California Public Employees' Retirement System

Comprehensive Review of the 2021 Experience Study

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October 25, 2021

Board of Administration
California Public Employees' Retirement System
Lincoln Plaza North
400 Q Street
Sacramento, CA 95811

Dear Board Members:

Gabriel, Roeder, Smith & Company (GRS) is pleased to present this report of a Comprehensive Review of the 2021 Experience Study of the California Public Employees' Retirement System (CalPERS). The purpose of the report is to provide a comprehensive peer review of the methodologies and recommendations of the 2021 Experience Study performed by the Actuarial Office (ACTO) of CalPERS. Unless otherwise noted, this comprehensive peer review is referred to as the Experience Study review throughout this report.

Based upon the Letter of Engagement No. 2020-0277, the objective of the Experience Study review is as follows:

- Perform a study of the following economic assumptions:
  - Future Annual Price Inflation
  - Future Wage Growth
  - Payroll Growth
- Perform a comprehensive peer review of the demographic Experience Study covering the period from 1997 to 2019. The review report will include a statement as to whether or not the assumptions recommended by ACTO are reasonable, appropriate, and in accordance with the Actuarial Standards of Practice (ASOPs). The review will include:
  - An examination of processes used by ACTO to analyze the data
  - Calculations of exposures and decrements
  - Calculations of the raw rates
  - Methods used to smooth the raw rates

We are pleased to report that we found the assumptions recommended by the Actuarial Office to be reasonable, appropriate, and in accordance with the Actuarial Standards of Practice (ASOPs).

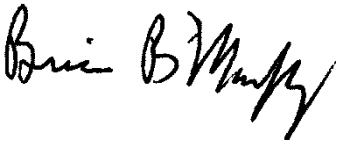
Throughout this report, the reader will note items where recommendations and suggestions are made. In interpreting our recommendations and suggestions, the Board of Administration should be aware that we agree with the Actuarial Office on the vast majority of methodologies and recommendations reviewed. We thank the Actuarial Office for their assistance in this project.

This report has been prepared by actuaries who have substantial experience valuing public employee retirement systems. To the best of our knowledge, this report is complete and accurate and was made in accordance with standards of practice promulgated by the Actuarial Standards Board.

The signing actuaries are independent of the plan sponsor.

Brian B. Murphy, Mita D. Drazilov and James R. Sparks are Members of the American Academy of Actuaries (MAAA) and meet the Qualification Standards of the American Academy of Actuaries to render the actuarial opinions contained herein.

Respectfully submitted,
Gabriel, Roeder, Smith and Company



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SECTION I

EXECUTIVE SUMMARY

Scope of Assignment

The California Public Employees' Retirement System (CalPERS) Actuarial Office (ACTO) engaged Gabriel, Roeder, Smith & Company (GRS) to provide a comprehensive peer review of the methodologies and recommendations of the 2021 Experience Study performed by CalPERS. Unless otherwise noted, this comprehensive peer review is referred to as the Experience Study review throughout this report.

Based upon the Letter of Engagement No. 2020-0277, the objective of the Experience Study review is as follows:

- Perform a study of the following economic assumptions:
  - Future Annual Price Inflation
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  - An examination of processes used by ACTO to analyze the data
  - Calculations of exposures and decrements
  - Calculations of the raw rates
  - Methods used to smooth the raw rates

Recreating the data was not part of this Experience Study review. To the extent that the Experience Study data was analyzed, the CalPERS Actuarial Office provided the participant, exposure and decrement data used in the demographic Experience Study.

The Experience Study review of the new and existing assumptions applied to the following groups:

- State Miscellaneous
- State Industrial
- State Police Officers & Firefighters (POFF)
- State Safety
- California Highway Patrol
- Schools
- Public Agency Miscellaneous
- Public Agency Safety
  - Fire
  - Police (this group also includes Sheriff)
  - County Peace Officers

The Experience Study review also applied to the following:

- Rate smoothing (graduation of the probabilities of decrement)
- Calculation of expected decrements using existing and new assumptions and comparison to actual decrements

Scope of Assignment

The Experience Study review applied to the following decrements:

- Service Retirement (varies by plan: State plans, Schools, Public Agency formula) and by member category and benefit formula)
  - Active Members (Age Service matrix and/or income replacement ratios)
- Pre-retirement Mortality (varies by sex, all plans combined)
  - Non-Industrial
  - Industrial
- Disability (varies by plan and member category)
  - Non-Industrial
  - Industrial
- Termination (varies by plan and member category)
  - With a refund
  - Without a refund
- Post-retirement Mortality (varies by sex, all plans combined)
  - Service Retirement
  - Non-Industrial Disability
  - Industrial Disability
- Salary Scale (Seniority, Merit and Promotion portion)

Review Methodology

For the Experience Study review, GRS received data from the CalPERS Actuarial Office from March 2021 through September 2021. In addition, we had numerous conversations with the Actuarial Office to gain further insight into the assumption setting process used by the Actuarial Office.

GRS calculated total exposures and actual decrements provided by the Actuarial Office as well as actual rates of decrement for the decrements being reviewed. Recreating the data was not part of this Experience Study review.

As part of the Experience Study review, GRS received census information from the Actuarial Office for all active and retiree members of the California Highway Patrol (CHP) group for the actuarial valuations from June 30, 1997 through June 30, 2019. GRS used this data to conduct a replication of certain Experience Study results (i.e., exposures, actual rates of decrement, actual payroll increases) for an individual group. The purpose of this analysis was to confirm on an individual record by record basis for a single group that the Actuarial Office's methods for development of Experience Study results are appropriate and accurate.

Since the methodology used in the Experience Study for each group was consistent across all groups, by validating the Actuarial Office's results for CHP specifically, we had confidence in then using the Experience Study census information provided for the other groups (i.e., exposures, actual decrements, actual payroll data) to tabulate exposures, actual decrements and calculate raw rates of decrement.

For each assumption set studied, GRS independently calculated actual to expected ratios (sometimes referred to as A/E ratios). The analysis of actual to expected ratios is a very common procedure when performing an Experience Study. In addition, GRS calculated exposure weighted R-squared values to assess the pattern of the proposed assumptions versus the actual experience. We also calculated 90% confidence intervals around each individual raw rate and maintained counts of the percentage of proposed rates that fell within the confidence interval. These results are shown in detail in Sections III and IV. Finally, we used our experience and actuarial professional judgement in assessing the Actuarial Office's proposed assumptions and methodologies.

GRS performed an independent analysis of the following economic assumptions: price inflation, wage inflation and payroll growth. These results are shown in Section II, in addition to our review of the merit and seniority pay increase assumptions.

Please note that GRS did not review the CalPERS 2021 Experience Study report since that was not part of the scope of assignment.

Summary of Experience Study Review

Key Findings

Based upon our Experience Study review, we are pleased to report that we found the assumptions recommended by the Actuarial Office to be reasonable, appropriate, and in accordance with the Actuarial Standards of Practice (ASOPs).

Summary of Recommendations and Suggestions

Based upon our Experience Study review, we have some recommendations and suggestions for the Actuarial Office. We believe that none of our recommendations and suggestions would have a material effect on the actuarial valuations for CalPERS.

Presented below is a summary of our recommendations and suggestions:

(1) Merit and Seniority Pay Increases
   a. We would suggest that the Actuarial Office treat the merit and seniority pay increase assumption as an economic assumption in future Experience Studies.
   b. We would suggest that the Actuarial Office consider excluding data in years where non-recurring activities occur (e.g., furloughs).

(2) Mortality Rates (Post-Retirement)
   a. For mortality after service retirement, the study is based upon amounts, but the Actuarial Office calculated credibility factors for each individual age using head count weighted methods and blended the (smoothed) raw results with a standard table. Amount weighted credibility methods should have been used which generally results in lower credibility being assigned to the subject data.
   b. By assembling data at individual ages and blending according to credibility, there is a small risk that smoothness in the final table may be less than desired. If the Actuarial Office continues this method, the Actuarial Office could add a final smoothness check to the end results.
   c. The Actuarial Office calculates the credibility factor Z, as the square root of the ratio of actual decrements to the number (or amount) required for full credibility. This is a textbook formula. However, instead of calculating the new rate as Z x raw rate + (1-Z) x standard rate, the Actuarial Office uses a graduated raw rate instead of the actual raw rate. We like that idea, since it will help remove bumpiness from the end result, mitigating the issue addressed above. However, we think that in that instance the Actuarial Office could also consider calculating Z as the square root of the ratio of (graduated raw rate x exposure) to the number (or amount) required for full credibility at each age. We don't think this is a significant issue. It is a suggestion for future consideration.
   d. The Actuarial Office calculates the number or amount required for full credibility at each age as p x 1,082 in the case of head count weighting, where p = (1-raw rate). Since the Actuarial Office replaces the raw rates with graduated raw rates throughout the calculation, with think that it would be reasonable to calculate p as (1-graduated raw rate), or alternatively to base p on the standard table. This is a minor matter.

Summary of Experience Study Review

e. For mortality after service retirement, CalPERS data is sufficient to be fully credible in 5-year age bands, but not in individual age groupings. The Actuarial Office could develop rates based on age bands, interpolate them to individual ages and graduate the results, thus creating a table fully reflective of CalPERS experience.
f. Another method that could be used is to develop A/E ratios in total and adjust the rates in the standard table by that ratio. This is a simple method that would likely also produce a good result provided that the shape of the standard table is reasonably representative of CalPERS experience.
g. While we believe it is acceptable to use head count weighted tables for disabled individuals, we recommend that CalPERS reconsider the matter in the next Experience Study.
h. We recommend that the Actuarial Office explain the reasoning behind the Whittaker Henderson parameter choices in the final report.

(3) Mortality (Pre-Retirement)
a. When adjusting the 1,082 full credibility number, use a p related either to the standard table (i.e., PubG-2010 Employee Mortality Tables) or to the graduated experience table.
b. When calculating the Z factor replace actual decrement counts with a hypothetical decrement count based upon the graduated raw rate and the exposure at the age under study.

(4) Mortality Projection Scale
a. The Society of Actuaries provides an automated excel workbook for producing alternative projection scales. We suggest that in the future the Actuarial Office develop an alternative scale using that tool if it does not think the current MP scale is appropriate for the CalPERS population.

(5) Retirement Rates
a. During the next study we recommend the Actuarial Office consider extending rates to higher ages consistent with System experience.
b. With the assumed rates of service retirement changing for Classic members, any PEPRA assumptions which were originally developed with the consideration of the Classic members' assumptions, we would recommend the PEPRA rates also be adjusted to remain consistent.
c. We recommend the Actuarial Office in future studies additionally review shorter periods to confirm there are no emerging trends in retirement patterns.
d. We recommend for the next Experience Study the Actuarial Office consider smoothing assumptions (either by graduation technique or manually) across ages where the experience appears generally consistent with a common trend (e.g., increasing, decreasing or level).
e. For the next review the Actuarial Office performs of an Experience Study, GRS recommends the Actuarial Office provide the reviewing Actuary with detailed analysis of assumption groups regardless of if the current assumptions are being changed or not.

Summary of Experience Study Review

(6) Disability Rates

a. We recommend the Actuarial Office review whether it would be more appropriate to set disability rates in total (i.e., non-industrial and industrial related disability combined) and then separately set an industrial versus non-industrial assumption based upon observed experience after reclassifications.

b. We recommend the Actuarial Office consider manually adjusting for or graduating rates separately for ages prior to and after eligibility of service retirement. Additionally, the Actuarial Office may wish to manually set rates at older ages to level out if graduated rates are declining but experience is showing an inconclusive trend.

c. We recommend for the next study the non-industrial disability use a similar methodology that the industrial related disability assumptions were reviewed (i.e., short experience period) to reflect more recent experience in the assumptions.

d. For the next review the Actuarial Office performs of an Experience Study, we recommend the Actuarial Office provide the reviewing Actuary with detailed analysis of assumption groups regardless of if the current assumptions are being changed or not.

(7) Termination Rates

a. We recommend for the next experience that exposures and actual decrements only be tabulated at ages/years of service where the proposed assumptions are being applied (i.e., greater than 0%) for total A/E purposes.

b. We recommend the Actuarial Office in future studies additionally review shorter periods to confirm there are no emerging trends in termination patterns.

SECTION II

ECONOMIC ASSUMPTIONS

Economic Assumptions
Introduction

Economic assumptions include **rates of investment return** (net of investment expenses based upon a passive investment strategy; sometimes net of administrative expenses), **price inflation**, **wage inflation** (the across-the-board portion of salary increases), pay increases due to **merit and longevity** and a **payroll growth assumption**. Unlike demographic activities, economic activities do not lend themselves to analysis solely on the basis of internal historical patterns because both salary increases and investment return are affected more by external forces; namely inflation (both wage and price), general productivity changes and the local economic environment which defy accurate long-term prediction. Estimates of economic activities are generally selected on the basis of the expectations in an inflation-free environment and then both long-term rates of investment return and wage inflation are increased by some provision for long-term price inflation.

If price inflation and/or productivity increases are lower than expected, it will probably result in both actual rates of salary increases and investment return that are below the assumed rates. Salaries increasing at rates less than expected produce lower liabilities. However, actual investment return below the assumed rate of investment return (whether due to manager performance, change in the mix of assets, or general market conditions) results in lower than expected asset amounts.

In accordance with the scope of the assignment, the specific economic assumptions reviewed in this report are price inflation, wage inflation, payroll growth and merit and seniority pay increases. A review of the investment return assumption (i.e., discount rate) is outside the scope of this assignment.

Sources considered in the analysis of the price inflation assumption included:

- Congressional Budget Office
    - 5-year and 10-year annual averages
- Federal Reserve Bank of Philadelphia quarterly survey of Society of Professional Forecasters
    - 5-year and 10-year annual averages
- Federal Reserve Bank of Cleveland Inflation Expectations
    - 10-year, 20-year and 30-year expectations
- Federal Reserve Bank of St. Louis Breakeven Inflation Rates
    - 10-year, 20-year and 30-year periods
- U.S Department of the Treasury Breakeven Inflation Rates
    - 10-year, 20-year, 30-year, 50-year and 100-year periods
- Social Security 2020 Trustees Report
- Future capital market expectations of firms that GRS monitors through our proprietary Capital Market Assumptions Modeler (CMAM)
    - The firms included in the 2021 CMAM are Aon, BlackRock, BNY Melon, Callan, Cambridge, JP Morgan, Meketa, Mercer, NEPC, RV Kuhns, Verus, and Wilshire.
    - In general, capital market expectations were provided covering a 10-year period. In addition, six of the thirteen firms provided capital market expectations over a 20-year to 30-year period.

Economic Assumptions
Introduction

For review of the merit and seniority pay increase assumptions, the Actuarial Office provided GRS the following assumption sets for review:

- CHP
- County Peace Officers
- POFF
- School Miscellaneous
- State industrial
- State Miscellaneous
- State Safety
- Public Agency Miscellaneous
- Public Agency Fire
- Public Agency Police

Sources considered in the analysis of the wage inflation, merit and longevity and payroll growth assumptions included:

- Actual CalPERS experience over the last 16 years (i.e., merit and longevity pay increases)
- Historical observations of inflation statistics (both price and wage and the relationship between them) both nationally and for CalPERS

Economic Assumptions
ASOP No. 27

Guidance regarding the selection of economic assumptions for measuring pension obligations is provided by Actuarial Standard of Practice (ASOP) No. 27. The standard requires that the selected economic assumptions be consistent with each other. That is, the selection of the investment return assumption should be consistent with the selection of the wage inflation and price inflation assumptions. ASOP No. 27 (Doc. No. 197) adopted by the Actuarial Standards Board (ASB) in June 2020 defines a reasonable economic assumption as an assumption that has the following characteristics:

(a) It is appropriate for the purpose of the measurement;
(b) It reflects the actuary's professional judgment;
(c) It takes into account current and historical data that is relevant to selecting the assumption for the measurement date, to the extent such relevant data is reasonably available;
(d) It reflects the actuary's estimate of future experience, the actuary's observation of the estimates inherent in market data (if any), or a combination thereof; and
(e) It is expected to have no significant bias (i.e., it is not significantly optimistic or pessimistic), except when provisions for adverse deviation or plan provisions that are difficult to measure are included (as discussed in Section 3.5.1) or when alternative assumptions are used for the assessment of risk, in accordance with ASOP No. 51, *Assessment and Disclosure of Risk Associated with Measuring Pension Obligations and Determining Pension Plan Contributions*.

Economic Assumptions
Price Inflation

Price inflation underlies both the wage inflation and investment return assumptions. The table below shows forward-looking price inflation forecasts:

Forward-Looking Price Inflation Forecasts[a]	
Congressional Budget Office[b]	
5-Year Annual Average	2.18%
10-Year Annual Average	2.29%
Federal Reserve Bank of Philadelphia[c]	
5-Year Annual Average	2.40%
10-Year Annual Average	2.30%
Federal Reserve Bank of Cleveland[d]	
10-Year Expectation	1.60%
20-Year Expectation	1.82%
30-Year Expectation	2.00%
Federal Reserve Bank of St. Louis[e]	
10-Year Breakeven Inflation	2.34%
20-Year Breakeven Inflation	2.43%
30-Year Breakeven Inflation	2.29%
U.S. Department of the Treasury[f]	
10-Year Breakeven Inflation	2.36%
20-Year Breakeven Inflation	2.39%
30-Year Breakeven Inflation	2.41%
50-Year Breakeven Inflation	2.45%
100-Year Breakeven Inflation	2.48%
Social Security Trustees[g]	
Ultimate Intermediate Assumption	2.40%

[a]End of the Second Quarter, 2021. Version 2021-10-21 by Gabriel, Roeder, Smith & Company

[b]*The Budget and Economic Outlook: 2021 to 2031,* Release Date: February 2021, Consumer Price Index (CPI-U), Percentage Change from Year to Year, 5-Year Annual Average (2021 - 2025), 10-Year Annual Average (2021 - 2030).

[c]*Second Quarter 2021 Survey of Professional Forecasters,* Release Date: May 14, 2021, Headline CPI, Annualized Percentage Points, 5-Year Annual Average (2021 - 2025), 10-Year Annual Average (2021 - 2030).

[d]Inflation Expectations, Model output date: June 1, 2021.

[e]The breakeven inflation rate represents a measure of expected inflation derived from X-Year Treasury Constant Maturity Securities and X-Year Treasury Inflation-Indexed Constant Maturity Securities. Observation date: June 1, 2021.

[f]*The Treasury Breakeven Inflation (TBI) Curve,* Monthly Average Rates, June, 2021.

[g]*The 2020 Annual Report of The Board of Trustees of The Federal Old-Age And Survivors Insurance and Federal Disability Insurance Trust Funds,* April 22, 2020, Long-range (75-year) assumptions, Intermediate, Consumer Price Index (CPI-W), for 2024 and later.

Economic Assumptions
Price Inflation

As can be seen from the previous table, forward-looking price inflation forecasts are below the current price inflation assumption of 2.50%.

For the firms included in the 2021 version of the GRS CMAM, the average price inflation assumption used in the forward-looking capital market expectations was 2.19% over the next 10 years and 2.21% over the next 20 to 30 years.

Based upon the reviewed data, we believe the Actuarial Office recommendation to reduce the price inflation assumption from 2.50% to 2.30% is reasonable.

Economic Assumptions
Wage Inflation and Payroll Growth

Wage inflation consists of two components, 1) a portion due to pure price inflation (i.e., increases due to changes in the CPI), and 2) increases in average salary levels in excess of pure price inflation (i.e., increases due to changes in productivity levels, supply and demand in the labor market and other macroeconomic factors).

We are generally comfortable with the wage inflation assumption exceeding the price inflation by 0.25% to 1.0%. In general, our experience has been that the difference between the wage inflation assumption and the price inflation assumption for public employee retirement systems nationally have been declining in recent years. Presented below is a table that shows the annual changes in average CalPERS payroll, CPI-U and the difference between the two (i.e., net).

