of risk and often times these risks will conflict with one another, meaning trying to reduce or eliminate one risk can end up increasing, or even producing, another kind of risk. Some risk mitigation strategies can actually cause the undesirable outcome from another risk to occur. Thus, it is important to clarify which risks are being analyzed but eventually assess the risk in a combined way focusing on the outcomes that are trying to be mitigated or completely avoided.

Put another way, the metrics and individual risks should always be put in context of the main goals of TMRS and the likelihood of creating certain undesirable outcomes.

For example, the standard deviation is typically used to define how risky a portfolio is. If the standard deviation is higher in portfolio A, it is considered more risky than portfolio B. Is this universally true? If a stakeholder is seeking out information on why a decision was made, is a meaningful answer “because the standard deviation is too high?” In this context, to most stakeholders, this is a meaningless answer, because having a high standard deviation is not the undesirable outcome they are concerned about. It is the adverse outcomes which the high standard deviation can create that they are concerned about.

Thus, at a macro level, we find it more useful to define rewards using the outcomes the Board would prefer to occur and risks as the undesirable outcomes the Board (and stakeholders as an extension) wishes to avoid. The following are some examples of each:

Common Desirable Outcomes	Common Undesirable Outcomes
Benefit security for members	Members don’t receive the benefits they currently expect to receive
How little can I expect to contribute?	How much could I potentially pay?
How predictable and stable is what I contribute?	By how much can what I pay change each year?
	Is it possible my contribution amount will grow faster than my budget?
How fast can we pay off the UAAL?	How likely is it that our funded ratio drops below a specific level?

There of course are other risks as well, many of which are non-financial, that also must be considered, like short term drawdowns, being different than peers in a bad outcome, perception of different asset classes and strategies, etc. This analysis is not addressing these risks, but they are important and should also be considered.

Benefit security risk is also a difficult one to analyze because it is dependent on a negotiation process. Thus, it is typically not explicitly modeled. But, it is likely that in Poor Outcomes, and definitely in Very Poor Outcomes, as contributions are exceeding certain levels the risk to benefit security is increasing. Thus, analyzing how much the employer could potentially pay and how low the funded level could drop are implicitly also evaluating the benefit security of the membership.

## Illustration

The efficient frontier will plot expected returns relative to standard deviations. Clearly a 100% stock portfolio will have more volatility and more uncertainty than a 100% bond portfolio.

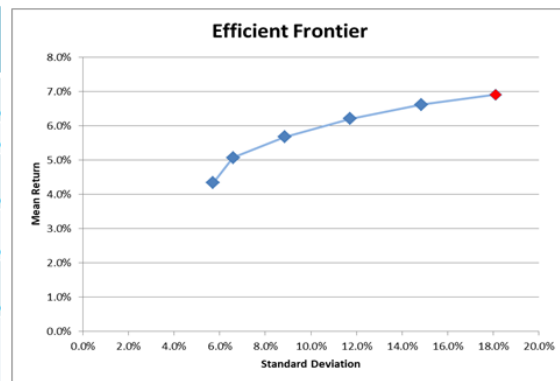
If constructing a portfolio between these two asset classes, both asset classes will benefit from some level of diversification. The question is how much and how would a Board know if it is getting enough return for any given additional unit of risk?

And also, is there a potential cost from not taking enough risk? And what does risk mean in this context?

It is important to distinguish between a wealthy investor investing additional assets, or even an individual investor trying to save for a generic goal, with a pension system. The pension system has an obligation to meet which is independent of the investment performance. The obligation is the benefit payment; it is not the contribution amount. This distinction should not be overlooked as any dollar not generated from investment earnings has to be offset with higher contributions.

To illustrate these points, we have used six generic portfolios across the spectrum of risk and reward using simple stocks and bonds. The following is some detail on the individual portfolios, as well as the efficient frontier.

	0% Stock	20% Stock	40% Stock	60% Stock	80% Stock	100% Stock
Median Return	4.3%	5.1%	5.7%	6.2%	6.6%	6.9%
Standard Deviation	5.7%	6.6%	8.9%	11.7%	14.9%	18.1%
Probability of a Negative Return	14.9%	15.5%	21.6%	25.7%	27.7%	28.4%
Probability of -10% Return	0.0%	0.0%	2.7%	6.8%	10.8%	15.5%
Worst Annual Return	-2.8%	-5.0%	-13.8%	-21.9%	-29.3%	-36.3%
Probability of Achieving 6.75% over 20 Years	14%	19%	22%	34%	44%	53%



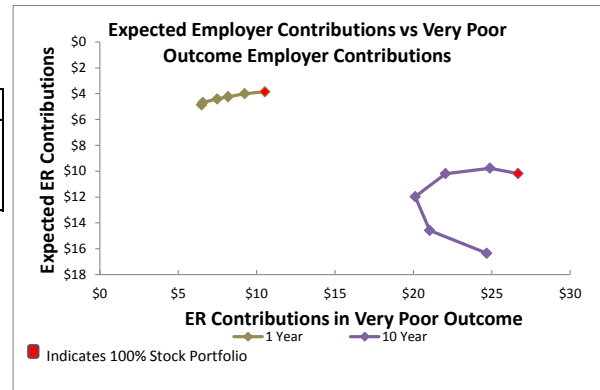
■ Indicates 100% Stock Portfolio

Stock portion is 75% Global Equity/25% Private Equity  
 Bond Portion is 75% Core Bond/25% Non-Core Bond  
 These are not historical. They are based on current capital market assumptions.

As shown, the higher the expected return, the higher the standard deviation. The higher standard deviation portfolios have substantially higher probability of a negative return in a given year and a much higher potential for a material loss. However, they also have a much higher probability of achieving the 6.75% investment return assumption over the next 20 years. Visually inspecting the efficient frontier, it is very difficult after the first step from a 0% stock mix to a 20% stock mix to evaluate whether the additional reward is worth this next step in risk, even though each progression lowers the projected employer contributions in the median outcome.

Thus, below we produce a different kind of efficient frontier that compares the expected costs in normal environments to those in very adverse environments. The expected cost in the normal environment has been sorted so that good outcomes are directionally “up” on the graph, just like the expected return on a typical efficient frontier.

	1 Year		10 Year	
	Expected	Very Poor Outcome	Expected	Very Poor Outcome
0% Stock	\$ 4.9	\$ 6.5	\$ 16.3	\$ 24.7
20% Stock	4.7	6.6	14.6	21.0
40% Stock	4.4	7.5	12.0	20.1
60% Stock	4.2	8.2	10.2	22.0
80% Stock	4.0	9.2	9.8	24.9
100% Stock	3.9	10.5	10.2	26.7



As shown above, over a one year time horizon, additional risk is not being rewarded. The line is almost straight across. This shows why pension funds, or any longer term financial arrangement, that has to mark to market on an annual basis eventually decreases their risk exposure over time.

However, at the 10 year time horizon some amounts of risk are being rewarded, and in fact the lowest level of “risk” according to the standard deviation is showing to be very costly in all environments. A 40% stock portfolio anticipates the employer putting in less in the expected (normal) scenarios at approximately \$12.0 compared to either the 20% or the 0% scenario, and, at the same time, producing less employer contribution in the Very Poor Outcomes, as well. Any move “up” and “to the left” on an efficient frontier is optimal.

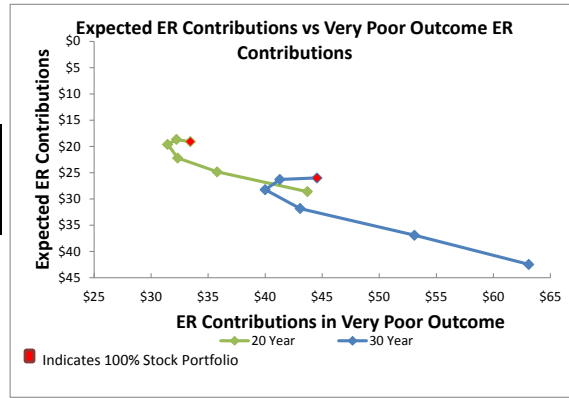
Likewise, the 80% stock portfolio is advantageous to the 100% portfolio. The diversification component from the bonds in the portfolio is generating about the same returns with less risk.