Change in Average CalPERS Pay versus CPI-U

Year (June to June)	CalPERS	CPI-U	NET
2004-2005	3.54%	2.53%	1.00%
2005-2006	3.49%	4.33%	-0.84%
2006-2007	5.36%	2.69%	2.67%
2007-2008	4.75%	5.02%	-0.27%
2008-2009	0.54%	-1.43%	1.97%
2009-2010	-0.29%	1.05%	-1.34%
2010-2011	2.98%	3.56%	-0.58%
2011-2012	-2.00%	1.66%	-3.66%
2012-2013	0.01%	1.75%	-1.74%
2013-2014	2.57%	2.07%	0.50%
2014-2015	2.13%	0.12%	2.00%
2015-2016	2.57%	1.00%	1.57%
2016-2017	4.11%	1.63%	2.47%
2017-2018	3.12%	2.87%	0.25%
2018-2019	3.16%	1.65%	1.51%
	Geometric Averages		
2004-2009 (5 Years)	3.52%	2.60%	0.92%
2009-2014 (5 Years)	0.64%	2.02%	-1.38%
2014-2019 (5 Years)	3.01%	1.45%	1.56%
2004-2019 (Last 15 Years)	2.38%	2.02%	0.36%
2009-2019 (Last 10 Years)	1.82%	1.73%	0.09%
2014-2019 (Last 5 Years)	3.01%	1.45%	1.56%

As can been seen from the table above, over the last 15 years, 10 years, and 5 years, the difference between the average payroll change and for CPI-U has been 0.36%, 0.09% and 1.56% respectively for CalPERS. **Based upon the reviewed data and a 2.30% price inflation assumption, we believe the Actuarial Office recommendation of a 2.80% wage inflation assumption is reasonable.**

Economic Assumptions
Wage Inflation and Payroll Growth

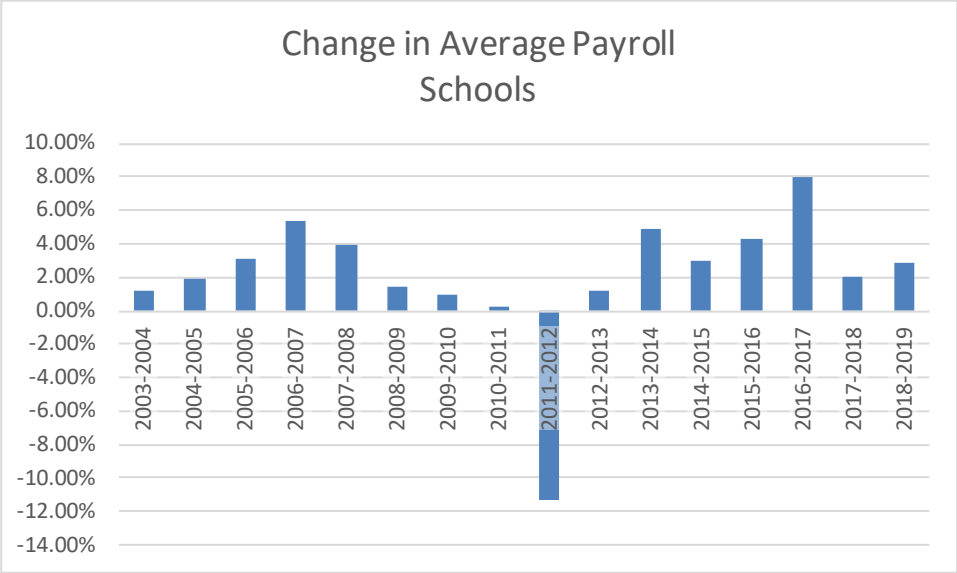
The payroll growth assumption is used in amortization payment calculations if the amortization method is level-percent-of-payroll. If all actuarial assumptions are met, and both the number of active members and their age and service characteristics remain relatively constant, it is expected that payroll growth will be the same as wage inflation. Based upon conversations with the Actuarial Office, there is not an expectation that the reduced compensation limit for PEPRA members will have any material effect on the payroll growth assumption. **Therefore, we believe the Actuarial Office recommendation of a 2.80% payroll growth assumption is reasonable.**

Economic Assumptions
Merit and Seniority Pay Increases

The Actuarial Office's study period for merit and seniority pay increases covered the period June 30, 2003 through June 30, 2019.

Even though ASOP No. 27 considers the merit and seniority portion of active member pay increases an economic assumption, the Actuarial Office characterized that assumption as a demographic assumption. This is not an uncommon practice in the public sector. However, we would suggest that the Actuarial Office treat the merit and seniority pay increase assumption as an economic assumption in future Experience Studies.

Our understanding is that the Actuarial Office estimates wage inflation on a group basis for determining what the actual merit and seniority pay increase assumptions are by group. The process for estimating wage inflation is the change in average payroll year over year. This is generally a reasonable method in cases where there is not unusual activity in a particular year. Presented below is a chart that shows the Actuarial Office's estimated wage inflation for the determining the actual merit and seniority pay increases for the Schools group. As can be seen, the estimated wage inflation for fiscal year 2012 was approximately -11%.



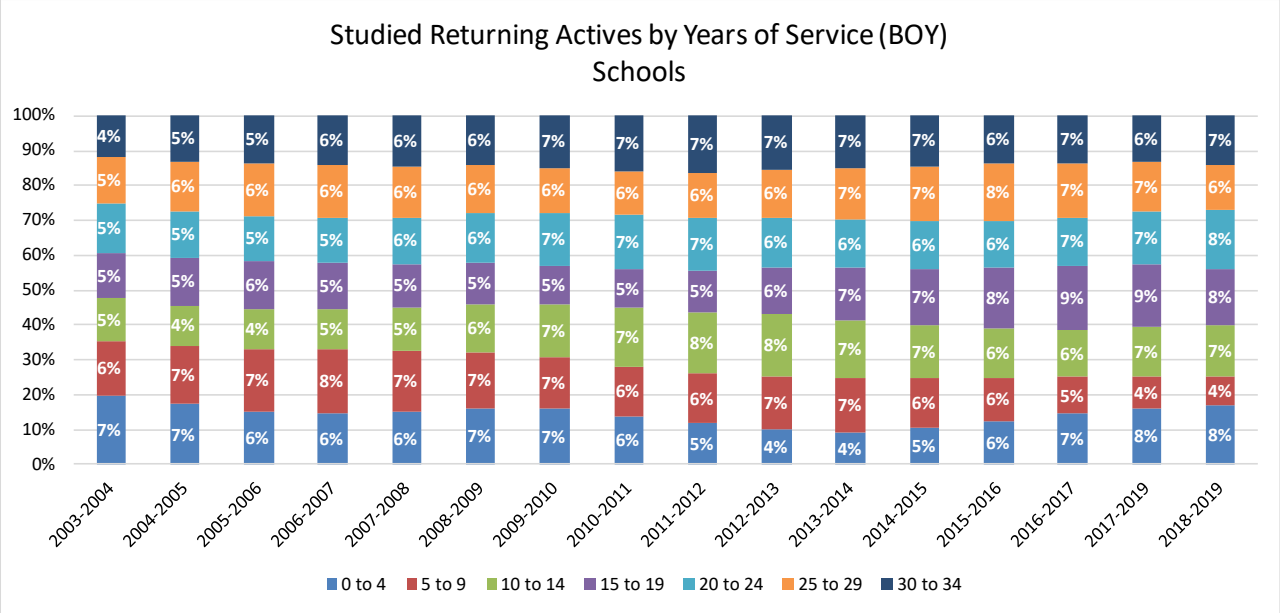
At first blush, this appears to an unreasonable result. After discussions with the Actuarial Office, it appears that there were furloughs during this time period. We would suggest that the Actuarial Office consider excluding data in years where non-recurring activities occur (e.g., furloughs).

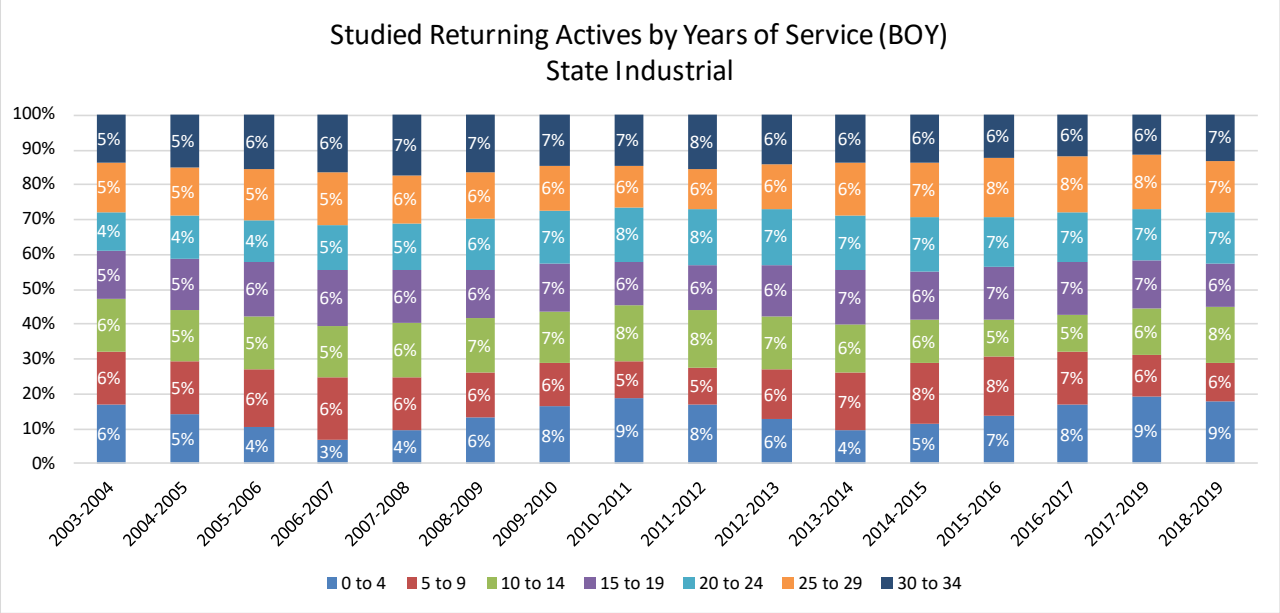
GRS reviewed merit & seniority increases excluding this data. Removal of this data did not have a material impact on the proposed assumptions.

Economic Assumptions
Merit and Seniority Pay Increases

As mentioned earlier, the process for estimating wage inflation by using the change in average payroll year over year is generally a reasonable method in cases where there is not unusual activity in a particular year. Unusual activity could be a significant change in the demographic characteristic from one year to the next for a group.

Presented below are two charts (Schools and State Industrial) that show the distribution by years of service and valuation year.





Economic Assumptions
Merit and Seniority Pay Increases

The purpose of this analysis was to observe changes in demographics that may be occurring that could be driving overall changes in average total payroll (skewing merit and seniority pay increases higher or lower). Based upon our review, the demographics of the population at least based upon YOS remained fairly level, and most importantly, did not appear to experience large swings in demographics for any specific one year to the next.

Based upon our review, we believe the proposed assumptions will provide a reasonable expectation of anticipated future experience. More detailed analysis may be found in Section IV.

SECTION III

DEMOGRAPHIC ASSUMPTIONS

Demographic Assumptions
Review of Experience Study Processes

As part of the Experience Study review, GRS received census information from the Actuarial Office for all active and retiree members of the California Highway patrol (CHP) group for the actuarial valuations from June 30, 1997 through June 30, 2019. GRS used this data to conduct a replication of certain Experience Study results (i.e., exposures, actual rates of decrement, actual payroll increases) for an individual group. The purpose of this analysis was to confirm on an individual record by record basis for a single group that the Actuarial Office's methods for development of Experience Study results are appropriate and accurate.

Since the methodology used in the Experience Study for each group was consistent across all groups, by validating the Actuarial Office's results for CHP specifically, we had confidence in then using the Experience Study census information provided for the other groups (i.e., exposures, actual decrements, actual payroll data) to tabulate exposures, actual decrements and calculate raw rates of decrement.

Below and on the following pages is a summary of GRS' replication of CHP Experience Study results for the following assumption sets: merit & seniority pay increases, service retirement rates, disability rates and termination rates.

Merit and Seniority Pay Increases

GRS reviewed the merit and seniority pay increases for CHP by calculating both growth in average payroll (used as base wage inflation for individual years) and total payroll growth for returning actives (based upon entry age and years of service) which is used to determine the merit and seniority portion of pay increases.

Our replication involved calculating payroll increases in total for CHP for individual valuation years, but also based upon individual entry ages/years of service. Generally speaking, GRS could replicate results to within a reasonable margin of error. More variance occurred when replicating at individual entry ages and years of service, but typically only varied by -0.50% to 0.50%. In aggregate, results matched to a high degree and GRS does not believe differences between GRS' analysis and the Actuarial Office's analysis would yield any material differences in the results.

Retirement Rates

GRS was able to replicate exposures for service retirement and actual service retirements to a very high degree. For the period June 30, 2007 through June 30, 2019, using CHP census valuation data we tabulated 11,765 exposures versus the Actuarial Office's total of 11,770. For actual retirements, GRS exactly replicated the Actuarial Office's total of 2,403.

In addition to replicating total retirement exposures and actual retirements, we also were able to closely match when tabulated by age and service. GRS tabulated ages based upon rounding at the middle of the fiscal year (time of assumed decrement) and service was truncated at the middle of the fiscal year. While tabulations varied slightly by ages and years of service, it could be observed the general trends of the retirement experience based upon age and service were consistent with the Actuarial Office's results.

Demographic Assumptions
Review of Experience Study Processes

Disability Rates

For our replication of disability experience for CHP, we studied both non-industrial disability and industrial disability separately.

GRS replicated the Actuarial Office's exposures for disability to an extremely high degree. For an example, our tabulation of exposures for non-industrial disability, specifically, was 91,471 records versus the Actuarial Office's calculation of 91,466 exposures for the period June 30, 2004 to June 30, 2019.

Our next step was to replicate actual incidences of non-industrial disability and industrial disability. Our preliminary analysis could replicate results in more recent years to a high degree of accuracy. However, census data from older valuations appeared to show inconsistencies. Certain records reported as a non-industrial disability in earlier years were then reported in later years as an industrial disability. Of the 12 records included in the Experience Study as non-industrial disabilities, it appeared only 7 of them were still reported as a non-industrial disability in recent valuations. The other 5 appeared to be reported as an industrial disability in more recent valuations. Similarly, with industrial disability, GRS' replication using prior valuation data to compare to the Actuarial Office's Experience Study results resulted in matching to a high degree in recent periods. For the period June 30, 2015 to June 30, 2019, GRS tabulated 219 industrial related disabilities versus the Actuarial Office's tabulation of 211. Over the full study period, June 30, 2004 to June 30, 2019, GRS tabulated 1,020 industrial disabilities versus the Actuarial Office's 711.

After discussions with the Actuarial Office, it is our understanding CalPERS has undertaken multiple data system updates over the past 20 years to improve the data reporting received from participating employers. Additionally, there were records who may have decremented from active employment under either non-industrial/industrial disability and then later were reclassified and the change was retroactively applied to their benefits. The Actuarial office provided GRS with additional data fields in the census data to determine records the experience study tabulated for studying disability experience. With that additional data, GRS could identify and replicate the Actuarial Office's non-industrial and industrial disability decrement counts used in the Experience Study. Additionally, we confirmed that the ages of the records in the census data matched the Experience Study results. GRS recommends the Actuarial Office review whether it would be more appropriate to set disability rates in total (i.e., non-industrial and industrial related disability combined) and then separately set an industrial versus non-industrial assumption based upon observed experience after reclassifications.

For purposes of developing new industrial disability assumptions, the Actuarial Office reviewed experience over three periods: 2004-2019, 2009-2019 and 2015-2019. We believe this was an important process for setting industrial disability assumptions so that more recent experience periods (i.e., 2015-2019) were reviewed in isolation to confirm the current (or newly proposed) assumptions were reasonable for a period where improved employer reporting has been effective.

Demographic Assumptions
Review of Experience Study Processes

Termination Rates

For our replication of the termination experience for CHP, we studied both those who terminate and refund along with terminate with vested benefits and remain in the System under an inactive status (i.e., deferring pension until retirement age).

For the period June 30, 2000 to June 30, 2019, GRS replicated the Actuarial Office's total exposures for termination decrements almost perfectly.

Exposures (6/30/2000 - 6/30/2019)							
Actuarial Office				GRS			
Terminate & Refund		Terminate & Vest		Terminate & Refund		Terminate & Vest	
Male	Female	Male	Female	Male	Female	Male	Female
124,431	10,737	103,981	9,481	124,443	10,737	103,992	9,481

Our next step was to replicate the actual incidences of termination (separating those who refunded or were vested and remained part of the System). For our preliminary analysis, the original census data we received did not include enough information to confirm whether a termination was also a refund or separation from service but still in the System (i.e., a vested termination). With that said, GRS could replicate the Actuarial Office's termination count in total to a high degree.

Similar to the discussion for disability rates, the Actuarial Office provided GRS with additional data fields in the census data to determine records the Experience Study tabulated for studying termination experience. With the additional data, GRS could identify and replicate all CalPERS termination records (both for refunding and vesting). Additionally, we confirmed the entry ages and years of service of the records in the census data matched the Experience Study results.

Demographic Assumptions – Mortality Rates

Summary of Review (Post-Retirement Mortality)

For review of the post-retirement mortality rates, the Actuarial Office provided GRS the following assumption sets for review:

- Healthy
  - Male
  - Female
- Non-Industrial Disability
  - Male
  - Female
- Industrial Disability
  - Male
  - Female

Our understanding is the exposure and decrement data that the Actuarial Office supplied included data on survivor beneficiaries of deceased retirees. Our preference is to exclude such people from the study because they are a "select" group (i.e., may exhibit survivorship bias). However, in our judgement inclusion or exclusion of this group is likely to lead to relatively similar end results.

CalPERS provides contribution rates for the following groupings of employees:

- State Miscellaneous
- State Industrial
- State Police Officers & Firefighters (POFF)
- State Safety
- California Highway Patrol
- Schools
- Public Agency Miscellaneous
- Public Agency Safety
  - Fire
  - Police (this group also includes Sheriff)
  - County Peace Officers

Post-retirement mortality is treated separately by gender and by type of retirement (Service, Industrial Disability, Non-industrial Disability), but other than that, data for all groups is pooled.

The Actuarial Office's study period for post-retirement mortality covered the period June 30, 2015 through June 30, 2019.

Demographic Assumptions – Mortality Rates

The following table summarizes the total exposures and actual decrements provided by the Actuarial Office and counts excluded by GRS for review of the actuarial assumptions. For post-retirement healthy mortality, GRS excluded ages under 50 for its analysis. GRS does not believe these adjustments had any material impact on results.

Mortality Decrements (Post-Retirement) (July 1, 2015 through June 30, 2019)						
	Exposures			Actual Decrements		
Assumption Group - Decrement	Total	GRS Studied	GRS Excluded	Total	GRS Studied	GRS Excluded
Male - Post Ret. Mortality - Healthy	909,540	904,620	4,920	28,347	28,329	18
Female - Post Ret. Mortality - Healthy	1,320,691	1,312,865	7,826	38,601	38,590	11
Male - Post Ret. Mortality - Industrial Related Disabled	113,527	113,527	0	2,553	2,553	0
Female - Post Ret. Mortality - Industrial Related Disabled	28,415	28,415	0	287	287	0
Male - Post Ret. Mortality - Non-industrial Related Disabled	49,182	49,182	0	2,227	2,227	0
Female - Post Ret. Mortality - Non-industrial Related Disabled	80,260	80,260	0	2,469	2,469	0

Demographic Assumptions – Mortality Rates

Analysis of Current and Proposed Assumptions (Post-Retirement Mortality)

The following tables provide GRS' analysis of the current and proposed assumptions for the below groups. Additional analysis of each group can be found in Section IV of this report.

Mortality Decrements (Post Retirement) (July 1, 2015 through June 30, 2019)									
	Actual*/Expected (A/E) Ratio			Exposure Weighted R-Squared (Age Based)			Percent Inside 90% Confidence Intervals (Age Based)		
Assumption Group - Decrement	Current	Proposed	Graduated Rates*	Current	Proposed	Graduated Rates*	Current	Proposed	Graduated Rates*
Male - Post Ret. Mortality - Healthy^	106%	99%	100%	0.9912	0.9924	0.9962	45%	84%	90%
Female - Post Ret. Mortality - Healthy^	111%	100%	100%	0.9930	0.9948	0.9974	40%	85%	94%
Male - Post Ret. Mortality - Industrial Disabled	128%	101%	100%	0.9671	0.9697	0.9702	60%	94%	97%
Female - Post Ret. Mortality - Industrial Disabled	140%	91%	100%	0.7182	0.7462	0.7536	83%	92%	98%
Male - Post Ret. Mortality - Non-industrial Disabled	123%	100%	100%	0.9292	0.9410	0.9503	68%	86%	92%
Female - Post Ret. Mortality - Non-industrial Disabled	116%	90%	100%	0.9085	0.9063	0.9249	67%	71%	88%

** Graduated rates of actual experience (i.e., raw rates).*

^ For Post-Retirement Mortality (Healthy), the actual decrements are benefit weighted.

The A/E ratios based upon the proposed rates are mostly at or near 100%. The exposure weighted R-squared measure improved in all but one set of proposed assumptions where it declined minimally. The percentage of the assumptions inside the 90% confidence intervals of the raw rates improved in the proposed assumptions from the current assumptions in all of the above assumptions. These summary statistics support the general reasonableness of the proposed assumptions reviewed.

Demographic Assumptions – Mortality Rates

Summary of Observations and Recommendations (Post-Retirement Mortality)

COVID-19

The CalPERS post retirement mortality study covers the period June 30, 2015 through June 30, 2019. The study period therefore ended prior to the acknowledged beginning of the COVID-19 pandemic. CalPERS recommends waiting until the next experience study to address the impact of COVID-19. We concur with this recommendation. We observed approximately 10% extra mortality in calendar 2020 in two fairly large state plans that we service. However, there is no evidence to date that the extra mortality will be a persistent effect. There are arguments on both sides. Some people assert that lingering effects of COVID among those who have been infected will lead to increased mortality for years to come. Others assert that recent advances in medical care, particularly vaccines, and increased attention to sanitation on an individual basis will actually lead to reduced mortality in the future. So, although mortality gains may be expected in the years immediately following the study, we do not think it is necessary to build recognition of those possibly transitory gains into mortality rates going forward. Indeed, in the next experience study, CalPERS may decide that certain experience is an anomaly that should be removed from the data or adjusted in some way.

Head Count Weighted versus Benefit Weighted Mortality Rates

Head count weighted rates provide estimates of the number of people who may die during an experience period without regard to their liabilities. A retirement program, however, is more affected by the liabilities that are removed by virtue of death than it is by the number of people who died. Benefit weighting is used as a proxy for liability weighting and is accepted actuarial practice. The Actuarial Office prepared the information in the following table regarding the variance in benefits by type of retirement:

	Standard Deviation of Benefit as a % of Average Benefit	
Decrement	Males	Females
Service Retirement	23%	17%
Non-industrial Disability	5%	13%
Industrial Disability	15%	10%

Based upon the data in this table, the Actuarial Office decided that benefit weighting is appropriate for Service retirement but not for either type of disability retirement. The data certainly indicates that there is less variance in disability benefit amounts than in service retirement benefit amounts. This may be because of benefit structure or because disabled individuals will in many cases have less service credit than people who retire voluntarily after meeting age and service conditions. From this, we can conclude that it is less important to use benefit weighting for disability retirements than for service retirements. We are also influenced by the fact that disabled mortality may be more influenced by the level of disability than by income. While we believe it is acceptable to use head count weighted tables for disabled individuals, we recommend that CalPERS reconsider the matter in the next Experience Study. One way to do that would be to develop tables both ways and determine whether or not there is a meaningful difference in rates by amount of benefit.

Demographic Assumptions – Mortality Rates

Mortality after Service Retirement (SR)

Graduation (i.e., Smoothing) Process

As a first step in the mortality table development, the Actuarial Office smooths amount weighted experience rates with a Whittaker Henderson Type B process. A Whittaker Henderson process incorporates goodness of fit based on the sum of the squares of the differences between experience rates and smoothed rates. It incorporates smoothness by summing the squares of the n^{th} differences of the smoothed rates. It uses a smoothing parameter to weight goodness of fit vs smoothness. A small smoothing parameter weights the process toward goodness of fit. A large smoothing parameter weights the process toward smoothness. The Actuarial Office uses n=4 and a smoothness parameter of 10,000,000. The Actuarial Office did not provide a justification for these parameter choices. We tested these parameters for a selection of ages for females in order to assess the reasonableness of the choices. While we only tested females, we believe that similar results would obtain for males. The smoothed rates resulting from various parameter choices are given below. The results for the parameters that CalPERS used are bolded.

		Smoothed Rates by Difference Parameter (Smoothing Parameter=10,000,000)					
Age	Raw Rate	2	3	4	5	6	9
65	0.00591	0.00587	0.00584	**0.00582**	0.00580	0.00579	0.00577
70	0.00963	0.00960	0.00958	**0.00958**	0.00958	0.00958	0.00959
75	0.01691	0.01727	0.01741	**0.01748**	0.01752	0.01756	0.01762
80	0.03395	0.03384	0.03389	**0.03400**	0.03411	0.03420	0.03437

A difference parameter of 2 corresponds to a straight line. In other words, if the second differences were all 0 are close to 0, the curve would be a straight line or close to a straight line. A difference parameter of 9 corresponds to an 8^{th} degree polynomial. A straight line would not be a good approximation for mortality rates, which tend to rise exponentially with increasing age. The use of a cubic fit for the data (n=4) appears reasonable to us, although higher values of n certainly could be used.

		Smoothed Rates by Smoothing Parameter in 000 (Difference Parameter =4)					
Age	Raw Rate	1	10	100	1,000	10,000	100,000
65	0.00591	0.00591	0.00590	0.00590	0.00587	**0.00582**	0.00582
70	0.00963	0.00963	0.00963	0.00961	0.00958	**0.00958**	0.00967
75	0.01691	0.01691	0.01692	0.01700	0.01728	**0.01748**	0.01754
80	0.03395	0.03395	0.03393	0.03383	0.03371	**0.03400**	0.03391

Smoothing parameters below 10,000 appear to produce smoothed rates nearly identical to the raw rates. An effect begins to be seen at 100,000. The choice of 10,000,000 appears within reason to us.
While we find these choices to be reasonable, we recommend that the Actuarial Office explain the reasoning behind these parameter choices in the final report.

Demographic Assumptions – Mortality Rates

Credibility Process

The Actuarial Office develops a separate credibility factor at each age based on head count weighted exposures and deaths and a 90% confidence interval with a 5% margin of error. The 90% confidence interval with a 5% margin of error is widely used, and we see no reason to question it, although a different choice could certainly have been made. The Actuarial Office then uses the square root method to produce a final rate based on a weighting of the smoothed amount weighted raw rates with the results of a "standard" table (i.e., 66% of PubG-2010 Retiree Mortality Tables and 34% of PubS-2010 Retiree Mortality Tables with a 2017 base year) that is presumed to be fully credible. For head count weighted data in individual age groupings, the distribution of deaths can be presumed to be binomial which eventually leads to the result that full credibility is achieved if the number of deaths is at least equal to p x 1,082.217 where p is the estimator of the survival probability. For p, the Actuarial Office uses the complement of the unsmoothed experience amount weighted mortality rate. We think doing so is reasonable for CalPERS. In other situations, we would tend to use a p value based on the standard table that is otherwise used in the smoothing process or based on the graduated rate that the Actuarial Office calculates.

For females age 70, the process produces 1,072 as the number of deaths needed for full credibility. If the p-value from the underlying standard table had been used, the result would have been 1070 – an inconsequential difference. At age 70, there were 592 actual deaths. The graduated raw rate is 0.00958. The square root method indicates that the weight to be assigned to the raw rates is the square root of the ratio of the actual deaths to the number needed for full credibility, which in this case is 0.743. The fully credible rate (from the Standard table) is 0.01107. Applying this method results in a new proposed mortality rate for age 70 females as follows:

$$0.743 \times 0.00958 + (1-0.743) \times 0.01107 = 0.00996$$

Unfortunately, this calculation is not completely correct from a theoretical point of view. When studies are done on an amount weighted basis, the threshold for full credibility is calculated with a different formula that typically results in more deaths needed for full credibility than the method that the Actuarial Office used. The correct formula is shown on page 20 of the Society of Actuaries monograph "Credibility Educational Resource for Pension Actuaries". Application of this formula requires analysis of original seriatim participant data, something outside the scope of this audit.

We independently calculated all of the mortality rates for both genders based on the data supplied and the method that CalPERS used. We reproduced those rates with a very high degree of accuracy (4^{th} or 5^{th} decimal place).

Demographic Assumptions – Mortality Rates

The important question, in our view, is not whether or not the methods used to develop the table were exactly 100% theoretically correct, but rather, is the end result reasonable based upon the data? In order to test the reasonableness of the final result, we compared annuity values at 5% interest between the proposed new table and the standard table for various ages. The results were as follows.

Value of $1,000 per Year at 5% Interest						
	Females			Males		
	Mortality Table			Mortality Table		
Age	Proposed	Standard	Diff%	Proposed	Standard	Diff%
60	$14,246.04	$14,170.76	-0.53%	$13,602.83	$13,448.83	-1.13%
70	$11,354.68	$11,248.80	-0.93%	$10,592.04	$10,386.90	-1.94%
80	$7,740.20	$7,729.03	-0.14%	$6,957.41	$6,828.26	-1.86%
90	$4,287.84	$4,410.30	2.86%	$3,681.78	$3,784.20	2.78%

The standard table produces slightly lesser annuity values at most ages than the proposed table. In our judgement the choice of the proposed table is reasonable. We believe the proposed table when combined with an appropriate mortality improvement scale will provide a reasonable expectation of anticipated future experience.

Demographic Assumptions – Mortality Rates

Mortality after Industrial Disability Retirement (IDR)

Details

The post IDR mortality study is based upon a head count weighted analysis of mortality. The Actuarial Office develops raw rates based upon head counts, in other words, the ratio of actual death to the number of people "exposed" to death at each age. CalPERS has an extensive data set that permits development of experience-based mortality rates, although the credibility at individual ages for IDR is quite low. For males, there were 2,553 deaths over the experience period, which would allow for full credibility on an aggregate basis. For females, there were only 287 deaths, which would allow for approximately 50% credibility based on the square root method.

Actuarial Office Process

As a first step in the mortality table development, the Actuarial Office smooths the experience rates with a Whittaker Henderson Type B process. The Actuarial Office uses n=4 and a smoothness parameter of 100,000. The Actuarial Office did not provide a justification for these parameter choices. While we find these choices to be reasonable, we recommend that CalPERS explain the reasoning behind these parameter choices in the final report.

The Actuarial Office develops a separate credibility factor at each age based on head count weighted exposures and deaths and a 90% confidence interval with 5% margin of error. CalPERS then uses the square root method to produce a final rate based on a weighting of the smoothed head count weighted raw rates with the results of a standard table (i.e., PubS-2010 Disabled Retiree Mortality Tables with 2017 base year) that is presumed to be fully credible. For head count weighted data, the distribution of deaths can be presumed to be binomial which eventually leads to the result that full credibility is achieved if the number of deaths is at least equal to p x 1082.217 where p is the estimator of the survival probability.

For females age 70, the process produces 1057 as the number of deaths needed for full credibility. The graduated raw rate is 0.02179. If the p-value from the underlying credible table had been used, the result would have been 1062 – an inconsequential difference. At age 70, there were 14 actual deaths. The square root method indicates that the weight to be assigned to the raw rates is the square root of the ratio of the actual deaths to the number needed for full credibility, which in this case is 0.115. This a very low credibility value, and is actually one of the highest one for females. The fully credible rate (from the Pub 2010 Safety disabled retiree table) is 0.01817. Applying this method results in a new proposed mortality rate for age 70 females as follows:

$$0.115 \times 0.02179 + (1-0.115) \times 0.01817 = 0.01858$$

The proposed new rates are very close to the standard table at all ages. This is a consequence of the low credibility of the experience rates. In fact, the difference in the age 70 rates is one of the largest differences between the two tables.

Demographic Assumptions – Mortality Rates

For males age 70, the process produces 1,058 as the number of deaths needed for full credibility. The graduated raw rate is 0.02267. If the p-value from the underlying credible table had been used, the result would have been 1061 – an inconsequential difference. At age 70, there were 90 actual deaths. The square root method indicates that the weight to be assigned to the raw rates is the square root of the ratio of the actual deaths to the number needed for full credibility, which in this case is 0.292. The fully credible rate (from the Pub 2010 Safety disabled retiree table) is 0.02157. Applying this method results in a new proposed mortality rate for age 70 females as follows:

$$0.292 \times 0.02267 + (1-0.292) \times 0.02157 = 0.02189$$

We independently calculated all of the mortality rates for both genders based on the data supplied. We reproduced those rates with a very high degree of accuracy (4^{th} or 5^{th} decimal place). The proposed new rates are also very close to the standard table at all ages.

We believe the proposed tables when combined with an appropriate mortality improvement scale will provide a reasonable expectation of anticipated future experience.

Mortality after Non-Industrial Disability Retirement (NIDR)

Details

The NIDR mortality study is based upon a head count weighted analysis of mortality. The Actuarial Office develops raw rates based upon head counts, in other words, the ratio of actual death to the number of people "exposed" to death at each age. CalPERS has an extensive data set that permits development of experience-based mortality rates, although the credibility at individual ages is quite low. For males, there were 2,227 death over the experience period. For females, there were 2,469 deaths over the period. In both cases this number of deaths would allow for full credibility in the aggregate.

Actuarial Office Process

As a first step in the mortality table development, the Actuarial Office smooths the experience rates with a Whittaker Henderson Type B process. The Actuarial Office uses n=4 and a smoothness parameter of 100,000. The Actuarial Office did not provide a justification for these parameter choices. While we find these choices to be reasonable, we recommend that CalPERS explain the reasoning behind these parameter choices in the final report.

Demographic Assumptions – Mortality Rates

The Actuarial Office then develops a separate credibility factor at each age based on head count weighted exposures and deaths and a 90% confidence interval with 5% margin of error. CalPERS then uses the square root method to produce a final rate based on a weighting of the smoothed head count weighted raw rates with the results of a standard table (i.e., PubNS-2010 Disabled Retiree Mortality Tables with 2017 base year) that is presumed to be fully credible. For head count weighted data, the distribution of deaths can be presumed to be binomial which eventually leads to the result that full credibility is achieved if the number of deaths is at least equal to p x 1082.217 where p is the estimator of the survival probability.

For females age 70, the process produces 1,057 as the number of deaths needed for full credibility. The graduated raw rate is 0.02538. If the p-value from the underlying standard table had been used, the result would have been 1,049 – an inconsequential difference. At age 70, there were 59 actual deaths. The square root method indicates that the weight to be assigned to the raw rates is the square root of the ratio of the actual deaths to the number needed for full credibility, which in this case is 0.236. (As with service retirement and IDR, we suggest consideration of an alternate method for calculating this factor). The fully credible rate (from the Pub 2010 General disabled retiree table) is 0.03025. Applying this method results in a new proposed mortality rate for age 70 females as follows:

$$0.236 \times 0.02538 + (1-0.236) \times 0.03025 = 0.0291$$

The proposed new rates are very close to the standard table at all ages. This is a consequence of the low credibility of the experience rates by age.

For males age 70, the process produces 1,044 as the number of deaths needed for full credibility. The graduated raw rate is 0.03552. If the p-value from the underlying credible table had been used, the result would have been 1,036 – an inconsequential difference. At age 70, there were 60 actual deaths. The square root method indicates that the weight to be assigned to the raw rates is the square root of the ratio of the actual deaths to the number needed for full credibility, which in this case is 0.240. The fully credible rate (from the Pub 2010 General disabled retiree table) is 0.0421. Applying this method results in a new proposed mortality rate for age 70 males as follows:

$$0.240 \times 0.03552 + (1-0.240) \times 0.04215 = 0.04056$$

Demographic Assumptions – Mortality Rates

We independently calculated all of the mortality rates for both genders based on the data supplied. We reproduced those rates with a very high degree of accuracy (4th or 5th decimal place). The proposed new rates are also very close to the standard table at all ages.

We believe the proposed tables when combined with an appropriate mortality improvement scale will provide a reasonable expectation of anticipated future experience.

Demographic Assumptions – Mortality Rates

Summary and Recommendations (Post-Retirement Mortality)

Presented below are the recommendations and suggestions resulting from our analysis of post-retirement mortality.

1. For mortality after service retirement, the study is based upon amounts, but the Actuarial Office calculated credibility factors for each individual age using head count weighted methods and blended the (smoothed) raw results with a standard table. Amount weighted credibility methods should have been used which generally results in lower credibility being assigned to the subject data.
2. By assembling data at individual ages and blending according to credibility, there is a small risk that smoothness in the final table may be less than desired. If the Actuarial Office continues this method, the Actuarial Office could add a final smoothness check to the end results.
3. The Actuarial Office calculates the credibility factor Z, as the square root of the ratio of actual decrements to the number (or amount) required for full credibility. This is a textbook formula. However, instead of calculating the new rate as Z x raw rate + (1-Z) x standard rate, the Actuarial Office uses a graduated raw rate instead of the actual raw rate. We like that idea, since it will help remove bumpiness from the end result, mitigating the issue addressed above. However, we think that in that instance the Actuarial Office could also consider calculating Z as the square root of the ratio of (graduated raw rate x exposure) to the number (or amount) required for full credibility at each age. We don't think this is a significant issue. It is a suggestion for future consideration.
4. The Actuarial Office calculates the number or amount required for full credibility at each age as p x 1,082 in the case of head count weighting, where p = (1-raw rate). Since the Actuarial Office replaces the raw rates with graduated raw rates throughout the calculation, with think that it would be reasonable to calculate p as (1-graduated raw rate), or alternatively to base p on the standard table. This is a minor matter.
5. For mortality after service retirement, CalPERS data is sufficient to be fully credible in 5-year age bands, but not in individual age groupings. The Actuarial Office could develop rates based on age bands, interpolate them to individual ages and graduate the results, thus creating a table fully reflective of CalPERS experience.
6. Another method that could be used is to develop A/E ratios in total and adjust the rates in the standard table by that ratio. This is a simple method that would likely also produce a good result provided that the shape of the standard table is reasonably representative of CalPERS experience.

Demographic Assumptions – Mortality Rates

Summary of Review (Pre-Retirement Mortality)

For review of the pre-retirement mortality rates, the Actuarial Office provided GRS the following assumption sets for review:

- Pre-retirement mortality
  - Miscellaneous
    - Male
    - Female
  - Safety
    - Male
    - Female

The Actuarial Office's study period for pre-retirement mortality covered the period June 30, 2004 through June 30, 2019.

Demographic Assumptions – Mortality Rates

The following table summarizes the total exposures and actual decrements provided by the Actuarial Office and counts excluded by GRS for review of the actuarial assumptions. For pre-retirement mortality GRS only included ages 15-90. GRS does not believe these adjustments had any material impact on results.

Mortality Decrements (Pre-Retirement) (July 1, 2004 through June 30, 2019)						
	Exposures			Actual Decrements		
Assumption Group - Decrement	Total	GRS Studied	GRS Excluded	Total	GRS Studied	GRS Excluded
All Misc Male - Non-Industrial Death	3,786,784	3,786,723	61	5,928	5,926	2
All Misc Female - Non-Industrial Death	6,044,917	6,044,868	49	5,571	5,567	4
All Safety Male - Industrial and Non-Industrial Deaths	1,493,558	1,493,554	4	1,398	1,398	0
All Safety Female - Industrial and Non-Industrial Deaths	513,000	513,000	0	402	402	0

Demographic Assumptions – Mortality Rates
Analysis of Current and Proposed Assumptions

Analysis of Current and Proposed Assumptions (Pre-Retirement Mortality)

The following tables provide GRS' analysis of the current and proposed assumptions for the below groups. Additional analysis of each group can be found in Section IV of this report.

Mortality Decrements (Pre-Retirement) (July 1, 2004 through June 30, 2019)									
	Actual*/Expected (A/E) Ratio			Exposure Weighted R-Squared (Age Based)			Percent Inside 90% Confidence Intervals (Age Based)		
Assumption Group - Decrement	Current	Proposed	Graduated Rates*	Current	Proposed	Graduated Rates*	Current	Proposed	Graduated Rates*
All Misc Male - Non-Industrial Death	112%	101%	100%	0.6370	0.6397	0.9463	63%	74%	92%
All Misc Female - Non-Industrial Death	103%	99%	100%	0.7555	0.7524	0.8977	70%	70%	84%
All Safety Male - Industrial and Non-Industrial Deaths	90%	107%	100%	0.6368	0.6732	0.7498	77%	84%	87%
All Safety Female - Industrial and Non-Industrial Deaths	96%	106%	100%	0.5620	0.4909	0.6446	88%	87%	92%

** Graduated rates of actual experience (i.e., raw rates).*

The A/E ratios based upon the proposed rates are mostly at or near 100%. The exposure weighted R-squared measure declined for some of the proposed assumptions, but declines were not of a magnitude to cause concern. The percentage of the assumptions inside the 90% confidence intervals of the raw rates either remained about level or improved in the proposed assumptions from the current assumptions. These summary statistics support the general reasonableness of the proposed assumptions reviewed.

Demographic Assumptions – Mortality Rates

Summary of Observations and Recommendations (Pre-Retirement Mortality)

Miscellaneous Employees

Miscellaneous employees are all those individuals not classified as Safety. In particular, the following groups are included:

- State Miscellaneous
- State Industrial
- Schools
- Public Agency Miscellaneous

There is no distinction between Industrial and Non-industrial death for miscellaneous employees.

The study is based on head count weighting rather than any type of liability weighting. We concur that head count weighting is reasonable for the intended purpose. There were over 5 thousand deaths for females and over 5 thousand death for males indicating a sufficient number of deaths for full credibility in the aggregate. The procedures are largely the same as for post-retirement mortality and we think they are reasonable. Our suggestions for future consideration are the same.

- When adjusting the 1,082 full credibility number, use a p related either to the standard table (i.e., PubG-2010 Employee Mortality Tables) or to the graduated experience table
- When calculating the Z factor replace actual decrement counts with a hypothetical decrement count based upon the graduated raw rate and the exposure at the age under study.

These are very minor matters that would not affect the end result materially. We believe the proposed tables when combined with an appropriate mortality improvement scale will provide a reasonable expectation of anticipated future experience.

Demographic Assumptions – Mortality Rates

Safety Employees

Safety employees are comprised of the following:

- State Police Officers & Firefighters (POFF)
- State Safety
- California Highway Patrol
- Public Agency Safety
    - Fire
    - Police (this group also includes Sheriff)
    - County Peace Officers

There were approximately 400 deaths for females and approximately 1,400 deaths for males indicating a sufficient number of deaths for full credibility in the aggregate for males, but not for females. The study is based on head count weighting rather than any type of liability weighting. We concur that head count weighting is reasonable for the intended purpose. The procedures are largely the same as discussed above and we think they are reasonable and our suggestions for improvement are the same.

- When adjusting the 1082 full credibility number, use a p related either to the standard table (i.e., PubS-2010 Employee Mortality Tables) or to the graduated experience table
- When calculating the Z factor replace actual decrement counts with a hypothetical decrement count based upon the graduated raw rate and the exposure at the age under study.

These are very minor matters that would not affect the end result materially. We believe the proposed tables when combined with an appropriate mortality improvement scale will provide a reasonable expectation of anticipated future experience.

Mortality Projection Scale

The Actuarial Office provided very general statistics on the rate of mortality improvement in its population and is proposing to use 80% of the MP-2020 projection scale. The statistics provided do not give us cause to disagree with the Actuarial Office on this assumption. The Society of Actuaries provides an automated excel workbook for producing alternative projection scales. We suggest that in the future the Actuarial Office develop an alternative scale using that tool if it does not think the current MP scale is appropriate for the CalPERS population.

Demographic Assumptions – Service Retirement Rates

Summary of Review

For the review of the service retirement decrement, the Actuarial Office provided to GRS the following 17 assumption sets for review:

- State Miscellaneous
- State Safety members
- State Industrial members
- Schools
- State Police Officers & Firefighters (POFF)
- California Highway Patrol members
- Public Agency Miscellaneous (PA Misc):
    - 2.0% multiplier at age 55
    - 2.5% multiplier at age 55
    - 2.7% multiplier at age 55
    - 2.0% multiplier at age 60
    - 3.0% multiplier at age 60
- Public Agency Safety – Police (PA Police):
    - 2.0% multiplier at age 50
    - 3.0% multiplier at age 50
    - 3.0% multiplier at age 55
- Public Agency Safety – Fire (PA Fire):
    - 2.0% multiplier at age 50
    - 3.0% multiplier at age 50
    - 3.0% multiplier at age 55

The Actuarial Office's study period for service retirement rates covered the period June 30, 2007 through June 30, 2019.