Therefore, the decision is then between the 40%, 60%, and 80% portfolios for the optimal reward vs risk, with 60% appearing to be substantially better than the 80% from a risk perspective.

What about longer time horizons? Riskier portfolios do have wider distribution of outcomes, but are those distributions high enough above the safer distributions to still be advantageous? And, are the lower distributed portfolios generating enough to keep up with the 6.75% return assumption? The following provides the same information at the 20 and 30 year time horizons.

Employer Contributions Over Period, Plus Remaining UAAL

	20 Year			30 Year		
	Expected	Poor Outcome	Very Poor Outcome	Expected	Poor Outcome	Very Poor Outcome
0% Stock	\$ 29	\$ 36	\$ 44	\$ 42	\$ 52	\$ 63
20% Stock	25	32	36	37	46	53
40% Stock	22	26	32	32	37	43
60% Stock	20	25	31	28	32	40
80% Stock	19	25	32	26	33	41
100% Stock	19	26	33	26	33	45



As can be seen, the “safer” portfolios are struggling at both longer term time horizons, and, in fact, the 40% stock portfolio has dropped behind the 60% in risk, as well. *The 60% stock portfolio actually produces less employer contributions in the Very Poor Outcomes than any of the other alternatives over both 20 and 30 year periods.* The 80% portfolio is expected to generate moderately more reward in the expected scenarios, but given how much more volatile it is in the 1 year and 10 year comparisons above, the 60% portfolio is looking advantageous compared to the others.

There are two other metrics to help assess risk in a pension plan in a similar way: contribution rate volatility and funded ratio. The following provides the probability of a contribution rate increase being 0.5% or 1.0% in a given year, as well as the probability that the funded ratio drops below 80% by 2040.

	Probability of Contribution Increase Greater Than		Probability Less than 80% Funded	
	0.50%	1.00%	In 2040 (MVA)	Anytime before 2040 (AVA)
0% Stock	36%	14%	79%	73%
20% Stock	26%	9%	58%	59%
40% Stock	23%	11%	48%	50%
60% Stock	24%	13%	34%	50%
80% Stock	25%	16%	31%	54%
100% Stock	27%	19%	31%	58%

As shown, the higher portion stock portfolios have substantially less probability of being less than 80% funded. In fact, the safest alternative all but guarantees the funded ratio will be less than 80% given enough time. More volatility does come with more contribution rate fluctuations, so that should be considered, as well.

## Summary

Once a guarantee has been made to pay another party a given amount of money at a specific point in time, the consideration of undesirable outcomes must change. Some would argue that a “safer” approach to investing is the most prudent, but this analysis partially asks: “Safe from what?” If cost is a

risk factor, and in today's environment it is typically the first issue asked or commented on, then the safer portfolios by traditional metrics appear to lock in higher projected costs.

However, there is a curve to the results above showing that there is a point where the risk is no longer being rewarded. We remind the reader that this is a model and it certainly has its limitations, but the generic recommendation often made to individual investors to be approximately 60% stocks appears to have merit based on this analysis.

## **SECTION VI**

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### **ANALYSIS OF ALTERNATIVE INVESTMENT PORTFOLIOS**

## Analysis of Alternative Investment Portfolios

This section will use the baseline projection results from Section III and the approaches presented in Section V to examine a narrower spectrum of alternate portfolios which include more diversification options than those presented earlier. The following is a summary of TMRS' current target asset allocation.

Asset Class	Comment
Global Equity	35% Traditional
Int. Duration Fixed Income	10% Traditional
Non-Core Fixed Income	20% 50% Alternative
Custom Real Return	10% 60% Alternative
Custom Real Estate	10% Alternative
Absolute return Strategies	10% Alternative
Private Equity	5% Alternative
Percent in alternatives	41%
Expected Return (Compound)	6.30%
Standard Deviation (Risk)	10.65%

The current portfolio has an expected compound return of 6.30% and a standard deviation of 10.65%. These metrics will be a starting point for comparing various portfolios. However, we have also indicated whether some or all of a given asset class would be considered "Alternative".

These classes have either implicit active management already built into the expectations or are made up of a group of sub-asset classes themselves and benefit from internal diversification, and thus it is difficult to compare the risk and reward characteristics to more traditional, or more segmented, asset classes. If left unconstrained, the optimizer would try to "fill up" those options first with small allocations to global equity, bonds, etc. In fact, the current characteristics of those classes are such that if completely unconstrained, the optimizer would not choose Global Equity or Int. Duration Fixed Income at all. This means for any unit of risk, the optimizer can find a better choice in the Alternative space than in the Traditional space. However, these classes also tend to have unique characteristics that require much more oversight, managing liquidity, active management, due diligence, fees, etc. Essentially, it takes more than a simple mathematical optimization model to differentiate between the risks and rewards of these classes.

Thus, for this analysis, we have grouped all of those classes together, basically creating one input for these strategies and then letting the optimizer choose between the remaining classes. This is consistent with how TMRS Staff and RVK have communicated with the Board in the past. The first main decision is what limits to put on these diversifying "Alternative" strategies, and then move on to other decisions. So for this analysis the current portfolio could be described as:

<u>Asset Class</u>	
Global Equity	35%
Int. Duration Fixed Income	10%
Other Traditional Strategies	14%
Non Traditional Strategies	41%
Expected Return (Compound)	6.30%
Standard Deviation (Risk)	10.65%

The optimizer will examine each unit of risk and develop the portfolio that produces the highest expected return for that amount of risk. For example, if a standard deviation of 10% is specified, the optimizer will find the portfolio that produces the highest expected return possible with a standard deviation of 10%, which may have an expected return of 6%. Then the optimizer moves on to the next unit of risk, perhaps 10.25%, and finds another portfolio, and so on.

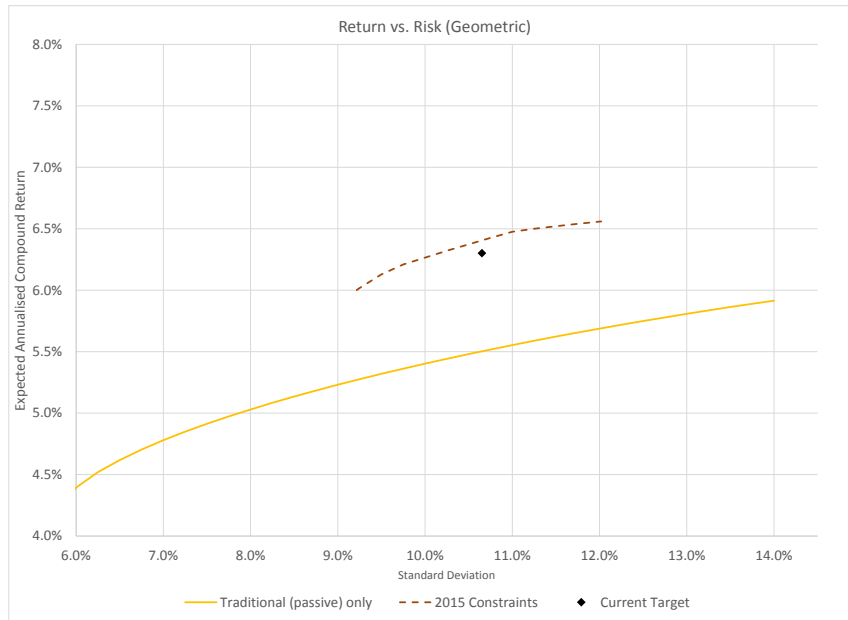
This process produces a tool called an efficient frontier which provides the full range of optimal portfolios across the entire risk spectrum. For example, the following would be the efficient frontier if only traditional asset classes were available.