For review of the retirement decrements, GRS tabulated the total exposures and decrements based upon only those who met the eligibility conditions of service retirement. For example, State Miscellaneous had 13,300 exposures (1,578 retirements) during the study period who were classified as having less than 5 years of service. While these records may have actually had greater than 5 years of service and been eligible for retirement, for purposes of developing exposures and decrements for the experience study, we believe these records should not be included if the valuation system assumes they would have similarly not been eligible for retirement. Including these records in the analysis could result in incorrect conclusions for experience study parameters such as Actual/Expected Ratios.

Demographic Assumptions – Service Retirement Rates

The following table summarizes the total exposures and actual decrements provided by the Actuarial Office and counts excluded by GRS for review of the actuarial assumptions. GRS only included exposures and decrements where the proposed rates of retirement were greater than zero.

Service Retirement Decrements (July 1, 2007 through June 30, 2019)						
	Exposures			Actual Decrements		
Assumption Group	Total	GRS Studied	GRS Excluded	Total	GRS Studied	GRS Excluded
State Miscellaneous	871,202	857,902	13,300	71,697	70,119	1,578
State Safety	119,682	116,589	3,093	10,141	10,010	131
State Industrial	47,668	46,219	1,449	4,026	3,965	61
Schools	1,405,175	1,393,938	11,237	98,950	98,652	298
POFF	117,371	116,480	891	17,340	17,261	79
CHP	11,770	11,766	4	2,403	2,401	2
PA Misc 2.0% @ 55	313,409	308,826	4,583	26,619	26,442	177
PA Misc 2.5% @ 55	204,458	201,860	2,598	19,038	18,940	98
PA Misc 2.7% @ 55	216,873	214,121	2,752	21,466	21,352	114
PA Misc 2.0% @ 60	44,903	43,671	1,232	2,813	2,772	41
PA Misc 3.0% @ 60	105,713	103,907	1,806	9,686	9,625	61
PA Police 2.0% @ 50	5,563	5,525	38	553	552	1
PA Police 3.0% @ 50	49,836	49,611	225	9,187	9,171	16
PA Police 3.0% @ 55	7,931	7,878	53	832	830	2
PA Fire 2% @ 50	843	835	8	84	84	0
PA Fire 3% @ 50	28,689	28,642	47	4,025	4,015	10
PA Fire 3% @ 55	8,844	8,825	19	934	932	2

Demographic Assumptions – Service Retirement Rates
Analysis of Current and Proposed Assumptions

Analysis of Current and Proposed Assumptions

The following tables provide GRS' analysis of the current and proposed assumptions for the below groups. Additional analysis of each group can be found in Section IV of this report.

Service Retirement Decrements (July 1, 2007 through June 30, 2019)						
	Actual/Expected (A/E) Ratio		Exposure Weighted R-Squared (Age Based)		Percent Inside 90% Confidence Intervals (Age Based)	
Assumption Group	Current	Proposed	Current	Proposed	Current	Proposed
State Miscellaneous	83%	99%	0.5982	0.9973	24%	84%
State Safety	87%	100%	0.7092	0.9972	28%	96%
State Industrial	89%	99%	0.5417	0.9987	52%	100%
Schools	85%	100%	0.6048	0.9983	20%	84%
POFF	100%	100%	0.5939	0.9999	45%	100%
CHP	117%	100%	0.8716	1.0000	50%	100%
PA Misc 2.0% @ 55	91%	100%	0.6042	0.9968	20%	88%
PA Misc 2.5% @ 55	96%	100%	0.6306	0.9946	36%	84%
PA Misc 2.7% @ 55	93%	100%	0.5699	0.9964	28%	88%
PA Misc 2.0% @ 60	68%	100%	0.5986	0.9919	24%	96%
PA Misc 3.0% @ 60	86%	100%	0.5686	0.9951	24%	92%
PA Police 2.0% @ 50	93%	100%	0.8449	1.0000	73%	100%
PA Police 3.0% @ 50	114%	100%	0.2637	0.9999	67%	100%
PA Police 3.0% @ 55	93%	100%	0.6690	1.0000	80%	100%
PA Fire 2% @ 50	99%	100%	0.6939	0.8728	93%	100%
PA Fire 3% @ 50	105%	100%	0.7590	1.0000	47%	100%
PA Fire 3% @ 55	93%	100%	0.5553	1.0000	47%	100%

The above statistics are for ages where the assumed rates of retirement are less than 100%.

The A/E ratios based upon the proposed rates are mostly at or near 100%. The exposure weighted R-squared measure improved for all of the proposed assumptions. The percentage of the proposed assumptions inside the 90% confidence interval of the raw rates was above 80% for all and above 90% for most. These summary statistics support the general reasonableness of the proposed assumptions reviewed.

Demographic Assumptions – Service Retirement Rates

Summary of Observations and Recommendations

The proposed service retirement rates vary by both attained age and service. Our understanding is the service used in the valuation system is the elapsed time a member has been part of CalPERS. GRS had no specific concerns with this measure for determining the service-based retirement assumption that is applicable. Generally speaking for all assumption groups, the proposed assumptions (on average) tightly match experience on an age-based approach. Reviewing results on a service-based approach, it can be observed for some groups that the proposed rates (on average) appear higher than experience (e.g., PA Police). This occurs because of the ages the assumed rates of service retirement go to 100%. Many groups have the retirement assumption set to 100% at ages between 60 and 75 despite experience suggesting lower rates at these higher ages.

During the next study GRS recommends the Actuarial Office consider extending rates to higher ages consistent with System experience.

The California Public Employees' Pension Reform Act (PEPRA), which took effect in January 2013, changes the way CalPERS retirement and health benefits are applied, and places compensation limits on members. Currently, members applicable to PEPRA have their own assumptions for rates of service retirement. At this time, there is not a material amount of experience to develop experience rated assumptions for these members. No changes in assumptions for PEPRA service retirements were made by the Actuarial Office. Generally speaking, current PEPRA assumptions have lower or the same rates of service retirement as the current assumptions for the Classic member counterparts. For example, the PEPRA group POFF with a 2.7% multiplier at age 57 has a rate of service retirement of 36% at age 60 with 30 years of service. This was the same percentage as the current assumption for Classic POFF members with the same age and years of service. Under the proposed assumptions, this rate was reduced to 31.1%. With the PEPRA rates of service retirement unchanged, a PEPRA member in this example would have a higher rate of retirement than their Classic member counterpart

With the assumed rates of service retirement changing for Classic members, any PEPRA assumptions which were originally developed with the consideration of the Classic members' assumptions, we would recommend the PEPRA rates also be adjusted to remain consistent.

GRS believes the study period of 12 years (July 1, 2007 to June 30, 2019) is a long period for setting assumptions. With that said, full credibility appears to have been given by the Actuarial Office to the 12-year period for selecting proposed service retirement assumptions. We believe this helped allow recent experience have a material impact on selecting the proposed assumptions. One aspect that cannot be determined with the longer period though is whether there are any emerging trends in recent years (i.e., 4 to 5 years) that could be materially different experience than prior years.

GRS recommends the Actuarial Office in future studies additionally review shorter periods to confirm there are no emerging trends in retirement patterns.

Demographic Assumptions – Service Retirement Rates

As mentioned in the previous paragraph, it appears the Actuarial Office gave full credibility to the experience when selecting service retirement assumptions. For many groups, there was considerable experience to develop assumptions applying full credibility to the experience period. However, some smaller assumption groups, such as PA Police with 2% multiplier at age 50, there was less experience. Looking at the average proposed assumptions using an age-based analysis, there were declines in the proposed rates of retirement at specific ages (57, 58, 61 and 64). GRS could not determine why these specific ages would have lower rates of retirement than previous ages for any specific reason. One approach to handle this, is to develop assumptions that average experience across multiple ages, especially if there is an overall trend, such as, rates increases at older ages.

GRS recommends for the next Experience Study the Actuarial Office consider smoothing assumptions (either by graduation technique or manually) across ages where the experience appears generally consistent with a common trend (e.g., increasing, decreasing or level).

GRS reviewed the exposures and actual service retirement experience for seventeen assumption groups. Groups not reviewed in detail were those in which the current assumptions were not being recommended change in the Experience Study; specifically, the assumption group Public Agency Safety (Fire/Police) 2% multiplier at age 55.

For the next review the Actuarial Office performs of an Experience Study, GRS recommends the Actuarial Office provide the reviewing Actuary with detailed analysis of assumption groups regardless of if the current assumptions are being changed or not.

Demographic Assumptions –Disability Rates

Summary of Review

For review of the rates of disability from active employment, the Actuarial Office provided GRS the following 9 assumption sets for review:

- Non-Industrial Disability:
  - CHP
  - State Industrial
  - PA CPO
  - PA Fire
  - PA Misc & Local Prosc Females
  - PA Misc & Local Prosc Males
  - PA Police, Other Safety, Local Sheriff & School Police
- Industrial Disability:
  - State Industrial
  - State Safety

The Actuarial Office's study period for disability rates covered the period July 1, 2004 through June 30, 2019.

The data in the below table was additionally provided by the Actuarial Office and summarizes the actual non-industrial disability decrements versus the expected decrements for the period July 1, 2004 through June 30, 2019. The expected decrements are based upon the current assumptions.

Non-Industrial Disability	2004-2019		
	Actual	Exp	A/E
State Miscellaneous Female	2,677	2,911.3	92.0%
State Miscellaneous Male	1,571	1,616.7	97.2%
State Industrial	498	613.7	81.1%
State Safety	478	519.3	92.0%
State POFF	380	379.9	100.0%
State CHP	12	14.4	83.5%
Schools Miscellaneous Female	2,423	2,691.2	90.0%
Schools Miscellaneous Male	1,492	1,609.5	92.7%
Public Agency Miscellaneous Female	1,335	1,514.3	88.2%
Public Agency Miscellaneous Male	1,173	1,369.0	85.7%
Public Agency Police	91	159.7	57.0%
Public Agency Fire	43	54.3	79.2%
Public Agency CPO	93	105.1	88.5%

Demographic Assumptions –Disability Rates

The data in the below table was additionally provided by the Actuarial Office and summarizes the actual non-industrial disability decrements versus the expected decrements for the periods July 1, 2015 through June 30, 2019, July 1, 2009 through June 30, 2019 and July 1, 2004 through June 30, 2019. The expected decrements are based upon the current assumptions.

Industrial Disability	2015-2019			2009-2019			2004-2019		
	Actual	Exp	A/E	Actual	Exp	A/E	Actual	Exp	A/E
State Industrial	7	18	40%	22	43	51%	35	60	58%
State Safety	616	555	111%	1,414	1,326	107%	1,784	1,862	96%
State POFF	1,217	1,247	98%	3,022	3,181	95%	4,030	4,761	85%
State CHP	211	201	105%	431	473	91%	711	725	98%
PA Police	1,317	1,383	95%	3,209	3,410	94%	4,618	5,050	91%
PA Fire	478	496	96%	1,206	1,236	98%	1,817	1,818	100%
PA CPO	291	274	106%	629	674	93%	908	984	92%

Demographic Assumptions –Disability Rates

The following table summarizes the total exposures and actual decrements provided by the Actuarial Office and counts excluded by GRS for review of the actuarial assumptions. GRS excluded no records for review of the disability assumptions.

Non-Industrial Disability Decrements (July 1, 2004 through June 30, 2019)						
	Exposures			Actual Decrements		
Assumption Group	Total	GRS Studied	GRS Excluded	Total	GRS Studied	GRS Excluded
State Industrial	116,968	116,968	0	498	498	0
CHP	91,466	91,466	0	12	12	0
PA Misc & Local Prosecutors Male	1,043,345	1,043,345	0	1,173	1,173	0
PA Misc & Local Prosecutors Female	1,097,367	1,097,367	0	1,335	1,335	0
PA Police, Other Safety, Local Sheriff, & School Police	296,024	296,024	0	91	91	0
PA CPO	119,253	119,253	0	93	93	0
PA Fire	181,582	181,582	0	43	43	0

Industrial Disability Decrements (July 1 2015 through June 30, 2019)						
	Exposures			Actual Decrements		
Assumption Group	Total	GRS Studied	GRS Excluded	Total	GRS Studied	GRS Excluded
State Safety	108,802	108,802	0	616	616	0
State Industrial	45,910	45,910	0	7	7	0

Demographic Assumptions –Disability Rates

Analysis of Current and Proposed Assumptions

The following tables provide GRS' analysis of the current and proposed assumptions for the below groups. Additional analysis of each group can be found in Section IV of this report.

Non-Industrial Disability Decrements (July 1, 2004 through June 30, 2019)									
	Actual/Expected (A/E) Ratio			Exposure Weighted R-Squared (Age Based)			Percent Inside 90% Confidence Intervals (Age Based)		
Assumption Group	Current	Proposed	Graduated Rates*	Current	Proposed	Graduated Rates*	Current	Proposed	Graduated Rates*
State Industrial	81%	91%	100%	0.6123	0.7097	0.7464	79%	93%	95%
CHP	84%	92%	99%	0.0076	0.0725	0.1270	100%	100%	100%
PA Misc & Local Prosecutors Male	86%	95%	100%	0.6827	0.7849	0.8136	80%	90%	98%
PA Misc & Local Prosecutors Female	88%	95%	100%	0.4439	0.4780	0.5497	79%	91%	95%
PA Police, Other Safety, Local Sheriff, & School Police	57%	91%	100%	0.0138	0.1073	0.1431	69%	94%	97%
PA CPO	88%	96%	100%	0.0060	0.0183	0.0761	85%	91%	97%
PA Fire	79%	90%	99%	0.0062	0.1046	0.1878	84%	100%	89%

Industrial Disability Decrements (July 1 2015 through June 30, 2019)									
	Actual/Expected (A/E) Ratio			Exposure Weighted R-Squared (Age Based)			Percent Inside 90% Confidence Intervals (Age Based)		
Assumption Group	Current	Proposed	Graduated Rates*	Current	Proposed	Graduated Rates*	Current	Proposed	Graduated Rates*
State Safety	111%	103%	100%	0.6443	0.6754	0.7049	82%	96%	92%
State Industrial	40%	99%	N/A	0.0332	0.0331	N/A	100%	100%	N/A

** Graduated rates of actual experience (i.e., raw rates).*

The A/E ratios based upon the proposed rates are mostly at or near 100%. Non-Industrial disability rates do appear to include some conservatism being consistently in the 90-100% range. The exposure weighted R-squared measure for disability was not given significant consideration in determining the reasonableness of the proposed assumptions, but the measure still generally improved when comparing the current assumptions to the proposed assumptions. The percentage of the assumptions inside the 90% confidence interval of the raw rates was around 90% or higher for every proposed assumption. These summary statistics support the general reasonableness of the proposed assumptions reviewed.

Demographic Assumptions – Disability Rates

Summary of Observations and Recommendations

The experience used in developing the proposed assumptions for non-industrial related disability was the entire 15-year period, meanwhile the experience used in developing the proposed assumptions for the industrial related disability was only the most recent 4-year period (July 1, 2015 through June 30, 2019).

The raw rates computed from the experience was graduated using Whittaker Henderson smoothing techniques. Generally, the graduated rates fit the experience well with exception of a couple observations:

- PA CPO & PA Misc & Local Prosecutors Male/Female Non-Industrial Disability: It was observed that the raw rates drop at age 50 (age eligible for service retirement). This led to graduated rates being lower at ages below 50 and graduated rates higher at ages above 50.
- Some groups have minimal actual decrements observed. The graduated rates resulted in increasing and decreasing rates at various age ranges, however looking at the experience using an "eye-test" doesn't necessarily show these trends (e.g., CHP non-industrial, PA Fire non-industrial).

GRS recommends the Actuarial Office consider manually adjusting for or graduating rates separately for ages prior to and after eligibility of service retirement. Additionally, the Actuarial Office may wish to manually set rates at older ages to level out if graduated rates are declining but experience is showing an inconclusive trend.

The newly proposed assumptions for non-industrial disability were developed by blending the current assumptions with the graduated rates of actual experience. The current assumptions were given 40% weighting and the graduated rates of actual experience were given 60% weighting in developing the proposed assumptions. While GRS agrees with the methodology of not always giving full credibility to recent experience and taking old assumptions into considering when setting new assumptions, we believe more emphasis on recent experience (e.g., the past 4-5 years) could have been applied. The graduated rates included all actual experience over the period July 1, 2004 through June 30, 2019 (15 years). Assuming exposures over the lasts 15 years were about the same each and every year, it can be estimated that about 6.7% weighting applies to each year of the 15-year period. Additionally, applying the 60% weighting that was used in developing the proposed rates, it can be estimated that the experience during the last 4-year period (July 1, 2015 through June 30, 2019) is only attributing to 16% of the final proposed assumptions (6.7% x 4 x 60% = 16%). A risk with this methodology is if there are any significant emerging trends, it would take many years for it to be fully reflected in the assumptions.

While the non-industrial related disability assumptions used a 15-year period to review and develop newly proposed assumptions, the industrial related disability assumptions reviewed three experience periods: 2004-2019, 2009-2019 and 2015-2019. Additionally, only the experience between July 1, 2015 and June 30, 2019 was used for developing graduated rates of actual experience to blend with current assumptions in the development of the proposed assumptions. We believe this was an important process for setting industrial disability assumptions with more recent experience.

GRS recommends for the next study the non-industrial disability use a similar methodology that the industrial related disability assumptions were reviewed (i.e., short experience period) to reflect more recent experience in the assumptions.

Demographic Assumptions – Disability Rates

GRS reviewed the exposures and actual decrement experience for seven out of thirteen of the non-industrial disability assumption groups and two out of seven industrial related disability assumption groups. Groups not reviewed in detail were those which the current assumptions were not recommending change in the Experience Study. The Actuarial Office did provide A/E ratios for these groups not reviewed in detail. Based upon the A/E ratios, the assumptions seemed reasonable.

For the next review the Actuarial Office performs of an Experience Study, GRS recommends the Actuarial Office provide the reviewing Actuary with detailed analysis of assumption groups regardless of if the current assumptions are being changed or not.

Demographic Assumptions – Termination Rates

Summary of Review

For review of the rates of termination (both refund and vesting) from active employment, the ACTO provided to GRS the following 21 assumption sets for review:

- State Miscellaneous Tier 1:
  - Male
  - Female
- State Miscellaneous Tier 2:
  - Male
  - Female
- State Safety
  - Male
  - Female
- State Industrial (Male and Female Combined)
- Schools
  - Male
  - Female
- POFF
  - Male
  - Female
- CHP
  - Male
  - Female
- PA Misc
  - Male
  - Female
- PA Police
  - Male
  - Female
- PA CPO
  - Male
  - Female
- PA Fire
  - Male
  - Female

The Actuarial Office's study period for termination rates covered the period June 30, 1997 through June 30, 2019. However, it is our understanding that the Actuarial Office determined that data from June 30, 1997 through June 30, 1999 was inconsistent with the remainder of the data and therefore this data was excluded for assumption setting purposes.

Demographic Assumptions – Termination Rates

The following table summarizes the total exposures and actual decrements provided by the Actuarial Office and counts excluded by GRS for review of the actuarial assumptions. GRS only included exposures and decrements where the proposed rates of termination were greater than zero.

Termination Decrements (Refund and Vesting) (July 1, 2000 through June 30, 2019)						
	Exposures			Actual Decrements		
Assumption Group - Termination Type	Total	GRS Studied	GRS Excluded	Total	GRS Studied	GRS Excluded
State Misc T1 Male - Refund	1,268,900	744,519	524,381	29,397	28,925	472
State Misc T1 Male - Vest	945,531	738,378	207,153	10,859	9,970	889
State Misc T1 Female - Refund	1,570,641	894,842	675,799	37,814	37,014	800
State Misc T1 Female - Vest	1,180,159	979,238	200,921	16,157	15,090	1,067
State Misc T2 Male - Refund	86,912	35,332	51,580	1,804	1,660	144
State Misc T2 Male - Vest	67,003	55,799	11,204	1,535	1,412	123
State Misc T2 Female - Refund	108,748	39,005	69,743	2,051	1,868	183
State Misc T2 Female - Vest	86,198	75,807	10,391	2,267	2,136	131
State Safety Male - Refund	211,830	210,099	1,731	4,580	4,580	0
State Safety Male - Vest	151,276	85,821	65,455	1,624	1,292	332
State Safety Female - Refund	207,116	199,915	7,201	6,917	6,912	5
State Safety Female - Vest	135,714	87,563	48,151	2,143	1,797	346
State Industrial - Refund	191,767	191,419	348	3,268	3,268	0
State Industrial - Vest	142,507	98,823	43,684	2,035	1,770	265
Schools Misc Male - Refund	1,571,078	1,563,980	7,098	73,860	73,847	13
Schools Misc Male - Vest	1,022,863	829,128	193,735	17,537	15,717	1,820
Schools Misc Female - Refund	3,866,453	3,842,289	24,164	181,871	181,813	58
Schools Misc Female - Vest	2,331,286	1,818,194	513,092	45,902	40,275	5,627
POFF Male - Refund	656,755	635,792	20,963	9,610	9,610	0
POFF Male - Vest	507,254	434,551	72,703	3,355	3,177	178
POFF Female - Refund	143,945	131,155	12,790	2,168	2,166	2
POFF Female - Vest	115,395	100,571	14,824	1,285	1,239	46
CHP Male - Refund	124,431	45,573	78,858	333	302	31
CHP Male - Vest	103,981	95,922	8,059	463	451	12
CHP Female - Refund	10,737	2,924	7,813	27	22	5
CHP Female - Vest	9,481	8,985	496	88	87	1

Demographic Assumptions – Termination Rates

The following table summarizes the total exposures and actual decrements provided by the Actuarial Office and counts excluded by GRS for review of the actuarial assumptions. GRS only included exposures and decrements where the proposed rates of termination were greater than zero.

Termination Decrements (Refund and Vesting) (July 1, 2000 through June 30, 2019)						
	Exposures			Actual Decrements		
Assumption Group - Termination Type	Total	GRS Studied	GRS Excluded	Total	GRS Studied	GRS Excluded
PA Misc Male - Refund	1,809,356	1,185,753	623,603	56,873	55,929	944
PA Misc Male - Vest	1,290,362	1,083,132	207,230	21,174	19,279	1,895
PA Misc Female - Refund	1,980,741	1,413,926	566,815	83,258	82,136	1,122
PA Misc Female - Vest	1,328,269	1,118,851	209,418	28,977	26,958	2,019
PA Police Male - Refund	416,113	248,802	167,311	4,782	4,697	85
PA Police Male - Vest	333,672	310,271	23,401	2,920	2,812	108
PA Police Female - Refund	45,393	31,290	14,103	727	721	6
PA Police Female - Vest	34,401	32,956	1,445	575	566	9
PA CPO Male - Refund	146,015	119,004	27,011	2,422	2,412	10
PA CPO Male - Vest	110,316	95,871	14,445	1,083	1,017	66
PA CPO Female - Refund	49,895	37,240	12,655	1,224	1,206	18
PA CPO Female - Vest	36,034	31,760	4,274	593	565	28
PA Fire Male - Refund	270,493	142,566	127,927	2,324	2,289	35
PA Fire Male - Vest	221,502	196,538	24,964	1,042	982	60
PA Fire Female - Refund	9,914	3,394	6,520	147	144	3
PA Fire Female - Vest	7,855	7,341	514	109	103	6

Demographic Assumptions – Termination Rates

Analysis of Current and Proposed Assumptions

The table below and on the following page provides GRS' analysis of the current and proposed assumptions for the below groups. Additional analysis of each group can be found in Section IV of this report.

Termination Decrements (Refund and Vesting) (July 1, 2000 through June 30, 2019)									
	Actual/Expected (A/E) Ratio			Exposure Weighted R-Squared (Service Based)			Percent Inside 90% Confidence Intervals (Service Based)		
Assumption Group - Termination Type	Current	Proposed	Graduated Rates*	Current	Proposed	Graduated Rates*	Current	Proposed	Graduated Rates*
State Misc T1 Male - Refund	104%	103%	N/A	0.9929	0.9948	N/A	27%	33%	N/A
State Misc T1 Male - Vest	99%	100%	100%	0.9977	0.9973	0.9984	85%	100%	97%
State Misc T1 Female - Refund	111%	103%	N/A	0.9881	0.9957	N/A	0%	33%	N/A
State Misc T1 Female - Vest	116%	100%	100%	0.9963	0.9975	0.9970	9%	91%	94%
State Misc T2 Male - Refund	64%	100%	100%	0.9440	0.9528	0.9547	20%	20%	50%
State Misc T2 Male - Vest	178%	108%	102%	0.0761	0.9009	0.9021	52%	73%	87%
State Misc T2 Female - Refund	64%	99%	100%	0.9574	0.9835	0.9848	40%	80%	70%
State Misc T2 Female - Vest	172%	104%	100%	0.0002	0.8952	0.8955	72%	83%	87%
State Safety Male - Refund	90%	100%	100%	0.9966	0.9967	0.9951	66%	88%	72%
State Safety Male - Vest	114%	131%	101%	0.8683	0.8980	0.9014	79%	50%	89%
State Safety Female - Refund	117%	100%	100%	0.9900	0.9931	0.9915	37%	80%	60%
State Safety Female - Vest	152%	123%	101%	0.9283	0.9240	0.9205	30%	53%	93%
State Industrial - Refund	100%	100%	100%	0.9873	0.9876	0.9789	65%	82%	65%
State Industrial - Vest	88%	119%	100%	0.7988	0.8569	0.8612	70%	77%	93%
Schools Misc Male - Refund	102%	102%	N/A	0.9935	0.9975	N/A	70%	75%	N/A
Schools Misc Male - Vest	98%	100%	100%	0.9811	0.9945	0.9931	54%	94%	91%
Schools Misc Female - Refund	109%	102%	N/A	0.9881	0.9981	N/A	45%	60%	N/A
Schools Misc Female - Vest	118%	99%	100%	0.9919	0.9971	0.9967	0%	94%	97%
POFF Male - Refund	107%	100%	100%	0.9448	0.9887	0.9839	31%	72%	76%
POFF Male - Vest	97%	107%	100%	0.9123	0.8865	0.8875	83%	73%	83%
POFF Female - Refund	125%	100%	100%	0.9082	0.9805	0.9766	58%	75%	71%
POFF Female - Vest	165%	106%	100%	0.9318	0.9359	0.9390	43%	89%	89%
CHP Male - Refund	91%	97%	100%	0.5996	0.9543	0.9593	80%	70%	80%
CHP Male - Vest	91%	103%	103%	0.7307	0.7223	0.7196	75%	83%	83%
CHP Female - Refund	108%	112%	100%	0.8776	0.8602	0.6110	88%	100%	86%
CHP Female - Vest	202%	117%	106%	0.6835	0.6873	0.6811	85%	95%	95%

** Graduated rates of actual experience (i.e., raw rates) produced and reviewed for assumption sets which have serviced-based only assumptions.*

Demographic Assumptions – Termination Rates

Termination Decrements (Refund and Vesting) (July 1, 2000 through June 30, 2019)									
	Actual/Expected (A/E) Ratio			Exposure Weighted R-Squared (Service Based)			Percent Inside 90% Confidence Intervals (Service Based)		
Assumption Group - Termination Type	Current	Proposed	Graduated Rates*	Current	Proposed	Graduated Rates*	Current	Proposed	Graduated Rates*
PA Misc Male - Refund	92%	102%	N/A	0.9624	0.9944	N/A	20%	33%	N/A
PA Misc Male - Vest	96%	100%	100%	0.9919	0.9952	0.9948	38%	86%	86%
PA Misc Female - Refund	109%	101%	N/A	0.9731	0.9953	N/A	0%	27%	N/A
PA Misc Female - Vest	120%	100%	100%	0.9909	0.9964	0.9953	0%	89%	91%
PA Police Male - Refund	112%	100%	99%	0.9944	0.9858	0.9670	7%	73%	29%
PA Police Male - Vest	99%	102%	101%	0.9530	0.9442	0.9410	81%	85%	85%
PA Police Female - Refund	132%	100%	99%	0.9864	0.9833	0.9681	60%	73%	57%
PA Police Female - Vest	172%	102%	101%	0.6733	0.6904	0.6949	38%	96%	88%
PA CPO Male - Refund	93%	100%	100%	0.9839	0.9851	0.9811	70%	60%	58%
PA CPO Male - Vest	96%	107%	101%	0.9260	0.9236	0.9230	93%	89%	89%
PA CPO Female - Refund	122%	100%	100%	0.9729	0.9830	0.9828	69%	81%	88%
PA CPO Female - Vest	155%	114%	101%	0.8245	0.8255	0.8219	43%	87%	91%
PA Fire Male - Refund	112%	100%	99%	0.9585	0.9975	0.9931	13%	87%	50%
PA Fire Male - Vest	100%	102%	101%	0.8809	0.8949	0.8916	93%	89%	93%
PA Fire Female - Refund	173%	99%	100%	0.8186	0.9780	0.9855	56%	100%	100%
PA Fire Female - Vest	264%	107%	117%	0.5709	0.5802	0.5998	73%	95%	95%

** Graduated rates of actual experience (i.e., raw rates) produced and reviewed for assumption sets which have serviced-based only assumptions.*

The A/E ratios based upon the proposed rates shown above and on the previous page are mostly at or near 100% with exception to a few assumption sets. The exposure weighted R-squared measure improved for the large majority of the proposed assumptions. Those that declined only declined minimally and did not cause concern. The percentage of the assumptions inside the 90% confidence intervals of the raw rates varied, but generally increased from the current assumptions. Ideally, the percentage of proposed assumptions inside the 90% confidence intervals would be 90% or higher, however it was observed for many assumptions (especially refund) the confidence intervals were very narrow and therefore assumptions developed based upon graduation of raw rates would fall outside of the intervals. It is also worth highlighting, some proposed termination assumptions are both age and service based, therefore while a proposed assumption for a specific age and service may be outside of a confidence interval on a service analysis, it may have fallen within a confidence interval on an age-based analysis. See Section IV for a detailed analysis of the current and proposed assumptions both on service and age basis. These summary statistics support the general reasonableness of the proposed assumptions reviewed.

Demographic Assumptions – Termination Rates

Summary of Observations and Recommendations

For the developing the exposures and actual decrements for termination assumptions, GRS only included records where the proposed assumptions were greater than 0%. If the proposed assumptions are 0% for specific ages or years of service, the decrement is effectively not being applied at those ages/years of service and therefore GRS would not consider these exposures because the records were not *exposed* to any decrement. A summary of the number of records excluded from the study are shown on a previous page. The inclusion of actual decrements at these ages/services results in skewing Actual/Expected (A/E) ratios. For example, the proposed assumptions could be higher than actual experience at most ages or years of service, but after inclusion of actual decrements outside the range of the assumptions, the A/E ratio may still equal 100% giving false confidence in the appropriateness of the assumption.

Some examples of assumption sets where the A/E ratios of proposed assumptions varied materially from 100% were the following:

- State Industrial terminate and vest proposed assumptions
- State Safety Males and State Safety Females terminate and vest proposed assumptions

GRS recommends for the next experience that exposures and actual decrements only be tabulated at ages/years of service where the proposed assumptions are being applied (i.e., greater than 0%) for total A/E purposes.

It was observed State Miscellaneous Tier 2 members now have termination and vesting assumptions that begin with only 5 years of service while vesting is at 10 years. The Actuarial Office confirmed this can occur due to members converting to Tier 1. The experience of Tier 2 members terminating and vesting with less than 10 years of service supports this assumption.

Similar to discussions for the other decrements, GRS believes the study period of 19 years (July 1, 2000 to June 30, 2019) is a long period for setting assumptions. With that said, full credibility appears to have been given by the Actuarial Office to the 19-year period for selecting proposed termination assumptions. One aspect that cannot be determined with the longer period though is whether there are any emerging trends in recent years (i.e., 4 to 5 years) that could be materially different experience than prior years.

GRS recommends the Actuarial Office in future studies additionally review shorter periods to confirm there are no emerging trends in termination patterns.

SECTION IV

DETAILED ANALYSIS

Detailed Analysis – Introduction

This section provides a detailed analysis of each assumption provided by CalPERS' Actuarial Office to GRS for review. More detailed descriptions of GRS' methodologies were provided in Section III of the report.

A brief summary of the exhibits included in this section is provided below:

Merit and Seniority Pay Increases: Page IV-3

Summary of the proposed merit & seniority increase assumptions reviewed. Charts are categorized by entry age groupings consistent with the proposed assumptions.

Post-Retirement Mortality: Pages IV-4 to IV-9

Summary of the System's post-retirement mortality experience for the period 6/30/2015 to 6/30/2019 by group reviewed. For healthy retiree assumptions, experience is shown based upon both a head-count weighted and benefit-weighted basis. Current assumptions are shown in blue. Proposed assumptions (as applicable to the central year of the study period, i.e., 2017) are shown in red.

Additionally, for comparison purposes, the applicable Pub-2010 mortality tables with rates projected using 80% of MP-2020 to 2017 are shown in orange.

Pre-Retirement Mortality: Pages IV-10 to IV-13

Summary of the System's pre-retirement mortality experience for the period 6/30/2004 to 6/30/2019 by group reviewed (i.e., "All Misc" and "All Safety"). "All Misc" refers to the Non-Pooled Public Agency Miscellaneous Plans, School Miscellaneous Plan, Industrial Plan, Miscellaneous Second Tier Plan and Miscellaneous First Tier Plan. "All Safety" refers to the Non-Pooled Public Agency Safety Plans, California Highway Patrol Plan, Peace Officers & Firefighters Plan and State Safety Plan. Current assumptions are shown in blue. Proposed assumptions applicable to roughly the central year of the study period, (i.e., 2010) are shown in red. Additionally, for comparison and replication purposes, the applicable Pub-2010 mortality tables are shown in orange.

Service Retirement: Pages IV-14 to IV-22

Summary of the System's service retirement experience for the period 6/30/2007 to 6/30/2019 by group reviewed. The summary of the service retirement assumptions is provided based upon a service-based analysis and an age-based analysis. The charts on the left of these pages are a summary of service retirement experience along with current (blue) and proposed (red) assumptions (weighted averages) based upon years of service. The charts on the right of these pages are a summary of service retirement experience along with current (blue) and proposed (red) assumptions (weighted averages) based upon age.

For display purposes, the charts include a maximum Y-Axis of less than 100%. Where the assumption lines extend beyond the graph, it can be assumed the assumption is 100% for that year of service/age and each year of service/age thereafter.

Detailed Analysis – Introduction

Non-Industrial Disability: Pages IV-23 to IV-26

Summary of the System's non-industrial disability experience for the period 6/30/2004 to 6/30/2019 by group reviewed. Current assumptions are shown in blue. Proposed assumptions are shown in red.

Additionally, for comparison and replication purposes, graduated rates of actuarial experience are shown in purple. For Non-Industrial Disability assumptions, experience rates were graduated using Whittaker Henderson graduation consistent with CalPERS' application.

Non-Industrial Disability: Page IV-27

Summary of the System's industrial disability experience for the period 6/30/2015 to 6/30/2019 by group reviewed. Current assumptions are shown in blue. Proposed assumptions are shown in red.

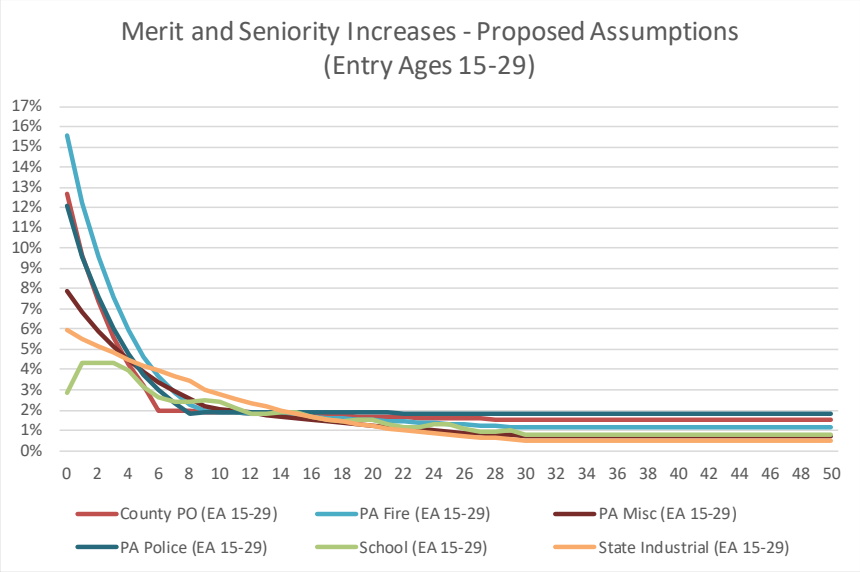
Additionally, for comparison and replication purposes, graduated rates of actuarial experience are shown in purple (if applicable). For State Safety Industrial Disability assumptions, experience rates were graduated using Whittaker Henderson graduation consistent with CalPERS' application.

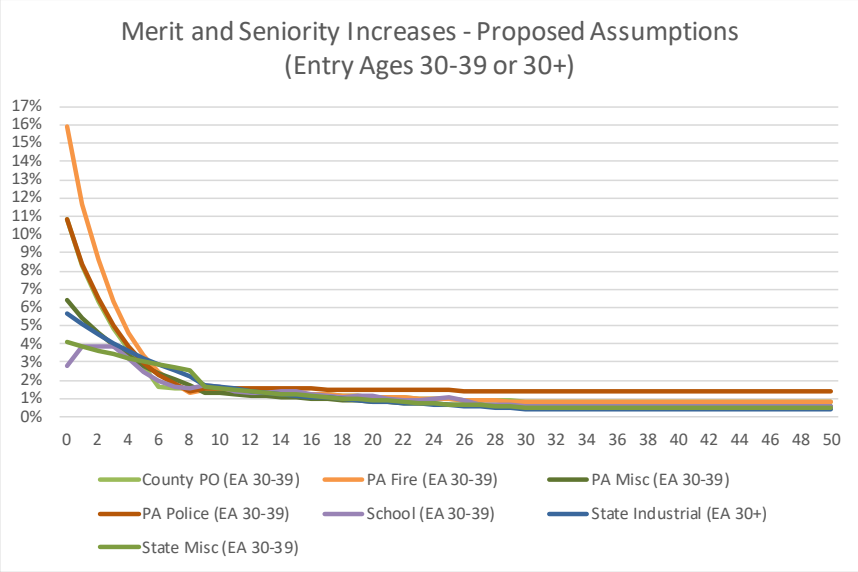
Termination (Refund and Vesting): Pages IV-28 to IV-48

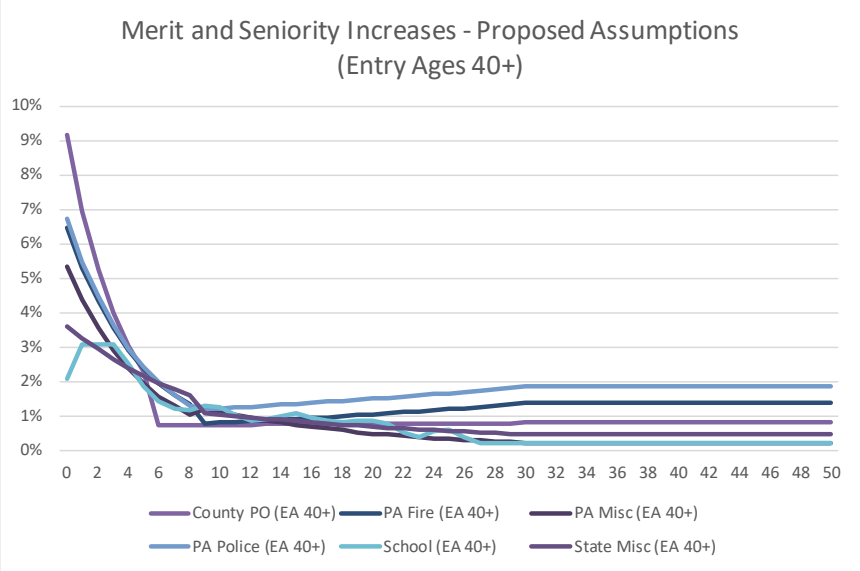
Summary of the System's termination experience for the period 6/30/2000 to 6/30/2019 by group reviewed. The summary of the termination assumptions is provided based upon a service-based analysis and an age-based analysis (both for refunding and vesting). Current assumptions are shown in blue. Proposed assumptions are shown in red.

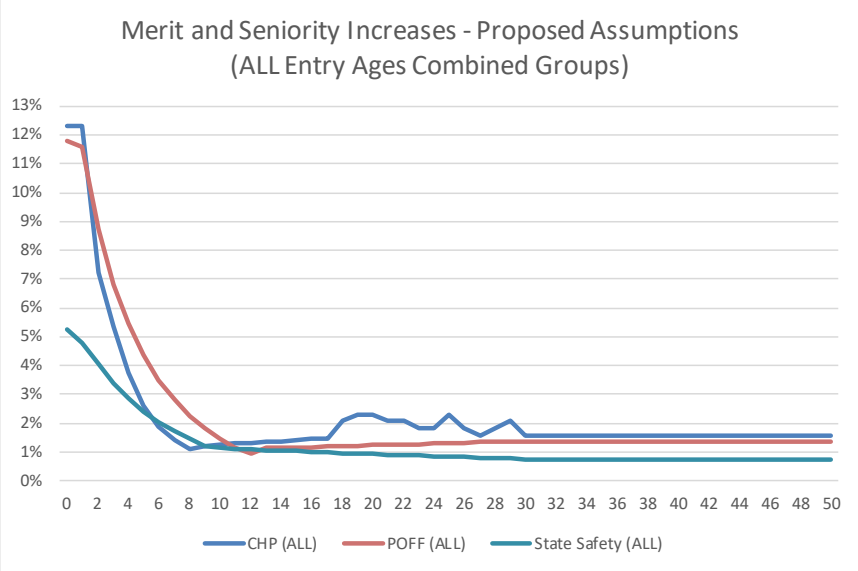
Additionally, for comparison and replication purposes, graduated rates of actuarial experience are shown in purple if the proposed assumptions are exclusively service-based (i.e., one-dimensional assumptions). For terminate and refund assumptions, experience rates were graduated using Whittaker Henderson graduation consistent with CalPERS' application. For terminate and vest assumptions, experience rates were graduated using different combinations of Whittaker Henderson graduation, Exponential smoothing or 2nd degree polynomial smoothing consistent with CalPERS' application.