So as the expected return moves up in the graph, the risk component is moving to the right. Now, this graph shows that any portfolio made up of only traditional asset classes will have a difficult time generating the 6.75% current assumed rate of return. In fact on this graph, to get above a 6% expected return takes a portfolio with a standard deviation of over 15%.

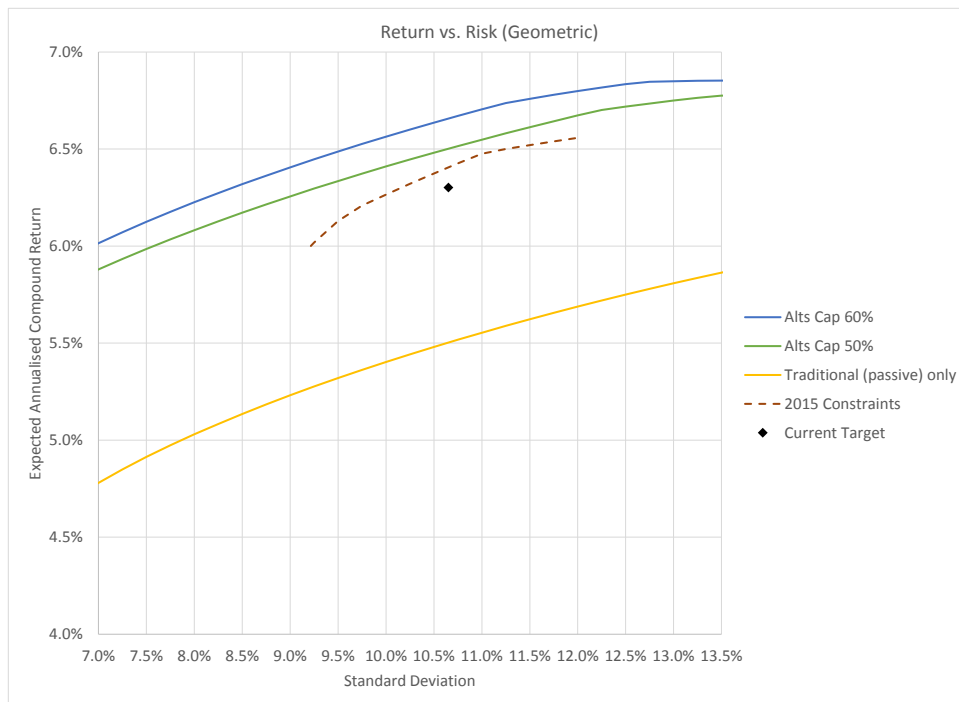
This shows why more and more institutional investors have moved towards non-traditional strategies. In the last asset allocation study, the Alternatives were constrained to 41% of the portfolio. In addition, there were other constraints put in the model, such as Private Equity could not be more than 5% of the total allocation, etc. The following includes a new efficient frontier using the constraints from the 2015 study and today's expectations,





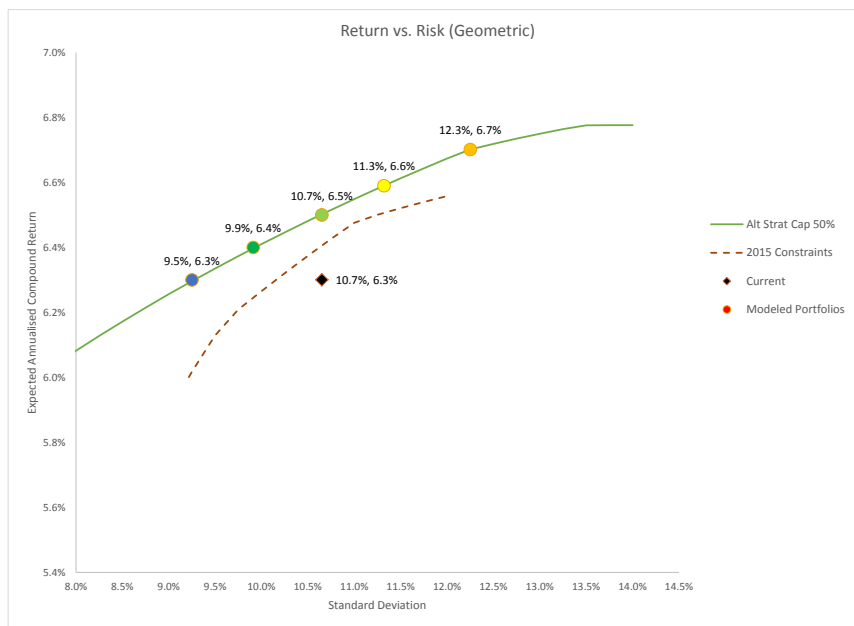
As shown, the additional diversification and the inclusion of non-traditional asset classes have produced an entirely different efficient frontier, with much better risk and return characteristics. However, the current portfolio is not expected to achieve 6.75%, and any options on this efficient frontier that are reasonably close require a substantial move to the right on the risk spectrum. In fact, the portfolios at the 6.5% level and higher all have no allocation to Int. Duration Fixed Income.

Some of the constraints in the 2015 study were because of the starting point in the portfolio. For example, the Private Equity was constrained at 5% because in 2015 the actual allocation was 0% and moving to anything higher than 5% in a three to four year period would be difficult. In addition, some of the internal resources required to implement some of the non-traditional strategies had to be developed. With today's portfolio and resources as a starting point, the Board could consider a different set of constraints. For illustrative purposes, the following provides more efficient frontiers based on two levels of additional constraints: 50% and 60% Alternatives.



As shown, mathematically there are other options that continue to produce better risk and return combinations, based on the assumptions used in this model, with higher allocations to the Alternatives. Some produce the same return as the current with less risk, some more return with similar risk, and some with enough more return to get much closer to the 6.75% assumed return, but with more risk.

A significant reason to perform an asset liability study is to evaluate other policies in comparison to current ones. Thus, to illustrate some of the metrics discussed in Section V and their impact on this decision, we have illustrated a range of portfolios from the 50% Alternatives efficient frontier. We chose the 50% Alternatives because it might be a reasonable next step in the development of the portfolio and because there was enough separation between points on the line to show some level of variance between options. The following is a graphical illustration of the selected portfolios.



The following described why the portfolios were modeled:

- The first achieves the same expected return as the current portfolio, but with less standard deviation
- The next moves up and to the left on the frontier, meaning it achieves slightly more return than the current portfolio but also with less standard deviation
- The next achieves more expected return, with the same standard deviation
- The next achieves even more expected return, but has to increase the standard deviation moderately to do so
- The next attempts to solve for something close to 6.75%, but doesn't push past a given point in the model. If you look visually you can see a material slope change at this point in the frontier.

The following is a summary of the characteristics of the illustrated portfolios.

	Current	Same Return, Less Risk	Some Return, Less Risk	More Return, Same Risk	Extra Return, More Risk	Higher Return, Higher Risk
	(1)	(2)	(3)	(4)	(5)	(6)
Median Return	6.3%	6.3%	6.4%	6.5%	6.6%	6.7%
Standard Deviation	10.7%	9.5%	9.9%	10.7%	11.3%	12.3%
Global Equity	35.0%	21.3%	25.2%	29.4%	33.4%	38.7%
Core Fixed Income	10.0%	17.1%	13.2%	9.0%	5.0%	0.0%
Other/Non-Alternatives	14.0%	11.6%	11.6%	11.6%	11.6%	11.6%
Alternative Strategies	41.0%	50.0%	50.0%	50.0%	50.0%	49.7%
Probability of a Negative Return	27%	24%	25%	26%	27%	29%
Probability of -10% Return	4%	2%	3%	4%	5%	6%
1/100 Worst Annual Return	-14.9%	-12.3%	-13.5%	-14.7%	-15.9%	-17.5%
Probability of Achieving 6.75% over 10 Years	44%	43%	45%	46%	47%	48%
Probability of Achieving 6.75% over 20 Years	43%	42%	44%	46%	47%	49%

Thus, clearly the three portfolios up or to the left from the current appear preferable. But how do the other portfolios, which must take on more "risk" to achieve more return, relate to the current portfolio? Is the additional expected return enough to warrant the additional volatility and uncertainty?