Detailed Analysis – Merit & Seniority Pay Increases





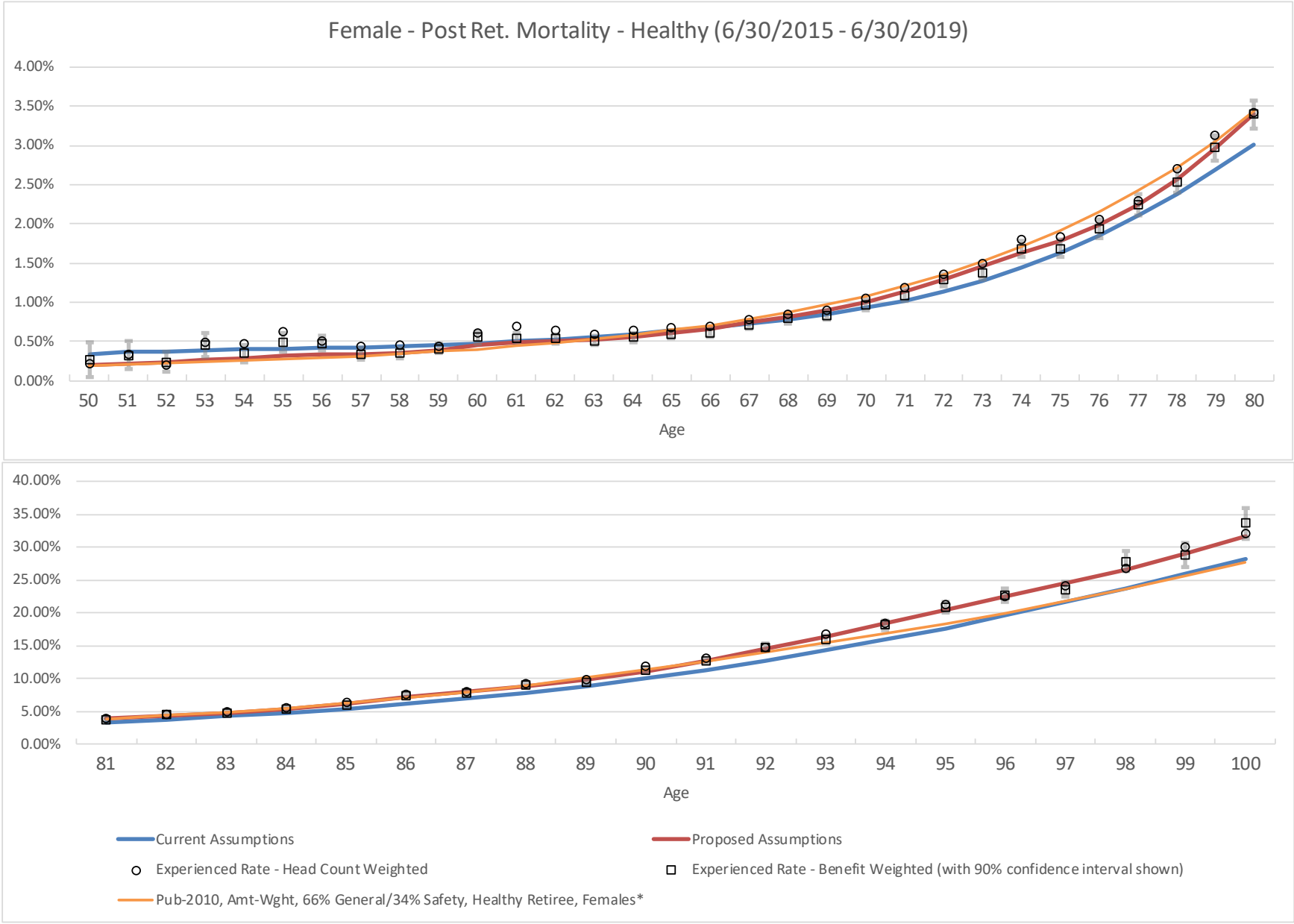




Detailed Analysis – Post-Retirement Mortality

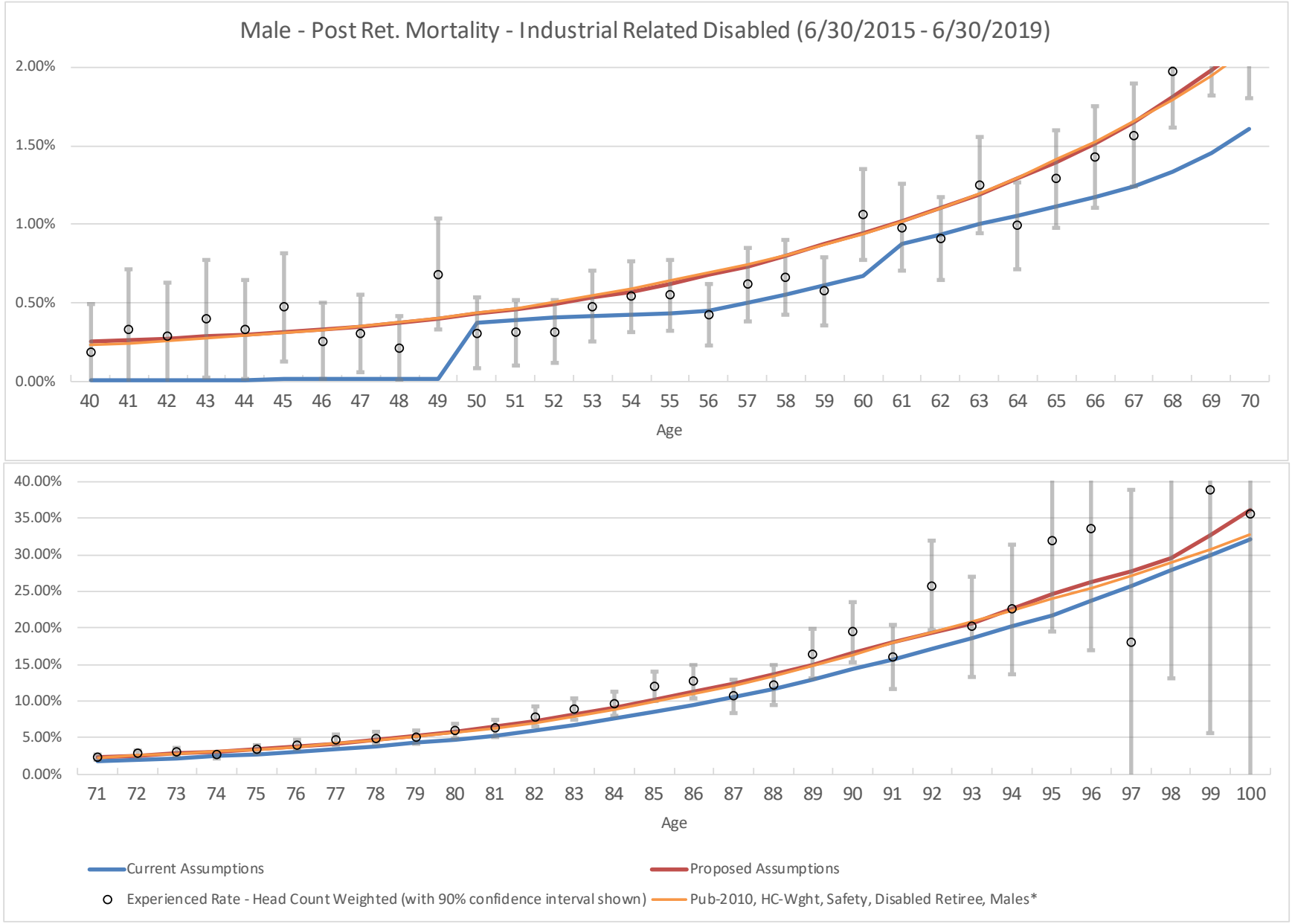
**Projected to ages shown during 2017 calendar year (central year of study period) with 80% of MP 2020 Females.*

Detailed Analysis – Post-Retirement Mortality



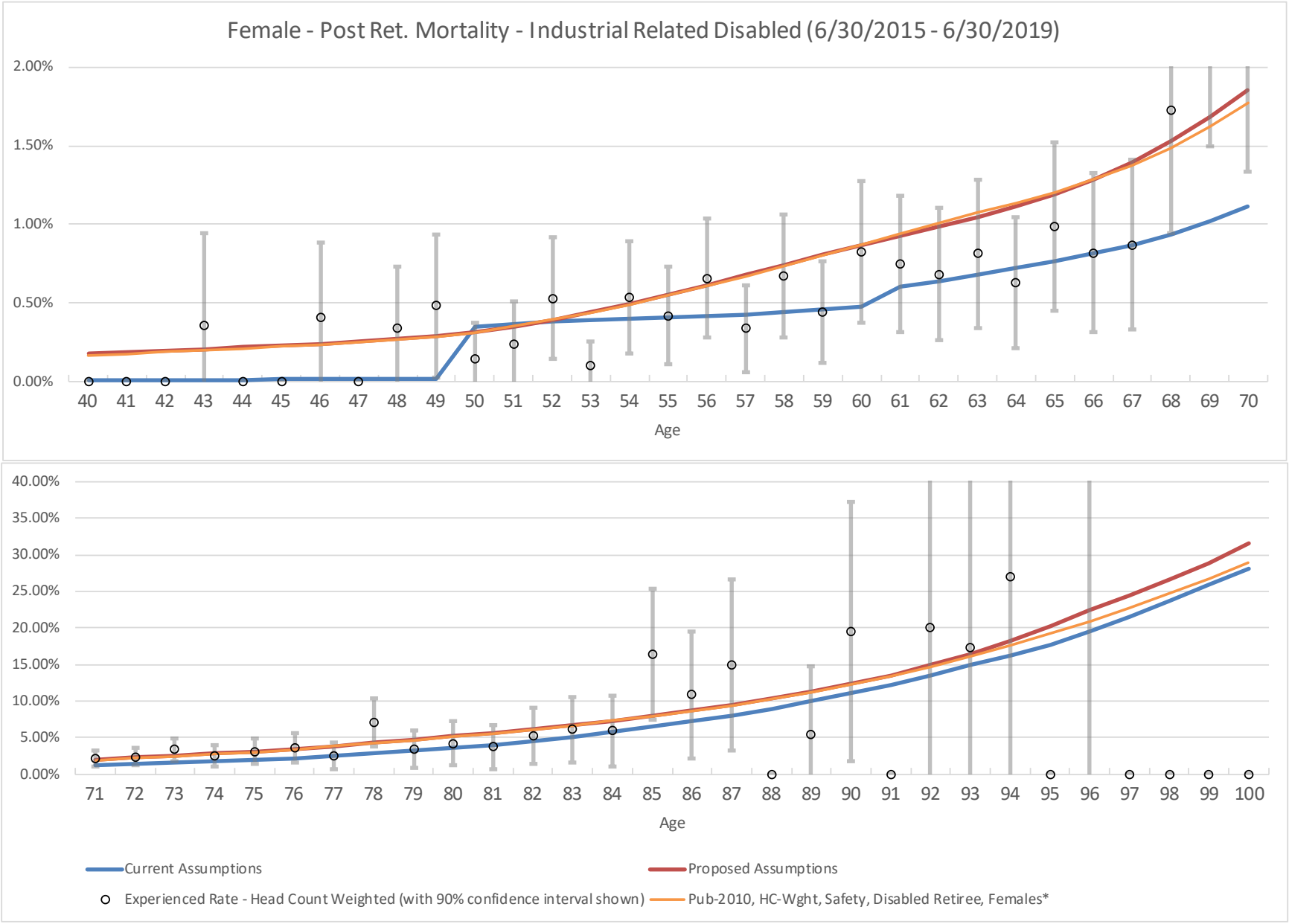
**Projected to ages shown during 2017 calendar year (central year of study period) with 80% of MP 2020 Females.*

Detailed Analysis – Post-Retirement Mortality



**Projected to ages shown during 2017 calendar year (central year of study period) with 80% of MP 2020 Males.*

Detailed Analysis – Post-Retirement Mortality

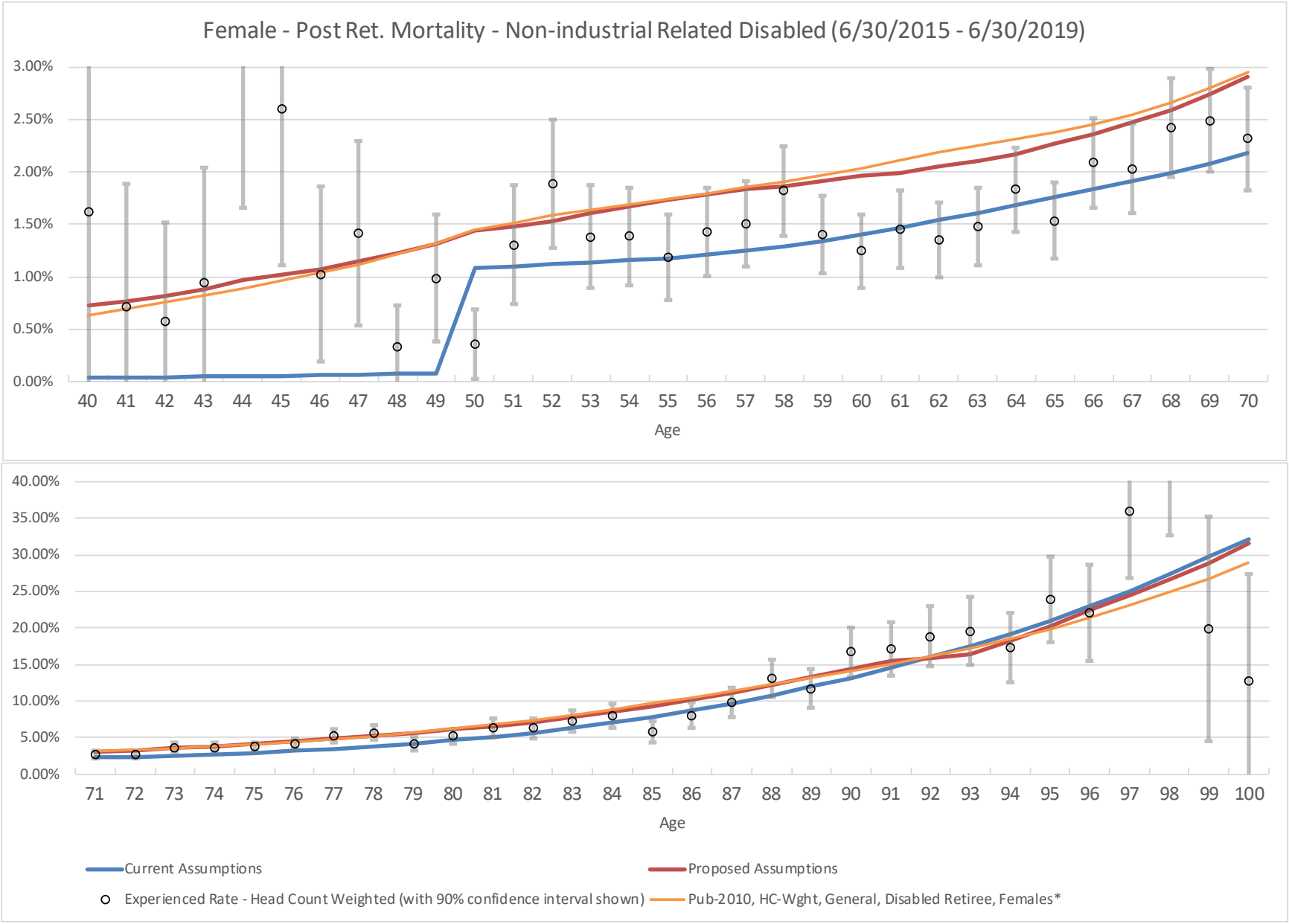


**Projected to ages shown during 2017 calendar year (central year of study period) with 80% of MP 2020 Females.*

Detailed Analysis – Post-Retirement Mortality

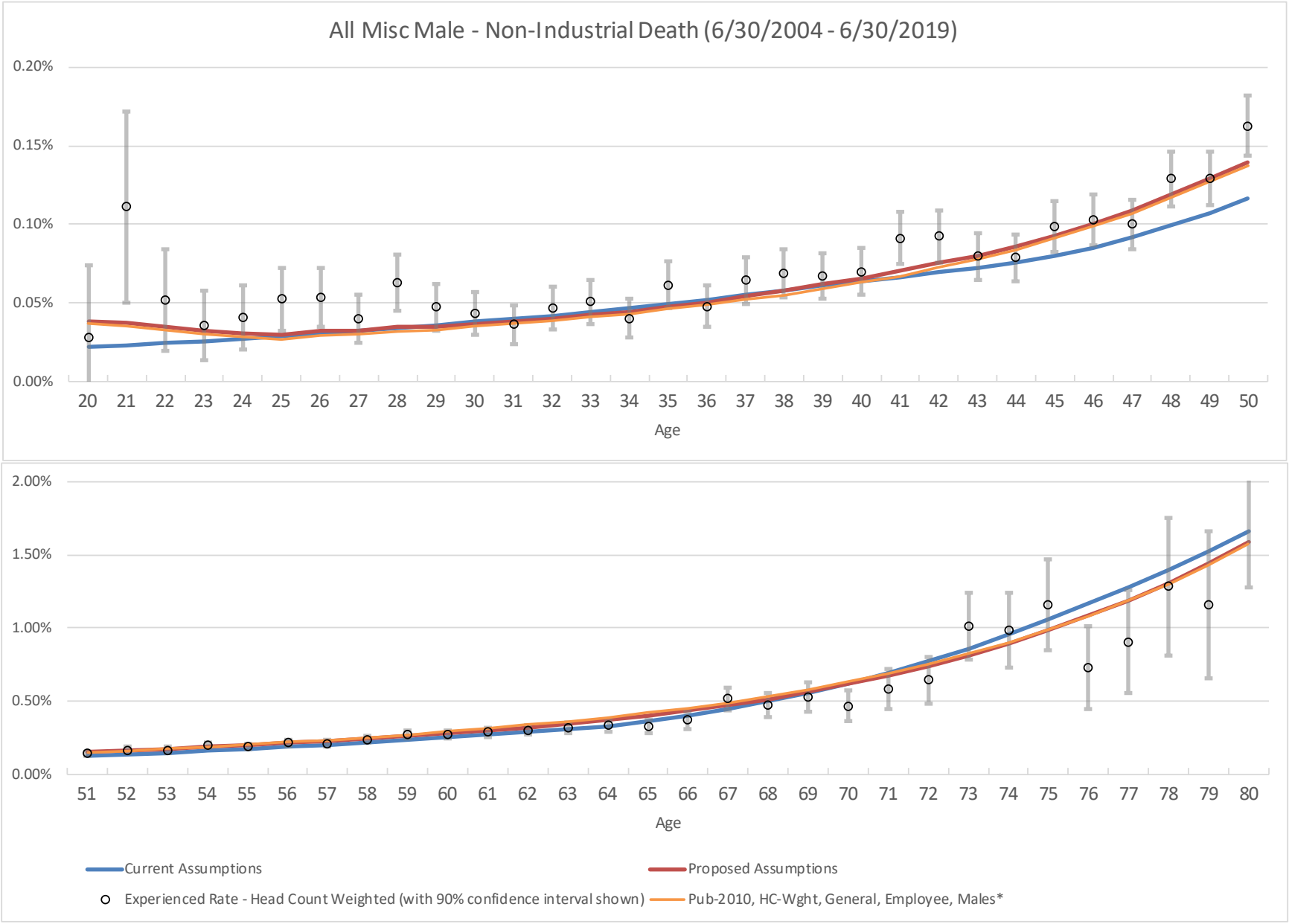
**Projected to ages shown during 2017 calendar year (central year of study period) with 80% of MP 2020 Males.*

Detailed Analysis – Post-Retirement Mortality



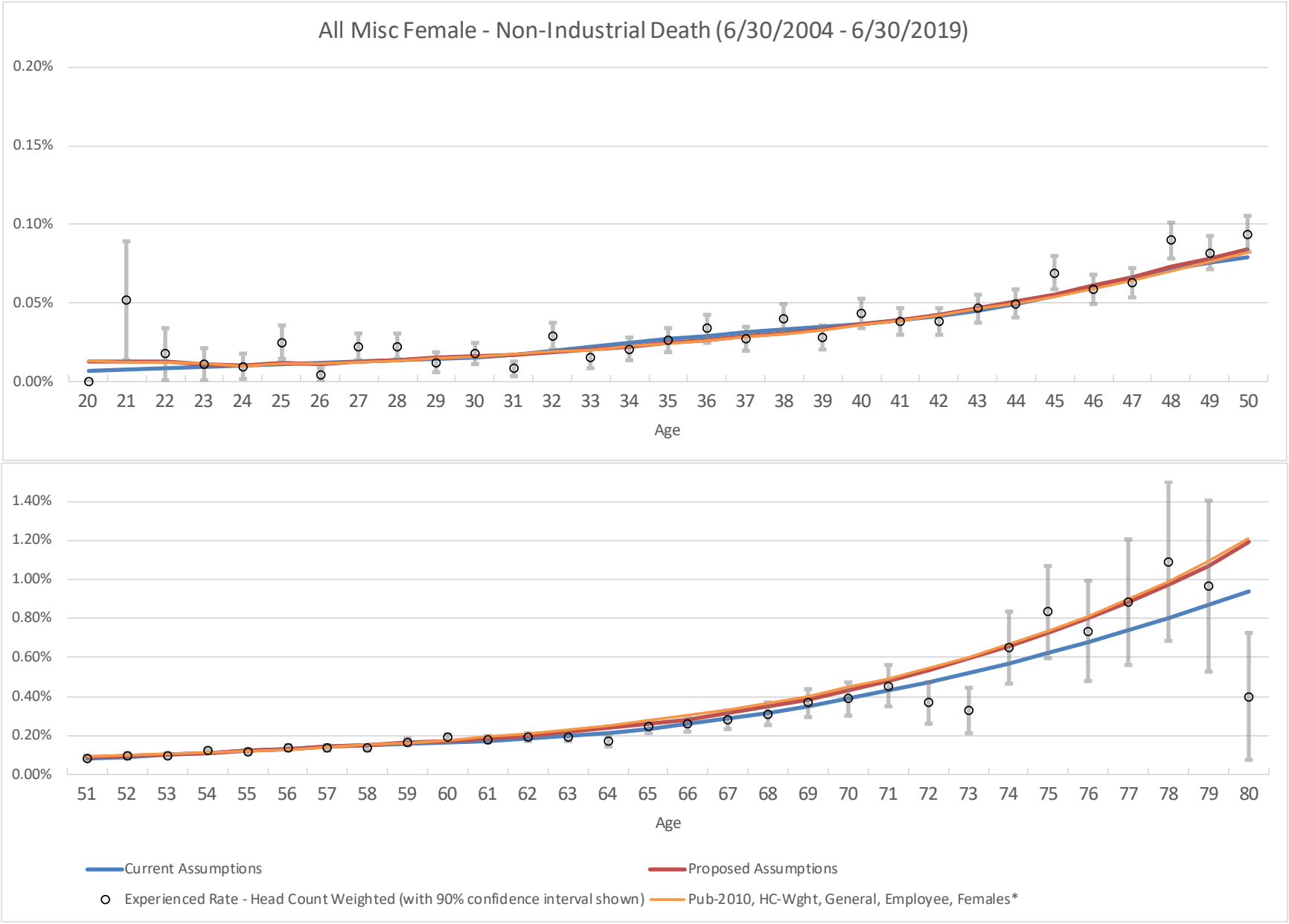
**Projected to ages shown during 2017 calendar year (central year of study period) with 80% of MP 2020 Females.*

Detailed Analysis – Pre-Retirement Mortality



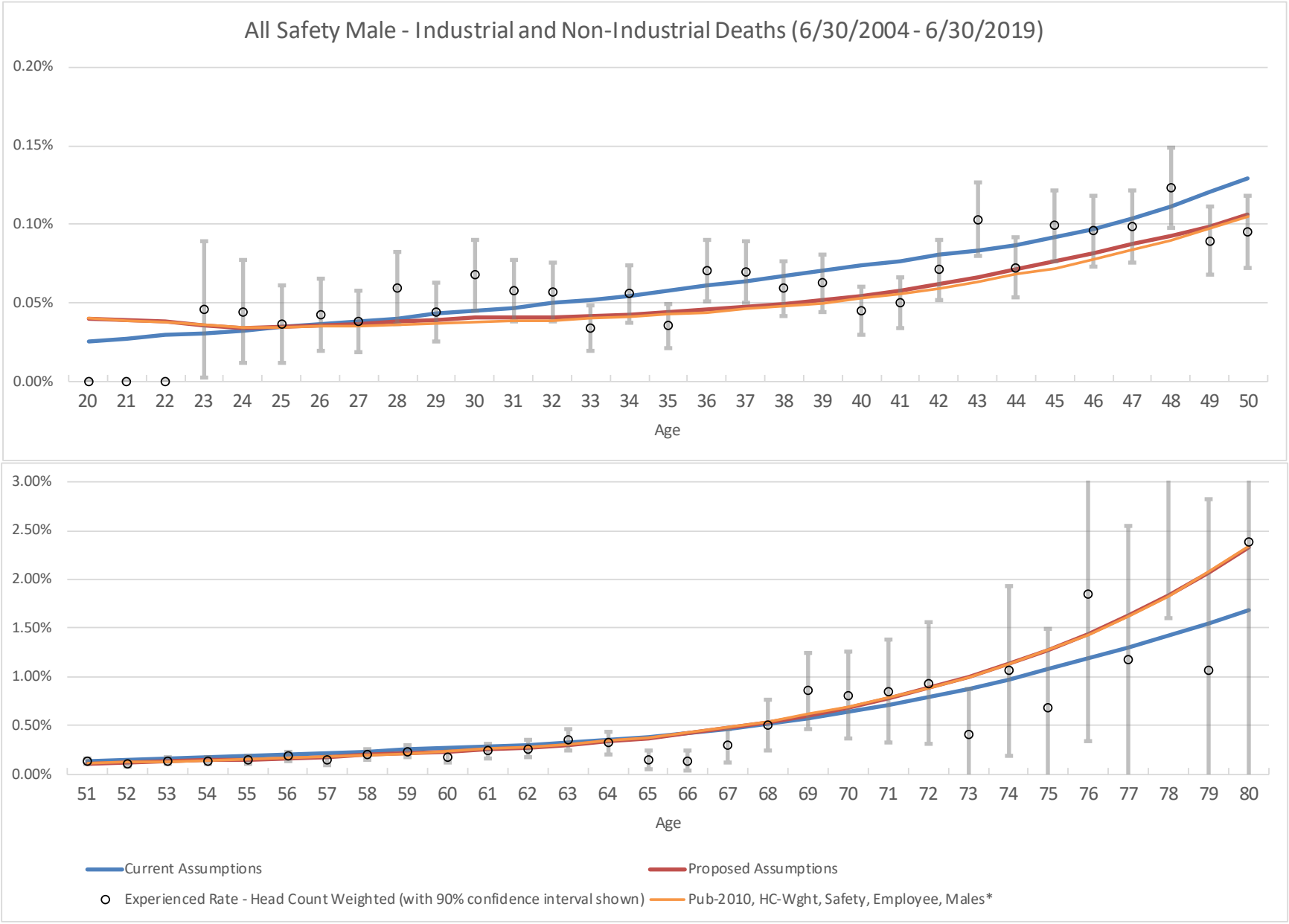
**Rates for ages shown during 2010 calendar year (roughly central year of study period)*

Detailed Analysis – Pre-Retirement Mortality



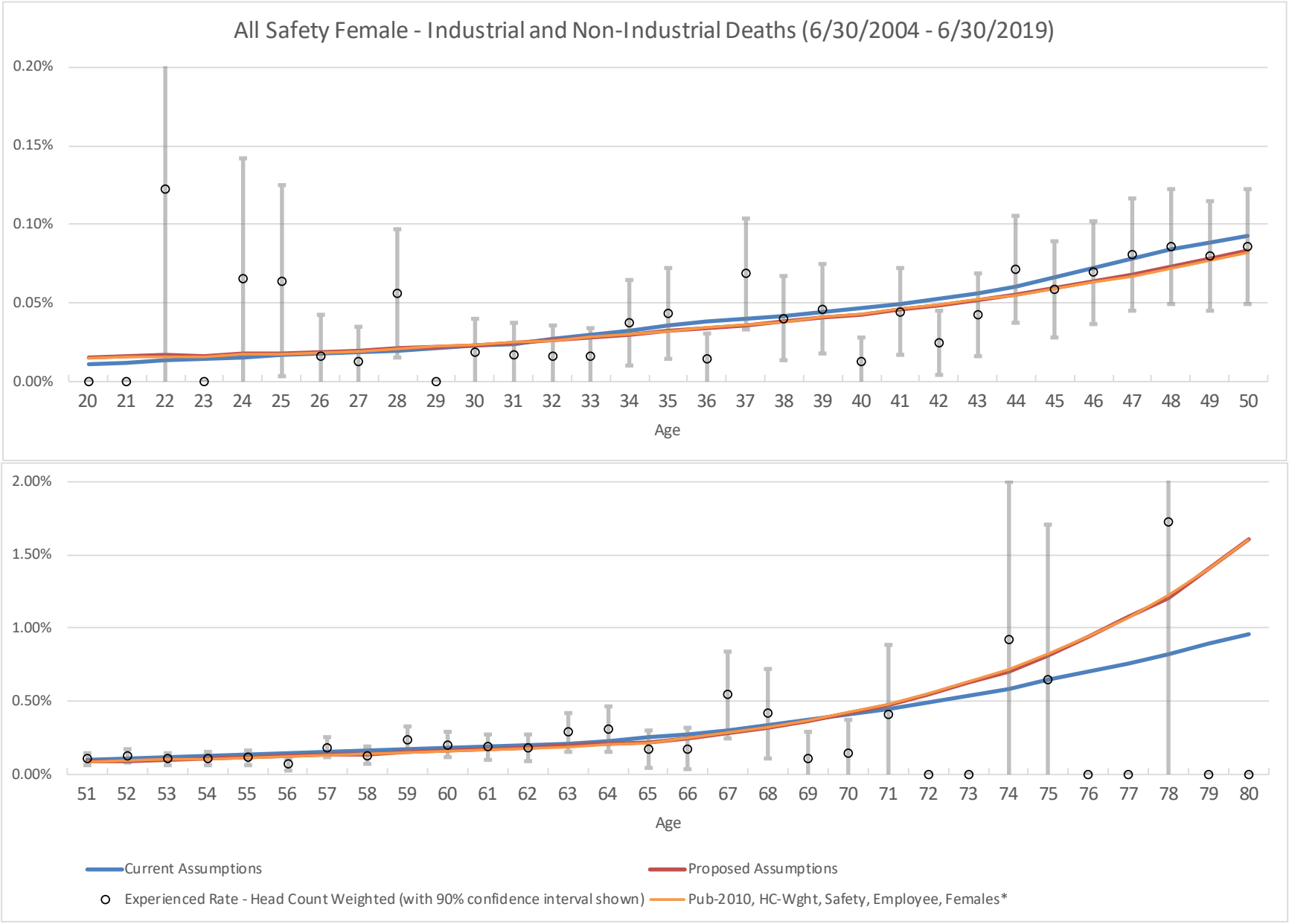
**Rates for ages shown during 2010 calendar year (roughly central year of study period).*

Detailed Analysis – Pre-Retirement Mortality



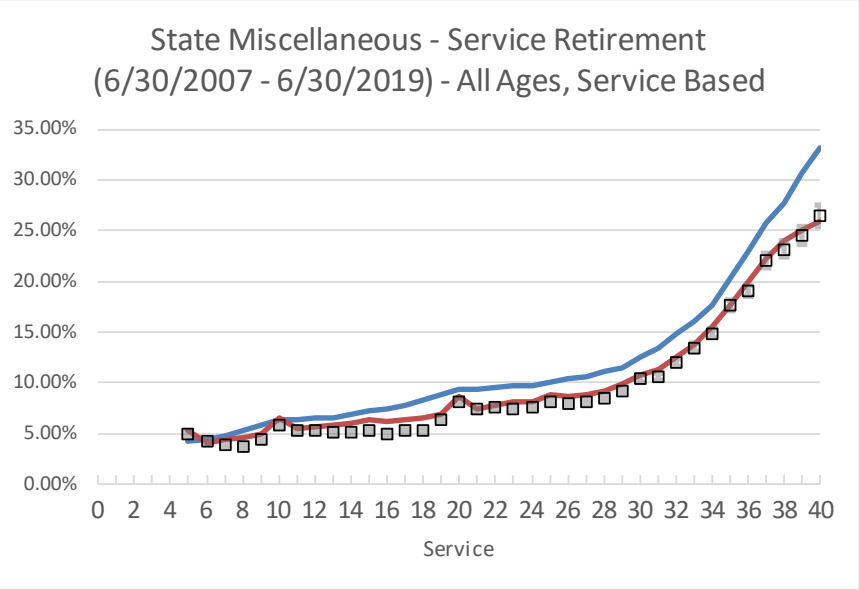
**Rates for ages shown during 2010 calendar year (roughly central year of study period).*

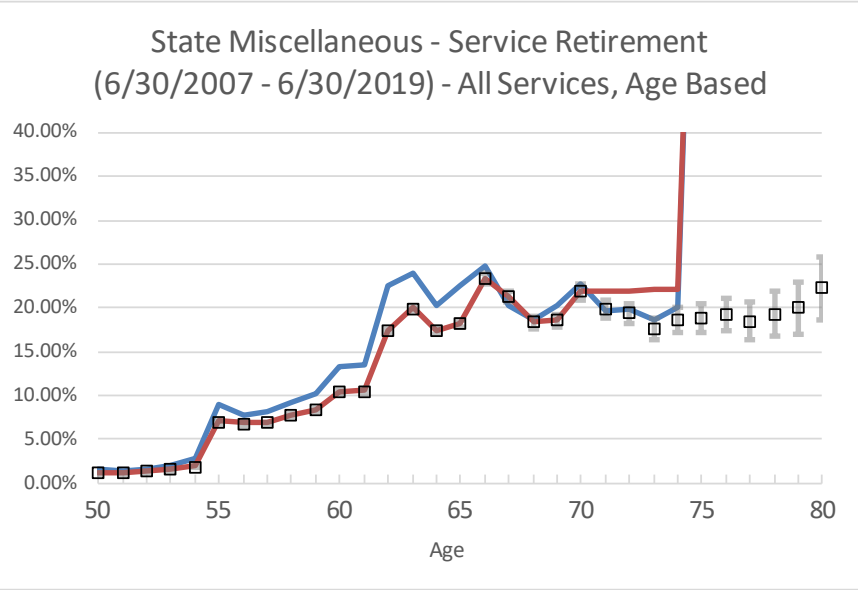
Detailed Analysis – Pre-Retirement Mortality

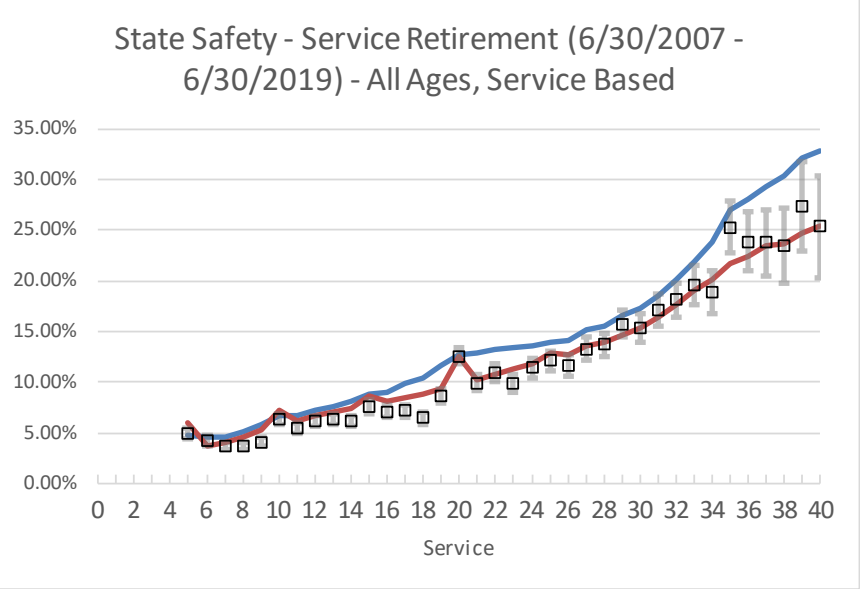


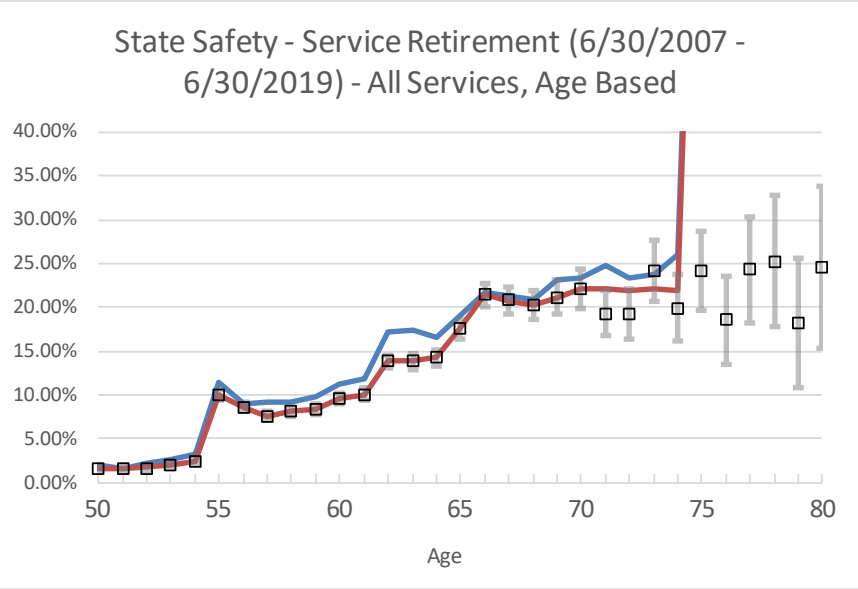
**Rates for ages shown during 2010 calendar year (roughly central year of study period).*

Detailed Analysis – Service Retirement



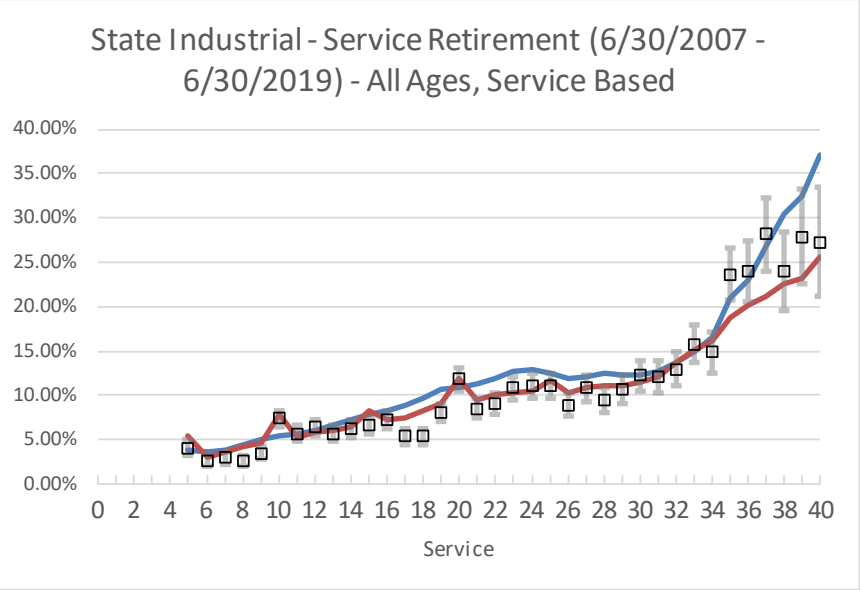


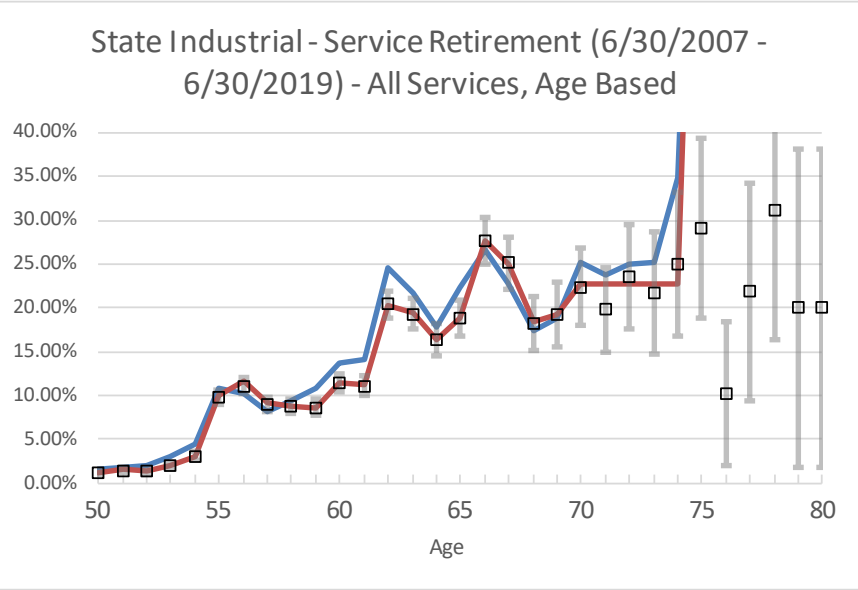


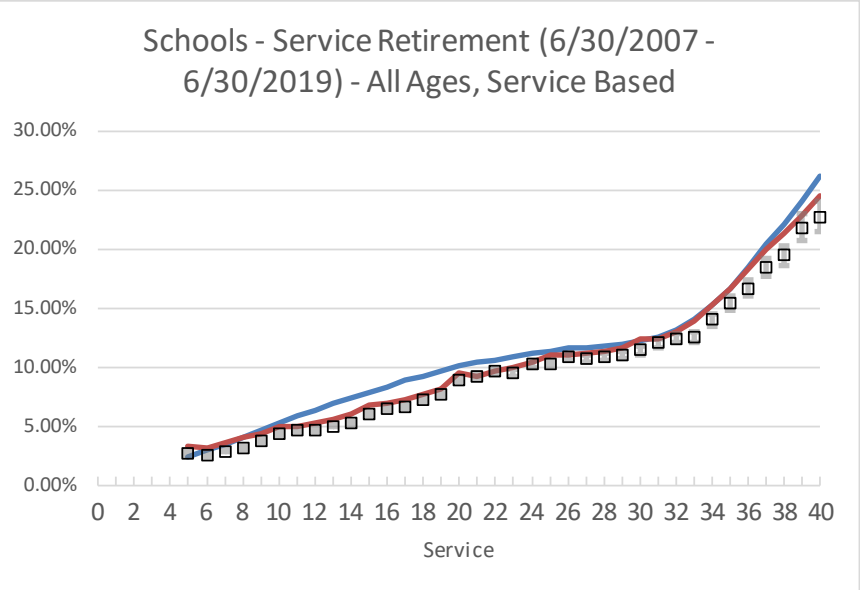


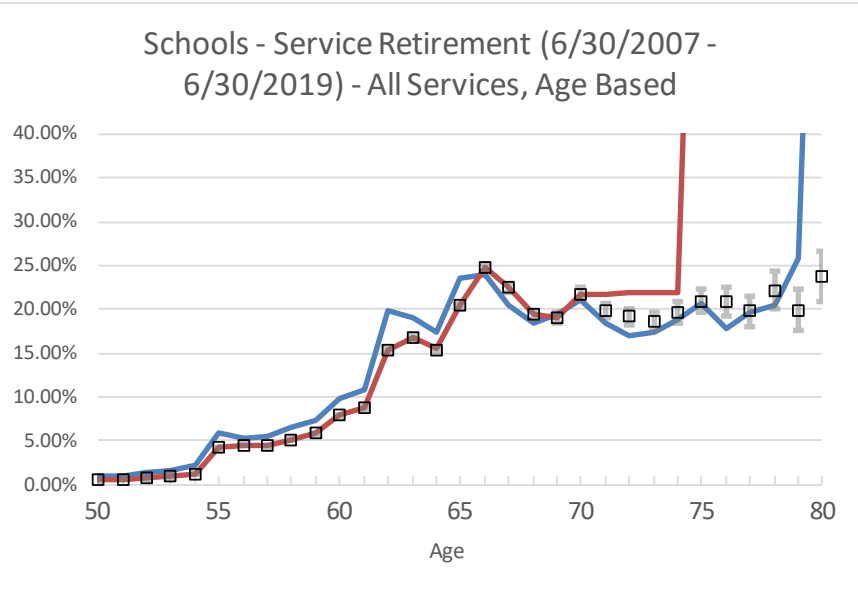
Avg. Current Assumptions | Avg. Proposed Assumptions | Experienced Rate (with 90% confidence interval shown)