For this analysis we have used other metrics to try to put the additional amount of risk into the context of having an obligation to pay benefits to retirees. The amount of the annuity payable to a retiree is independent of the amount of earnings generated. Thus, even though the standard deviation of the portfolio might be higher, does that lead to higher contributions, higher probabilities of declining funded ratios, or higher contribution volatility? These tend to be the financial risks that stakeholders of pension plans tend to focus on.

So, revisiting the economic cost variables discussed previously, we calculated the total projected employer contributions based on the alternative portfolios at the median, the 1 in 4 outcome, and the 1 in 20 outcome. The total projected employer contribution is the accumulated contributions, plus any remaining UAAL at the end of the horizon, all discounted with inflation back to 2019.

We also did this for the Effective Contribution Rate. The Effective Contribution Rate is the contribution as a percentage of payroll that would need to be collected over the specified time horizon (in this case 20 years) to fully amortize the UAAL created by that scenario, meaning all 5,000 scenarios have a unique Effective Contribution Rate determined based on the result of that actual trial that would produce a

UAAL of \$0 at the end of the 20 years. This metric can take on several meanings, but the simplest understanding would be the rate that the actual contribution rate would trend towards as the experience unfolds. Any difference in this rate and the current actual rate would be an economic cost that is pushed into a future generation.

For this analysis we focused on TMRS cities with repeating USC and COLAs, as they will be the most volatile. The results are in the following table:

20 Year Time Horizon			Total Contributions			Effective Contribution Rate		
	Expected Return	SD	Expected	Poor Outcome	Very Poor Outcome	Expected	Poor Outcome	Very Poor Outcome
Current	6.3%	10.7%	\$ 18.3	\$ 25.2	\$ 33.4	16.4%	21.3%	27.4%
● Same Return, Less Std Dev	6.3%	9.5%	18.2	24.6	31.8	16.3%	20.8%	26.1%
● Some Return, Less Std Dev	6.4%	9.9%	17.7	24.4	32.0	15.9%	20.6%	26.3%
● More Return, Same Std Dev	6.5%	10.7%	17.1	24.1	32.3	15.5%	20.4%	26.5%
● Extra Return, More Std Dev	6.6%	11.3%	16.7	23.8	32.7	15.2%	20.3%	26.7%
● Higher Return, Higher Std Dev	6.7%	12.3%	16.3	23.6	33.1	15.0%	20.2%	27.1%

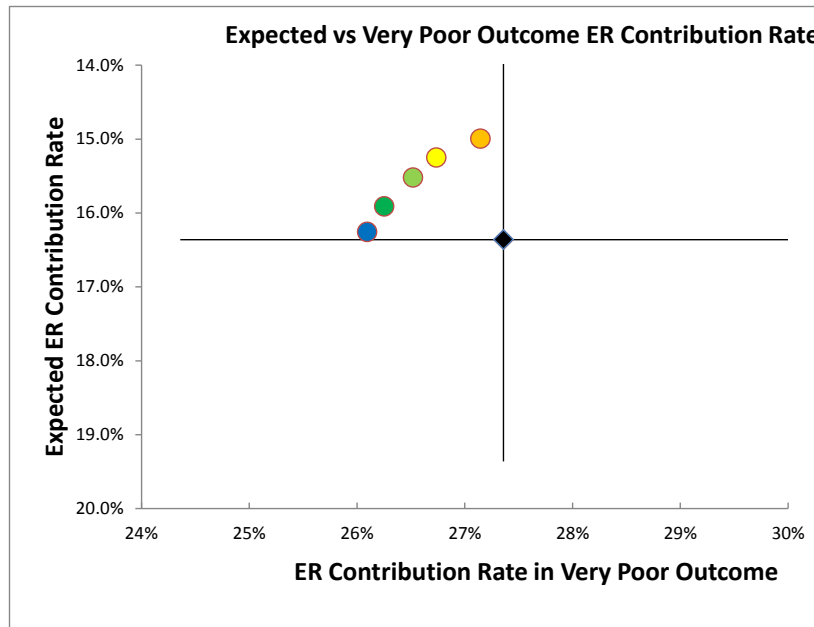
\$ in billions

In the Expected outcome, the higher the expected return of the portfolio, the lower the expected contributions. This makes sense as they are expected to generate more investment earnings, and thus if the benefits are the same, the contributions would be less. For the Effective Contribution Rate, this group currently has an aggregate contribution rate of 14.9%, thus in the last portfolio that is expected to achieve the 6.70% also has an Effective Contribution Rate close to 14.9%. With the Current portfolios 6.3% expected return, the Effective Contribution rate is 16.4%, or 1.5% higher. This analysis is proving the adage that over time the actual cost is based on what is actually earned, not what is assumed will be earned.

In the adverse outcomes, when comparing the options to each other, the pattern looks as anticipated: as the outcomes become more adverse, the riskier portfolios begin to slightly underperform. However, it should be noted that in the 1 in 4 outcome, the higher standard deviation portfolio still produces less contributions.

Comparing the other portfolios back to the current, all of the illustrated portfolios produce less contributions across the entire spectrum of outcomes. This would not be true at the 10 year time horizon, and is very dependent on the assumptions used for the asset classes, especially the amount of risk premium assumed to be generated, but is a rather different view of the potential risk in the context of cost.

The same pattern is presented in the Effective Contribution Rate. The following is an efficient frontier, but mapping the Effective Contribution Rate in the expected outcome against the 1 in 20 outcome, and notice that all alternative portfolios are up and to the left of the current one. Note that contribution rates on the y-axis has been plotted in reverse order to make a higher dot (i.e. lower contribution rate) the desired outcome just like a typical efficient frontier.



Thus, given a 20 year time frame (and giving this model full credibility) this analysis would suggest all of the alternative portfolios are “less risky” in the context of the amount of contributions as the potential adverse outcome is actually smaller.

This analysis also points out another important note to consider: *the amount of contribution in the Very Poor Outcome is substantially higher than the current contribution level of 14.9% across all portfolios.* If an environment that produces a 1 in 20 outcome develops, all of the portfolios modeled produce Effective Contribution Rates 10% higher than current contribution levels. So the total amount of risk mitigation that can be created is rather small.

What about funded status and contribution rate volatility? We also examined these metrics for all of the portfolios. The following provides some data points.

	Expected Return		Probability of Contribution Increase Greater Than		Probability Less than 80% Funded		Prob, >100% Funded
			0.50%	1.00%	In 2040 (MVA)	Anytime before 2040	Anytime before 2040 (AVA)
Current	6.3%	10.7%	19%	7.0%	31%	34%	45%
Same Return, Less Std Dev	6.3%	9.5%	17%	5.2%	28%	28%	42%
Some Return, Less Std Dev	6.4%	9.9%	18%	5.7%	27%	29%	45%
More Return, Same Std Dev	6.5%	10.7%	18%	6.2%	26%	30%	49%
Extra Return, More Std Dev	6.6%	11.3%	18%	6.8%	26%	31%	52%
Higher Return, Higher Std Dev	6.7%	12.3%	19%	7.6%	26%	32%	54%

The two middle columns show the probability the contribution rate increases by more than 0.5% or 1% in any given year. This group has a current contribution level of 14.9%, so that would be equivalent to increasing to 15.4% or 15.9% in one valuation cycle. As shown, as the standard deviation increases, the contribution rates get more volatile, but all are no more so than the Current. That is because the Current is not expected to generate 6.75%, which is generating actuarial losses and thus has a bias to create increases in cost.

All of the alternatives also show quite lower probability of being less than 80% funded in 2040, and the higher the expected return the higher probability of achieving full funding in the next 20 years.

Thus, all of the potential investment strategies relative to the current investment strategy appear to include the following financial advantages:

- Higher expected return per unit of asset risk (return divided by standard deviation)
- Higher expected return per unit of liability risk (expected contributions divided by adverse contributions)
- Lower expected economic cost
- Higher expected ending funded status
- Lower contribution volatility in all but the highest standard deviation portfolio

The purpose of this exercise was to provide more context and other methods of assessing the riskiness of a given portfolio choice in the context of typical actuarial valuation results and long term costs. The standard deviation, capital market risk (short term), and the other risk metrics should also be considered.

Likewise, and just as importantly, other non-financial risks should be considered, although these are not in the purview of this analysis. Stakeholders should understand all of the illustrated portfolios have higher allocations to a more diverse set of asset classes, many of which require much more oversight, managing liquidity, active management, due diligence, fees, etc. Essentially, it takes more than a simple mathematical optimization model, or an actuarial projection, to differentiate between the risks and rewards of these classes. Thus, in the upcoming asset allocation study, one of the first main decisions is what limits to put on these diversifying “Alternative” strategies, and then move on to other decisions.

## **SECTION VII**

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### **ANALYSIS OF ALTERNATIVE FUNDING STRATEGIES**

## Analysis of Alternative Funding Strategies

This type of model can also be used to test various funding policies, and the accompanying parameters, against each other to put their risks and rewards into context, as well. For this analysis, we used the portfolio that expects a 6.6% return from the above section. We are in no way recommending that as a choice, or presuming that would be the portfolio chosen by the Board, but used it because it produces outcomes closer to the current 6.75% return assumption and the lower median return of the current portfolio actually produces a bias when examining funding strategies.

The current policy is based on 10 year asset smoothing and 25 year layered amortization of any UAAL and actuarial losses. The current layered methodology is the most commonly used policy in the industry, although there are several others. We employ offsetting techniques that are non-traditional to attempt to dampen the year to year volatility in the contribution rate. These techniques are used both in the amortization and asset smoothing process and will offset any experience in one direction, whether a gain or a loss, against previous experience in the opposite direction before continuing with the layered recognition.

The following compares the current 25 and 10 layered approach used at TMRS to a more traditional application of the layered approach with the same parameters.

	Probability of Contribution Increase Greater Than 0.50%	Probability Less than 80% Funded In 2050 (MVA)
Traditional 25/10	31%	25%
TMRS 25/10	18%	25%

As shown, the offsetting techniques in the amortization and asset smoothing methods decrease the volatility quite a lot, without giving up downside protection. Thus, we will continue to utilize those techniques going forward.

### Negative Amortization

In recent years, the pension community has become focused on a concept known as negative amortization. In addition, the major credit rating agencies have publically stated that negative amortization is seen as an adverse factor in their analysis.

As is the case with any liability, the UAAL accrues interest. When using an increasing amortization policy, naturally the payments made earlier in the pattern are lower than the payments made later in the pattern. With a long period, this can produce payments at the beginning that are quite low and can even be below the amount of interest being accrued. This is when negative amortization occurs. The result is an increase in the UAAL from one year to the next, even if the actuarially determined contribution is met. In most cases, this issue arises when the remaining amortization period gets beyond 20 years.



The mathematics behind negative amortization at varying amortization periods is shown in the figure below. This example shows six different scenarios with differing amortization periods and a UAAL of \$100,000. The interest rate is 6.75% and annual payroll growth is 3.00%, which are the current assumptions for TMRS.

As shown, scenario C, with a funding period of approximately 20 years, is in a position to cover the interest charges allowing the principal to be reduced from the beginning to the end of the year. Scenario A and B, with even lower periods, have amortization payments that more than cover the interest and are able to materially pay down the principal. This is one of the reasons current industry best practices are focusing on a 20 year amortization period.

NEGATIVE AMORTIZATION EXAMPLE						
Scenario	A	B	C	D	E	F
Amortization Period (in Years)	10	15	20	21	25	30
UAAL at Beginning of Year	\$ 100,000	\$ 100,000	\$ 100,000	\$ 100,000	\$ 100,000	\$ 100,000
Interest on UAAL	6,750	6,750	6,750	6,750	6,750	6,750
Amortization Payment Based on Amortization Period	(11,684)	(8,462)	(6,876)	(6,652)	(5,944)	(5,339)
UAAL at End of Year	95,066	98,288	99,874	100,098	100,806	101,411
Net Change	\$ (4,934)	\$ (1,712)	\$ (126)	\$ 98	\$ 806	\$ 1,411

For periods greater than 20 years, the UAAL is expected to grow from year to year, even if the required contribution is met. At a 30 year period, amortization payments are covering only about 80 percent of the interest charges and the UAAL grows nominally. This holds true even if the payroll is assumed to be increasing and the period is decreasing by one year annually. As the payroll growth increases and the contribution stream grows, a greater portion of the interest will be paid. Eventually contributions will allow for interest plus an increasing portion of the principal to be paid and the UAAL will decline.

An alternative approach would be to not incorporate payroll growth into the amortization calculation. This would be a level dollar approach similar to a home mortgage. Even a 30 year period with level dollar would be estimated to cover the interest and thus not experience negative amortization. However, 30 year level dollar would be more volatile than 20 year level percent, so just pulling out the payroll growth concept doesn't address the issue.

## Industry Best Practices

While there are no regulatory or prescribed statutes that would keep a pension system from using a funding policy that uses negative amortization, the actuarial standards of practice and related industry practice notes strongly recommend systems use policies that do not incorporate negative amortization. Thus, based on TMRS' current set of assumptions, best practice is an amortization objective not to exceed 20 years. An amortization period in this range would help the fund avoid negative amortization which occurs when contributions to the pension trust fund do not cover the interest accruing on the UAAL.

The most notable and comprehensive document available for guidance on funding policy is “Actuarial Funding Policies and Practices for Public Pension Plans” by the Public Plans Community of the Conference of Consulting Actuaries. While not authoritative, this comprehensive document provides commentary and does approximate the general thoughts of the actuarial community on this subject.

The CCA PPC white paper provides discussion on the range of possible funding policies and categorizes individual policy parameters on a range from Model Practices to Unacceptable Practices. Concerning amortization strategies, the paper offers the following comments:

*“The amortization policy should reflect explicit consideration of the level and duration of negative amortization, if any.”*

*“For gains and losses, balancing demographic matching and volatility control leads to an ideal amortization period range of 15 to 20 years.*

*b. Longer than 20 years becomes difficult to reconcile with demographic matching, the intergenerational aspect of interperiod equity described in general policy objective 2.*

*i. 20 years is substantially longer than either average future service for actives or average life expectancy for retirees.”*

The 10 year asset smoothing period, with the 15% corridor, is found to be an acceptable practice. The 25 year layered amortization process is also defined as an acceptable practice, but with conditions.

However, the paper does not directly address the combination of specific parameters. The combination of 25 and 10 yields a 35 year period from when a significant event would occur to when it would eventually be fully amortized. Given the lengthy write up against negative amortization in the paper, and the paper not fully categorizing the 25 year layered as acceptable, the 35 year combined period would not be categorized as a current industry best practice.

Thus, in the upcoming experience study we are recommending that one of the two parameters be shortened by 5 years. These parameters impact the contribution volatility and the protection against downside events, so the following exhibits provides those metrics based on the current 25/10, as well as 25/5 and 20/10.

	Probability Contribution Rate Changes	Probability of Contribution Increase Greater Than			Probability Less than 80% Funded		Prob, >100% Funded
		0.00%	0.50%	1.00%	In 2050 (MVA)	Anytime before 2040 (AVA)	Anytime before 2040 (AVA)
25/10 Layered	99%	50%	18%	7%	25%	31%	52%
25/5 Layered	99%	51%	28%	12%	23%	43%	59%
20/10 Layered	99%	50%	22%	9%	20%	26%	53%

As shown, all three recalculate the rate each year, so the probability of some kind of change is 99%. Both of the two alternatives provide more downside protection than the current, which is why they are more standard in the industry, but both also increase contribution rate volatility, with the 5 year smoothing doing so by quite a large margin.

We find the 20/10 combination preferable to both the 25/10 and the 25/5. It is slightly more volatile than the current, but decreases the probability of going below 80% funded by 20%, from 25% to 20%. It also removes negative amortization from TMRS policies and puts them inside industry best practices.

## Possible Other Funding Policies

The information above assumes the funding policy remains as is, with different parameters. With the offsetting techniques applied in the formula to dampen experience, the 20/10 layered numbers above are the most optimized combination under the “layered” structure. As shown, there is an approximate 22% probability of having a 0.5% increase in contribution rate in a given year. If stakeholders feel the contribution rate volatility is too high, then the only options will be utilizing a different structure all together, or utilizing some form of direct rate smoothing.

A direct rate smoothing mechanism would use the rate that comes out of the set formula, and then apply another round of smoothing. The most common and most defensible approaches work from above by holding the rate steady when the underlying formula would suggest the rate could be reduced, waiting for experience to bring the rate back up in a future year.

There are two forms that would be easiest to transition to given TMRS’ current policies (more explanation is provided on each of these two approaches later in this section):

1. Keep the layered approach, but don’t let the contribution rate decrease until UAAL is fully amortized. We will define this as the Disciplined approach. This approach is used by some peer systems, including TCDRS in an elective manner.
2. Keep the current contribution rate until one of two triggers occurs: 1. UAAL is fully amortized or 2. the 20 year ADC exceeds the current rate. If the 20 year ADC exceeds the current rate, the current rate is reset upwards to meet the requirement. We will define this as the Floating approach. This approach is used by some peer systems as well, including Utah and South Carolina. In fact, this approach was singled out in a positive manner in the recent stress testing paper by Pew as showing a strong ability to manage contribution rate volatility.

The Disciplined approach is going to be rather path dependent. Since the model is built on the layered approach, if the beginning years have some adverse experience or a significant adverse event occurs, the contribution would likely increase in the same manner it would under the layered approach. This approach would depend on positive experience occurring first to generate a cushion between the formula rate and the actual contribution rate.

The Floating approach would be a different emphasis all together. The approach is emphasizing stable contribution rates and deemphasizing reaching 100% funded *by a specific date*. If an adverse event occurs, including population decline or slow payroll growth, the approach would try to extend the period out before trying to extend the rate up.

For example, assume a significant new loss occurs when a City’s UAAL is expected to be fully amortized in 8 years based on the current rate. The Layered approach, and the Disciplined approach to the extent there has been no cushion created, will add a new layer on top for the new loss. The current UAAL would remain on the 8 year path. Thus, the contribution rate would increase materially for 8 years, and then drop to the normal cost plus the new layer.

The Floating approach, however, would try to extend the 8 years out to the extent that it could. So, if extending the 8 out to a 15 is enough to not have to increase the rate, the rate will not change. *This*

manipulation of the period reduces volatility substantially as it is managing volatility horizontally in time, not just vertically. However, this approach is only appropriate when the maximum period does not entail negative amortization.

The following exhibit provides the same metrics as the analysis above, but includes the two alternate approaches:

	Probability Contribution Rate Changes	Probability of Contribution Increase Greater Than			Probability Less than 80% Funded		Prob, >100% Funded
		0.00%	0.50%	1.00%	In 2050 (MVA)	Anytime before 2040 (AVA)	Anytime before 2040 (AVA)
25/10 Layered	99%	50%	18%	7%	25%	31%	52%
20/10 Layered	99%	50%	22%	9%	20%	26%	53%
20/10 Disciplined	43%	38%	18%	8%	18%	25%	62%
20/10 Float	25%	20%	10%	5%	23%	29%	56%

As shown, the Disciplined approach basically brings the volatility back in line with the current approach and parameters. However, the downside protection is very good. ***If the Board wishes to emphasize downside protection over contribution volatility, the Disciplined approach appears optimal.***

The Floating approach reduces volatility in half but gives back some of the downside protection, although still better than the current. Thus, ***if the Board wishes to emphasize stable contribution rates while still remaining in best practices, the Floating approach appears optimal.***

The reader may have noticed the change to compare funded ratios at 2050 versus 2040 from previous sections. With 10 year smoothing and 2040 only being 20 years from now, more time was needed to see the true difference in the methodologies beginning to manifest.

## Combinations of Strategies

Ultimately, TMRS will have one set of strategies to deploy, so it is important to consider what the package would look like. For illustrative purposes, we have compared the expectations of:

- 1) the current portfolio with the current 25/10 layered funding policy, to the
- 2) 6.6%/11.3% portfolio with a 20 year Floating approach.

As shown, the metrics appear better across the entire spectrum: higher funding ratios, lower contributions, and lower contribution volatility.

	Expected		20 Year Contribution Dollars			20 Year Effective Contribution Rate			Probability of Contribution Increase Greater		Probability Less than 80% Funded		Prob, >100% Funded
	Return	SD	Expected	Poor Outcome	Very Poor Outcome	Expected	Poor Outcome	Very Poor Outcome	0.50%	1.00%	In 2050 (MVA)	Anytime before 2040 (AVA)	Anytime before 2040 (AVA)
Current Portfolio 25/10 Layered	6.3%	10.7%	\$ 18.3	\$ 25.2	\$ 33.4	16.4%	21.3%	27.4%	19%	7%	31%	34%	45%
Extra Return, More Risk 20/10 Floating	6.6%	11.3%	\$ 16.7	\$ 23.9	\$ 32.9	15.2%	20.3%	26.5%	10%	5%	23%	29%	56%

As with any changes to the portfolio, there is no specific timeframe for implementing any of these policies. In fact, a change to one of the alternative funding policies would likely need at least another year

to fully vet the many different circumstances that could arise from having 880 potentially different circumstances. This analysis provides the Board more detail on various options and any combination could be investigated further if desired.

## More Description of Alternative Approaches to Funding

### Layered Approach

The analysis above introduces three approaches to funding: Layered, Disciplined, and Floating. Besides “Layered”, the terms Disciplined and Floating are not typical industry terminology. The authors have interjected those terms to be able to assign a descriptive label to the methodologies and more easily refer to them in the analysis. This discussion will provide more detail on what the three approaches are, how they would react in given situations, and what their advantage and disadvantages are.

Layered polices are very common, even outside the actuarial pension community. Many accounting structures recognize various items over time, such as depreciation, or most debt is structured in this way, with a definable beginning, payment structure, and ending point. So beginning with the UAAL at the time of inception and any new gain or loss that occurs during the annual valuation process, a new amortization layer is created with a set payment schedule. Losses will increase amortization payments and gains will produce amortization credits. The aggregate of all previous layers produce the total contribution for a given year. The following is an example from the 2018 valuation for a TMRS city:

Source	Original Balance	Remaining Balance as of December 31, 2018	Payment FY2019	Payment FY2020	Payment FY2021	Years Remaining
2013 Valuation (Fresh Start)	\$ 25,099,074	\$ 24,675,183	\$ 1,886,498	\$ 1,943,093	\$ 2,001,386	18
2014 Experience	(1,320,133)	(1,295,929)	(99,078)	(102,050)	(105,112)	18
2015 Experience	475,691	489,202	28,669	29,529	30,415	27
2015 Actuarial Changes	(138,287)	(135,808)	(10,383)	(10,694)	(11,015)	18
2016 Experience	1,484,334	1,493,926	96,693	99,594	102,582	23
2017 Experience	(355,659)	(352,621)	(26,959)	(27,768)	(28,601)	18
2018 Experience	(154,344)	(154,344)	(11,800)	(12,154)	(12,519)	18
<b>Unfunded Actuarial Accrued Liability</b>		<b>\$ 24,719,609</b>	<b>\$ 1,863,640</b>	<b>\$ 1,919,550</b>	<b>\$ 1,977,136</b>	
<b>Projected Payroll</b>			<b>\$ 28,398,811</b>	<b>\$ 29,250,775</b>	<b>\$ 30,128,298</b>	
<b>Amortization Payment as a Percent of Payroll</b>			<b>6.56%</b>	<b>6.56%</b>	<b>6.56%</b>	
<b>Equivalent Single Amortization Period = 18.4 years</b>						

This approach fixes the date that any variance from a valuation cycle will be fully amortized. Each year, the payment schedules for all previous layers increases by the payroll growth rate, and then a new layer is added on (or could be a credit). This process of annually adding on a new layer creates volatility in the contribution rate. All previous layers cannot assist in dampening any impact from the experience of a given year.

This approach is inherently volatile, as the formula is recalculated each year. As the process moves throughout time, eventually every valuation will be experiencing volatility from both new layers being added and old layers falling off as they are amortized. For example, pension plans that utilized 20 year layers in the 1990s, a time during which large gains were producing amortization credits, are now

experiencing volatility from those large credits being removed from the calculation. However, compared to the other approaches, it will produce the lowest contribution in a given year, at least over the short to medium term.

The following summarizes the advantages and disadvantages of the Layered funding approach:

Advantages	Disadvantages
Logical, systematic approach	Contribution rate will change each year
Occurrences from past years are itemized and tracked	The contribution rate in a given year will be impacted by any new layers being added, and any past layers falling off
Produces the lowest contribution in a given year, compared to other appropriate choices	Lots of data from past valuations must be tracked

### Disciplined Approach

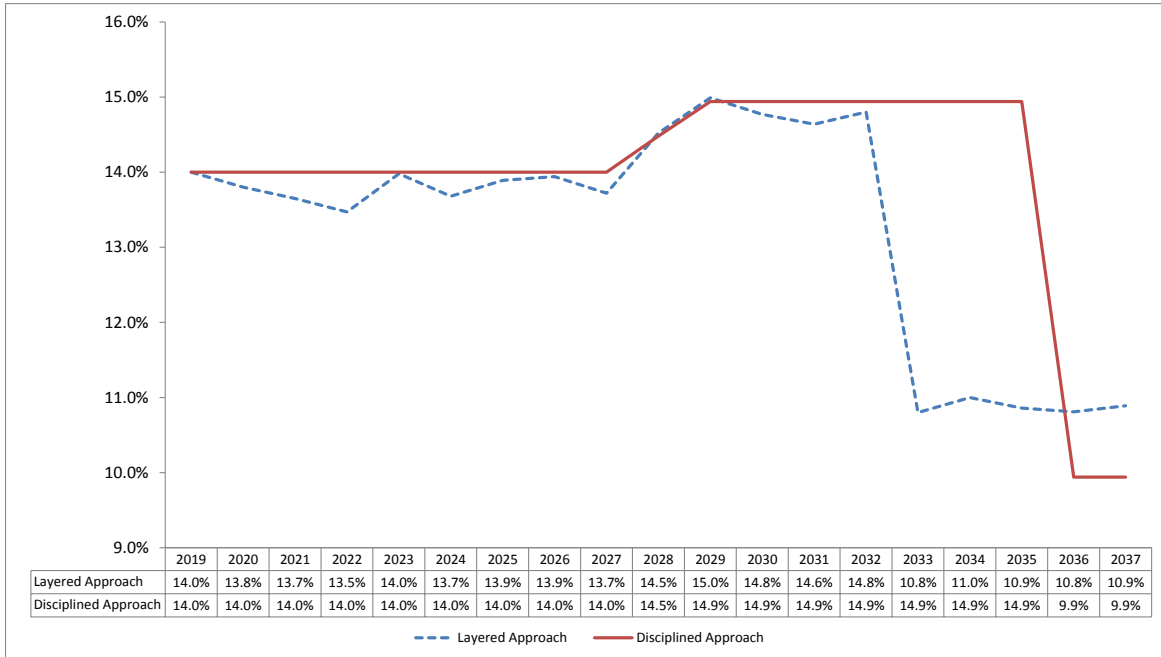
This approach uses the same mechanism as the Layered approach for the first step in determining the required contribution for a given year. For this explanation we will define that as the Layered ARC. But, the Disciplined Approach adds an additional emphasis towards stable contribution rates and reaching full funding over minimizing the contribution rate. This is accomplished by keeping the contribution rate steady from one year to the next until one of two conditions is met: 1) the plan reaches 100% funded status or 2) the Layered ARC exceeds the current contribution rate. If the plan reaches 100% funding, then the contribution will reduce to an amount close to the normal cost. If the Layered ARC exceeds the current rate, then the employer must contribute the Layered ARC and that becomes the new rate for future comparisons. This is an approach that has been discussed in TMRS meetings before and one that some cities are already implementing on a voluntary basis.

One way to describe this type of approach is as a goal oriented policy. Define the goals first, such as stable contributions and being 100% funded, and then allow your actions to take you towards those goals. To fully understand the concept, a stakeholder must understand the funding policy as a series of years, not one year. There will be volatility in the financial markets, and from demographic sources, and thus there will be volatility in any formula that is directly tied to that volatility. The only way to truly produce stability is to use a process that removes itself from that year to year process. The Disciplined Approach is the way to achieve the goals of contribution stability and better funding that is closest to the current policy used at TMRS.

However, the strategy requires positive experience to occur first to see any advantage. Essentially, the strategy is building up a reserve in the distance between the Layered ARC and the actual contribution rate if positive experience occurs. If the experience over the short term does not allow for any buildup of reserve, there will not be any margin to keep rates from increasing when adverse experience eventually occurs. Also, since the Layered ARC is keeping track of historical gains and losses and still amortizing those over fixed periods of time, any large negative event will still be put over its own 20 year period and will receive no assistance from earlier layers.

The following is an example that compares the Layered Approach to the Disciplined Approach. The first part of the scenario starts with moderately good experience and displays the advantage of the method.

However, about 8 years in there is an adverse event that occurs, and this shows that the contribution rate is still at risk. This unit has a current large UAAL base that will be fully amortized in 15 years.



As shown, early in the pattern the Disciplined Approach is more stable and eliminates the need for contribution increases in 2023, 2025, and 2026. However, the only lever being reserved is the contribution rate itself, and thus when an adverse event occurs in 2027, the new layer is added on top of the old rate. In 2033 when the original base is fully amortized, the rate under the Layered Approach drops quite significantly, while the Disciplined Approach continues on until the UAAL itself is truly fully extinguished. This is why the approach does so well in pushing the funded ratio up, as it is less concerned about events in the past and emphasizes reaching the 100% funding goal.

The following summarizes the advantages and disadvantages of the Disciplined funding approach:

Advantages	Disadvantages
Emphasizes reaching 100% funding	Relies on experience to create the margin for future adverse outcomes
Stabilizes contribution rates, providing margin to dampen contribution volatility	The contribution rate in a given year will still be impacted by any large new layers being added
Systematic approach	Lots of data from past valuations must be tracked
Occurrences from past years are itemized and tracked	May be complicated to integrate with benefit changes

## Floating Approach

This approach uses the same goal oriented mechanism as the Disciplined approach as in not changing the rate until either reach full funding is reached or a minimum calculated amount exceeds what is currently being contributed, but does so with a different underlying formula. Instead of using a traditional, layered, closed amortization strategy as the minimum, the approach uses a 20 year open strategy as a minimum.

This is not an open amortization strategy. Open amortization refinances the amortization period each year to keep the same 20 year period, thus the contribution rate declines over time and the UAAL is never reduced to zero.

Instead, the main mechanism in this approach is to keep the rate at current levels, which should reduce the effective period by one each year and ultimately eliminate the UAAL. Thus, if assumptions are met, it will actually look like a closed strategy.

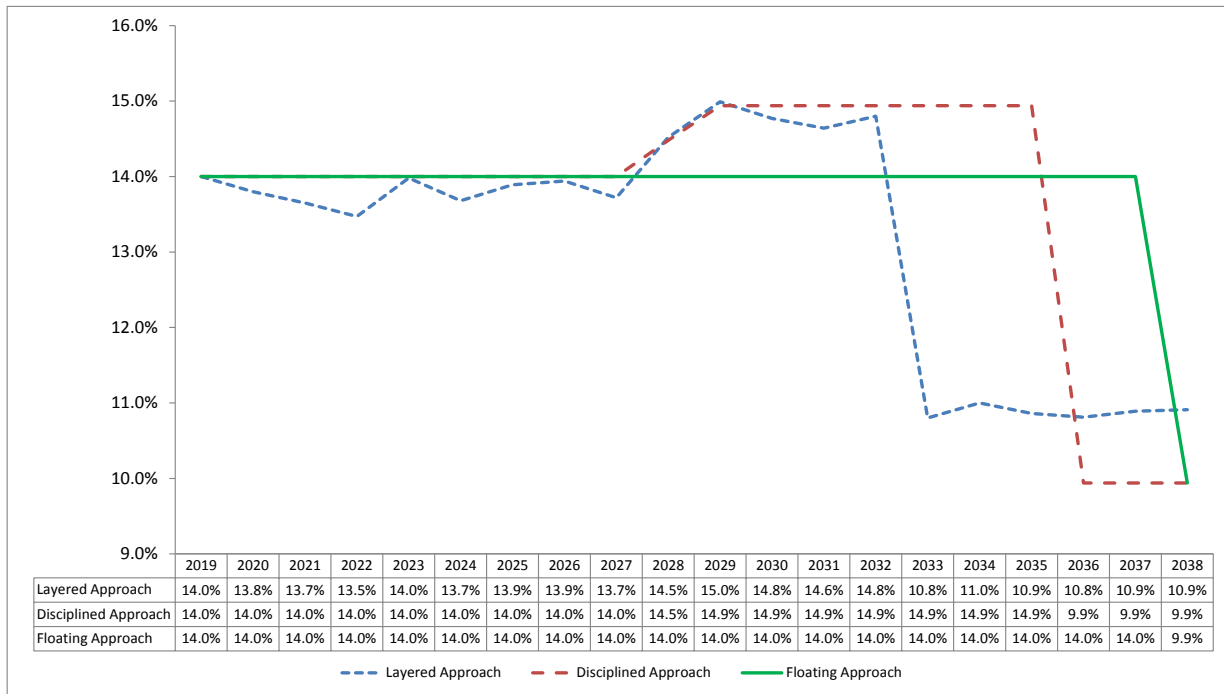
The 20 year minimum is used as the trigger for change. At any point in the future, if the current contribution rate is not expected to fully pay off the UAAL in the next 20 years, then the rate is increased accordingly.

Now, as time moves forward and experience is close to expected, then the effective period should be decreasing annually and that is where the reserve against future adverse experience is being created. *Thus, this approach has an expected reserving mechanism built into the process and it does not require positive experience to create the margin.*

For example, if starting at 20 years, 6 years into the future the experience has been close to expected and thus the effective period is now 14. In order to increase the contribution rate, an adverse event has to be significant enough to increase the effective period all the way back up to 21 years. So the approach is going to use more years to manage the funding progress first and then move to higher contribution rates.

The potential downside is that it can take longer to eventually reach 100% funding as the period is allowed to continually float. The following is the same example as before, but now includes the Floating Approach.





As shown, by the time the adverse event occurs in 2027, the effective period had decreased enough to provide cushion and the approach extended the time 5 more years than originally planned. The Disciplined Approach went up in 2027 and then came down 2 years earlier than the Floating. Both alternative approaches reach 100% status by 2038, whereas the original Layered approach has not by the end of the graph.

This chart attempts to illustrate the advantages and disadvantages of each approach against one another. One important point: the total amount of contribution is about the same across all three approaches. The funding policy does not dictate the amount of contribution over time, it dictates the timing of those contributions. *The decision is based on what pattern is desired.*

One way to think about the Floating Approach is that the approach is focused on stabilizing contribution rates and reducing the UAAL to \$0, it just does not emphasize when exactly that occurs.

The following summarizes the advantages and disadvantages of the Floating Approach to funding:

Advantages	Disadvantages
Stabilizes contribution rates, providing a built in mechanism to dampen contribution volatility	Does not focus on a predetermined point in time to reach 100% funding
Emphasizes reaching 100% funding	May be complicated to integrate with benefit changes
Deemphasizes results from a single valuation	Quite different from current approach
Simple mathematical approach, eliminates tracking of historical layers	

## **SECTION VIII**

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### **DESCRIPTION OF METHODS AND ASSUMPTIONS**

## Description of Methods and Assumptions

Except for those presented below, the actuarial assumptions and methods are the same as outlined in the December 31, 2018 actuarial valuation of TMRS.

These actuarial assumptions were developed primarily from the actuarial investigation of the experience of TMRS over the four year period from December 31, 2010 to December 31, 2014. They were adopted in 2015 and first used in the December 31, 2015 actuarial valuation. The post-retirement mortality assumption for healthy annuitants and Annuity Purchase Rate (APRs) are based on the Mortality Experience Investigation Study covering 2009 through 2011 and dated December 31, 2013. In conjunction with these changes first used in the December 31, 2013 valuation, the System adopted the Entry Age Normal actuarial cost method and a one-time change to the amortization policy. These assumptions apply to both the Pension Trust and the Supplemental Death Benefits Fund as applicable.

### Most Applicable Actuarial Assumptions

Investment Return Assumption: 6.75%  
Discount Rate: 6.75%  
General Wage Inflation: 3.00%  
Payroll Growth Assumption: 3.00%  
Price Inflation: 2.50%

### Benefit Provisions

Units were grouped into four categories:

- Group 1: units not providing a repeating USC or COLA
- Group 2: units providing a repeating USC, but no COLA
- Group 3: units providing a repeating USC and COLA
- Group 4: units providing a repeating USC, and an ad hoc COLA

Units were assumed to retain their current benefit package. Units in Group 4 were assumed to continue to give their ad hoc COLAs perpetually into the future.

### Stochastic Model

5,000 30 year projections were performed for each asset class as well as price and wage inflation assuming each class was lognormally distribution. For each scenario modeled, the annual return was calculated based on the portfolio allocation, with annual rebalancing. Liabilities, payrolls, and benefit payments were all adjusted for actual inflation and wage inflation experience. The projections assumed annual returns with middle of year cash flows for contributions and benefit payments.

For shorter term metrics, such as cash flows and sensitivity to short term inflation, the full standard deviation was used to create the distributions. All other longer term models used 70% of the annual standard deviations below to create the multiple period trials. This lower standard deviation dampens the potential wide distribution of outcomes that can be created by typical monte carlo simulation to the extent volatility in annual returns is not all generated by longer term fundamental outcomes.

Capital market assumptions and correlations were provided by RVK, except for the general wage inflation expectations and correlations which were developed by GRS.

	<b>Geometric Return</b>	<b>Standard Deviation</b>	<b>Global Equity</b>	<b>Fixed Income</b>	<b>Non-Core Fixed Income</b>	<b>Real Return</b>	<b>Real Estate</b>	<b>Absolute Return</b>	<b>Private Equity</b>	<b>CPI</b>	<b>GWI</b>
<b>Global Equity</b>	6.3%	18.4%	1.00								
<b>Fixed Income</b>	3.6%	6.0%	-0.02	1.00							
<b>Non-Core Fixed Income</b>	6.0%	11.3%	0.76	0.17	1.00						
<b>Real Return</b>	6.0%	9.1%	0.52	0.22	0.70	1.00					
<b>Real Estate</b>	5.6%	13.9%	0.10	-0.15	-0.09	0.11	1.00				
<b>Absolute Return</b>	5.6%	9.0%	0.81	0.11	0.78	0.61	-0.05	1.00			
<b>Private Equity</b>	8.3%	21.3%	0.75	-0.26	0.50	0.53	0.27	0.72	1.00		
<b>CPI</b>	2.5%	1.5%	0.06	-0.11	-0.01	0.07	0.15	0.15	0.12	1.00	
<b>GWI</b>	3.0%	2.0%	0.29	-0.02	-0.01	0.07	0.30	0.15	0.29	0.40	1.00