Detailed Analysis – Service Retirement

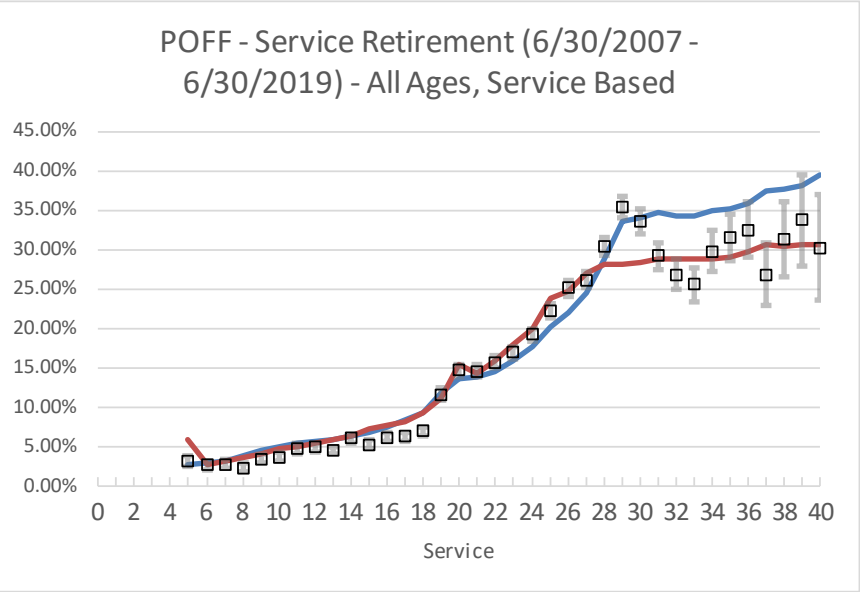


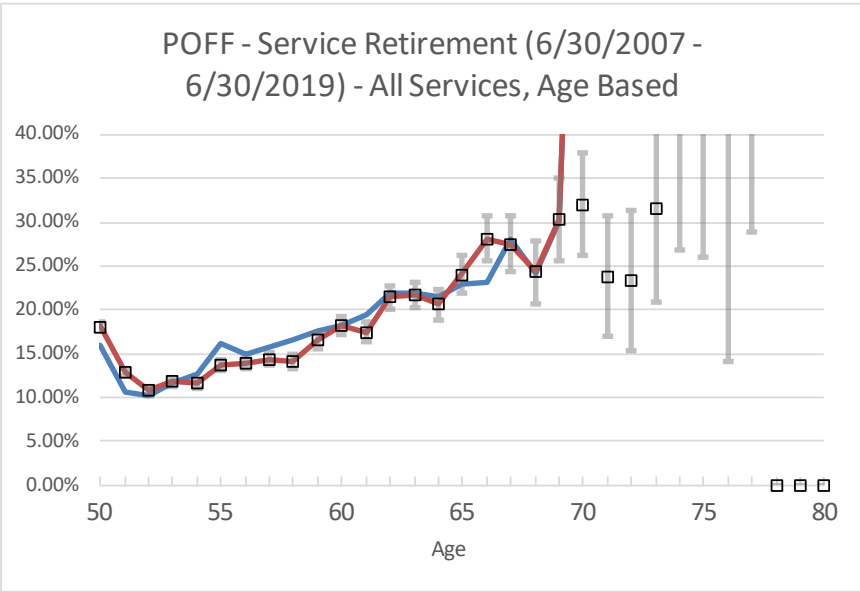


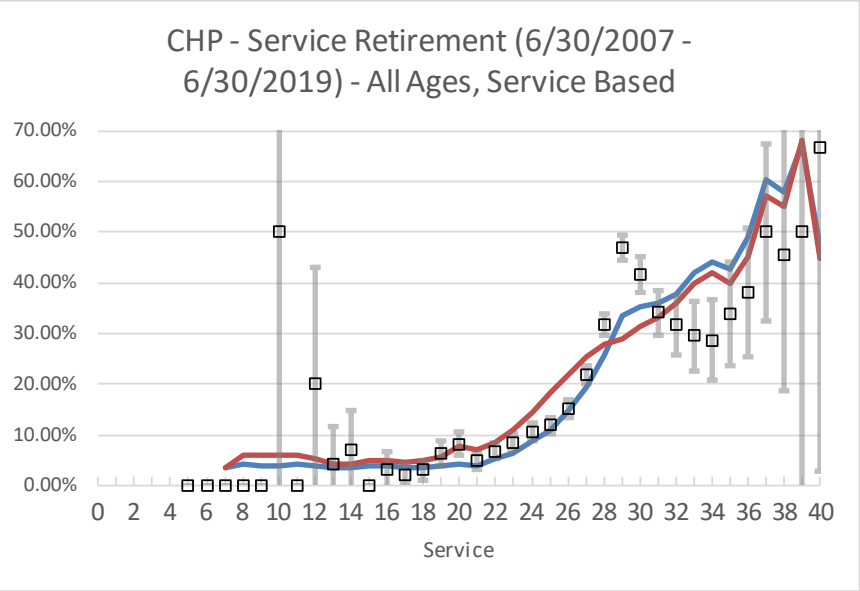


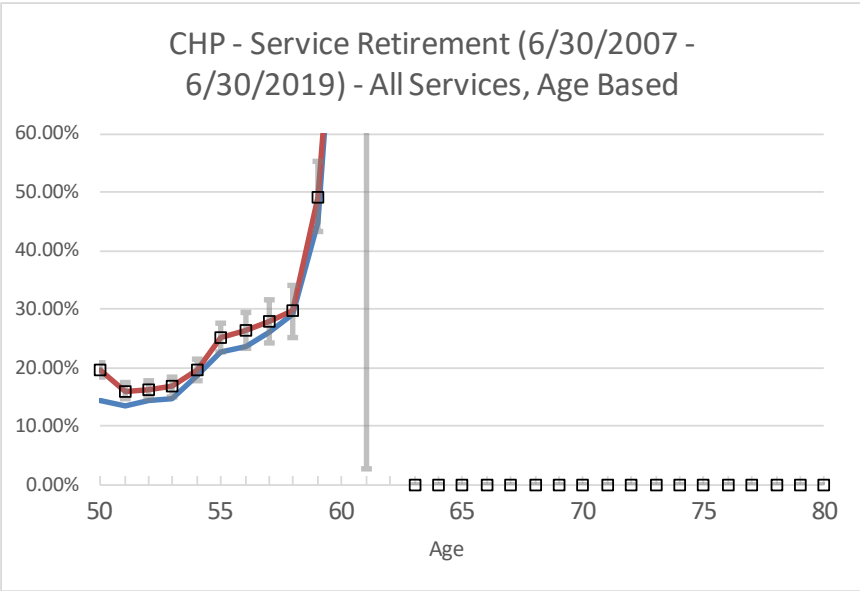


Detailed Analysis – Service Retirement

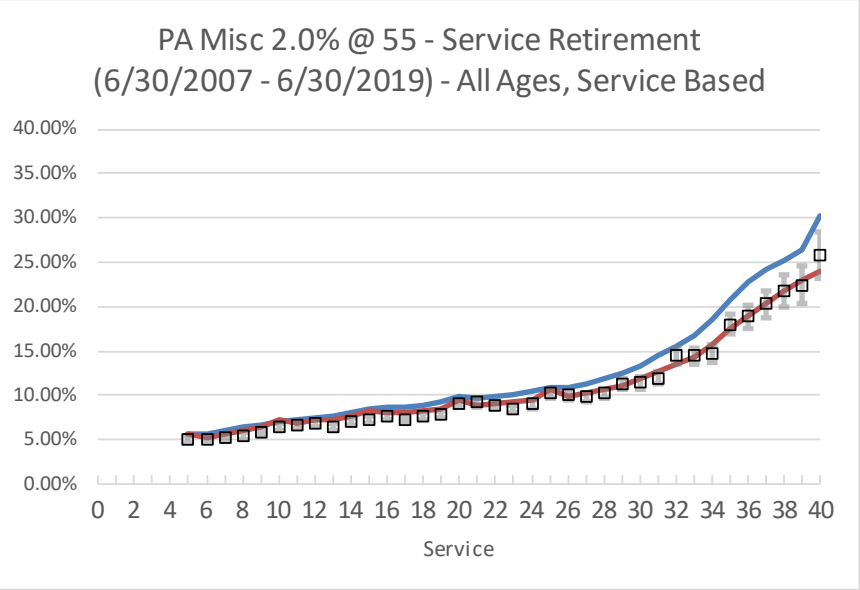


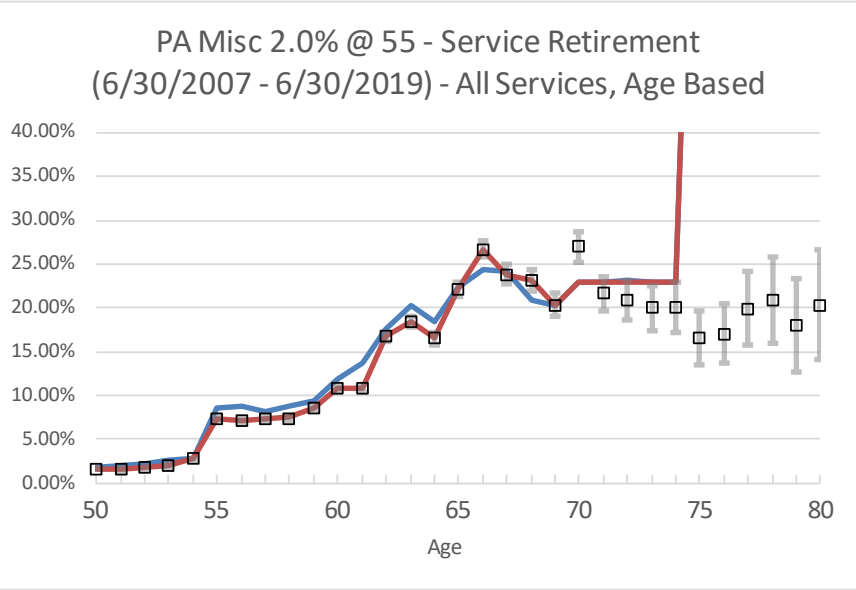


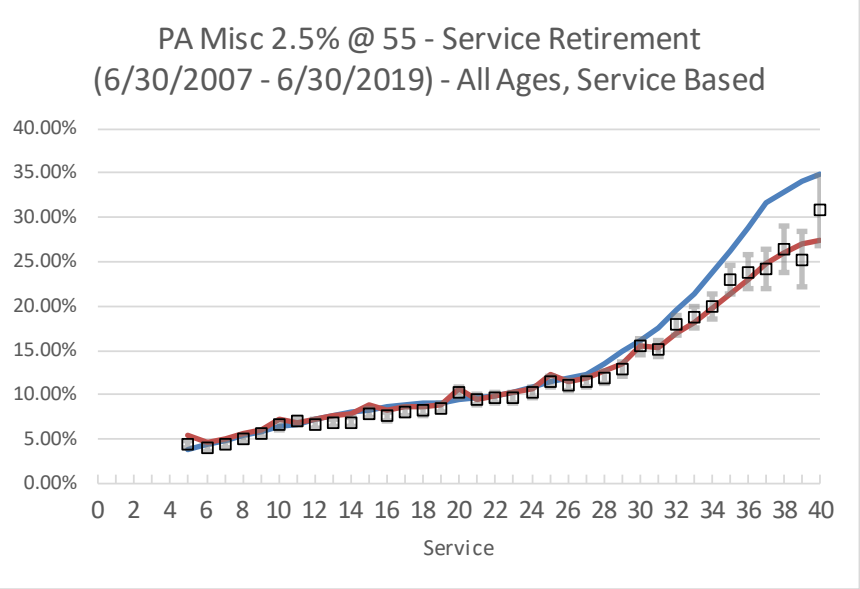


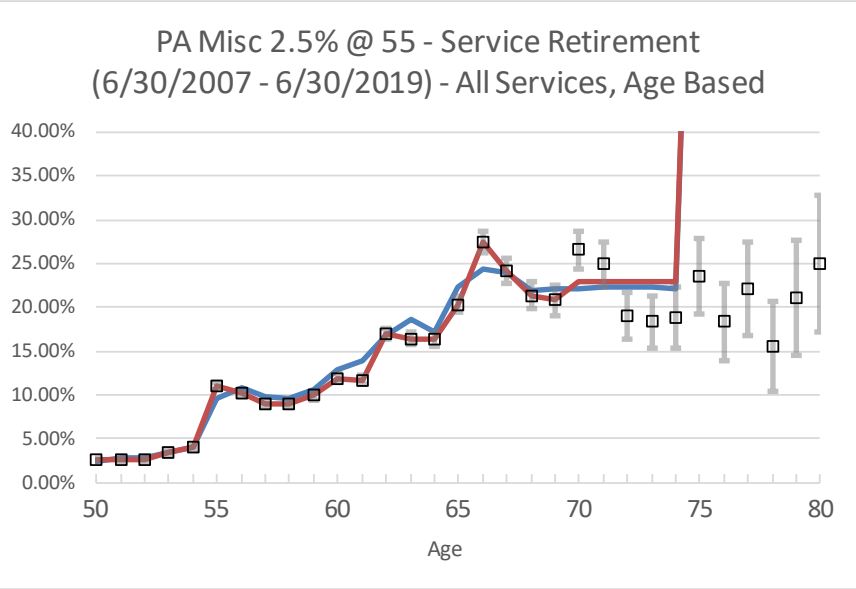


Detailed Analysis – Service Retirement

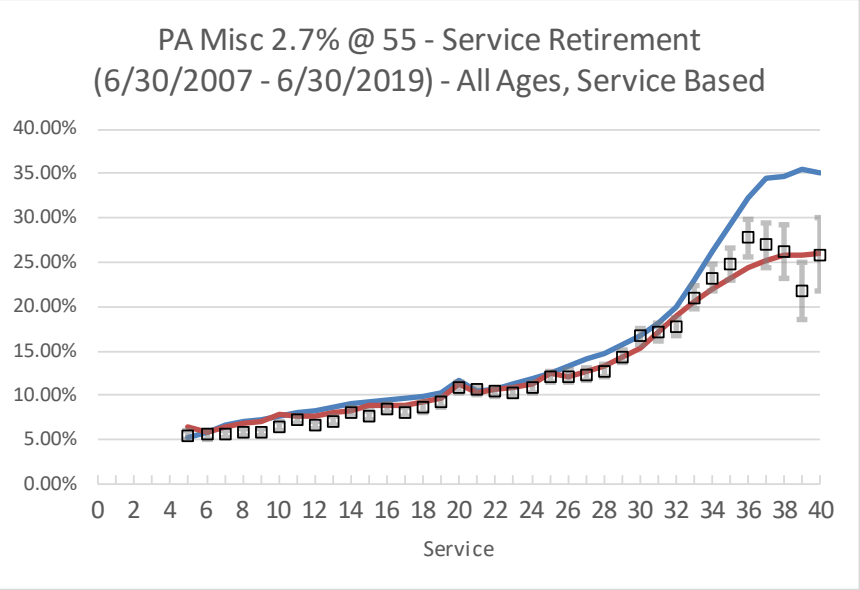


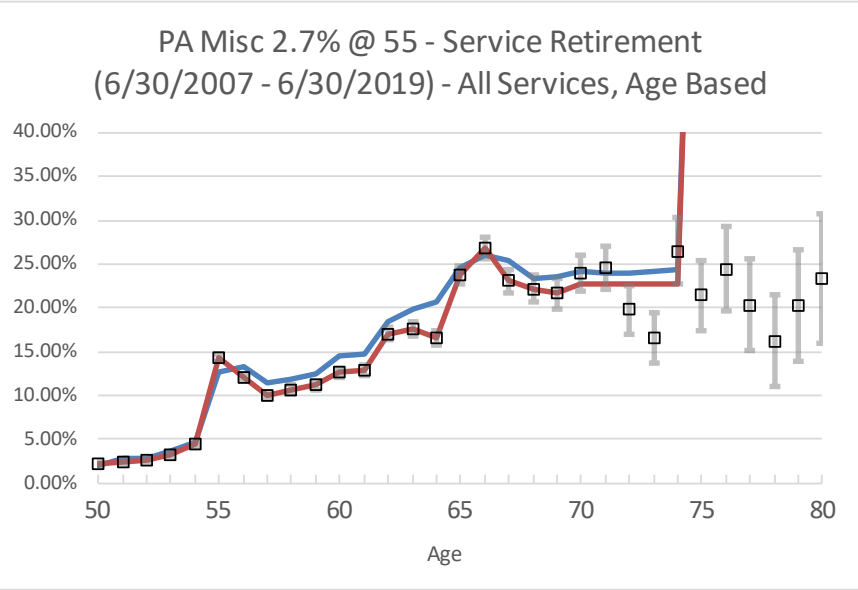


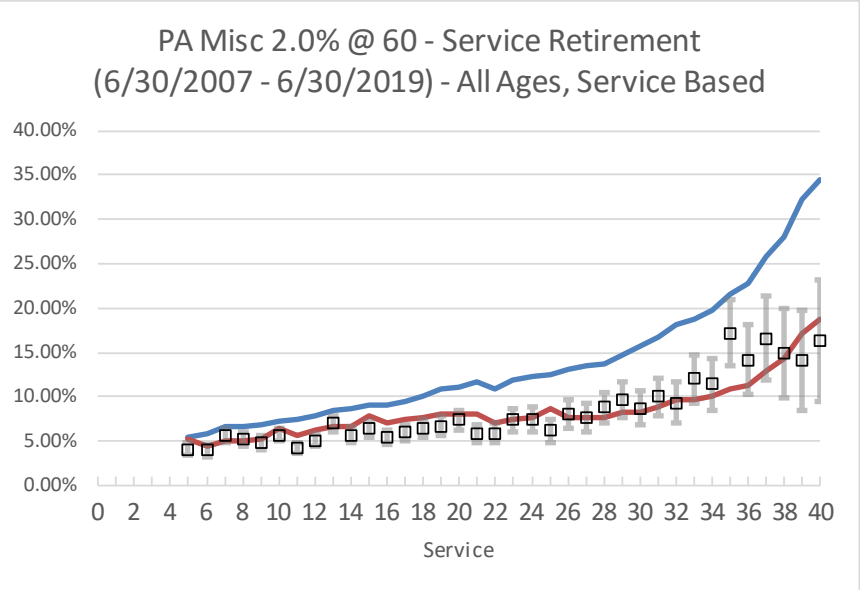


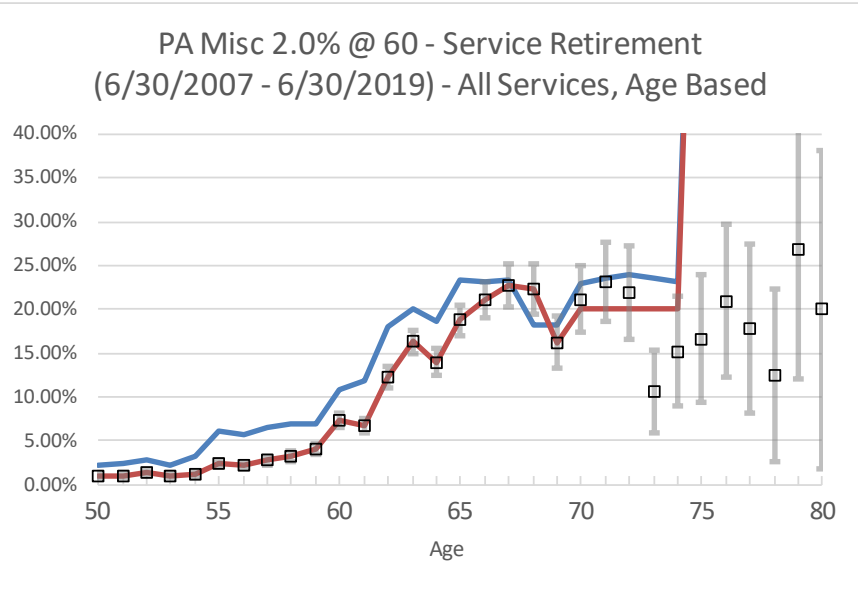


Detailed Analysis – Service Retirement

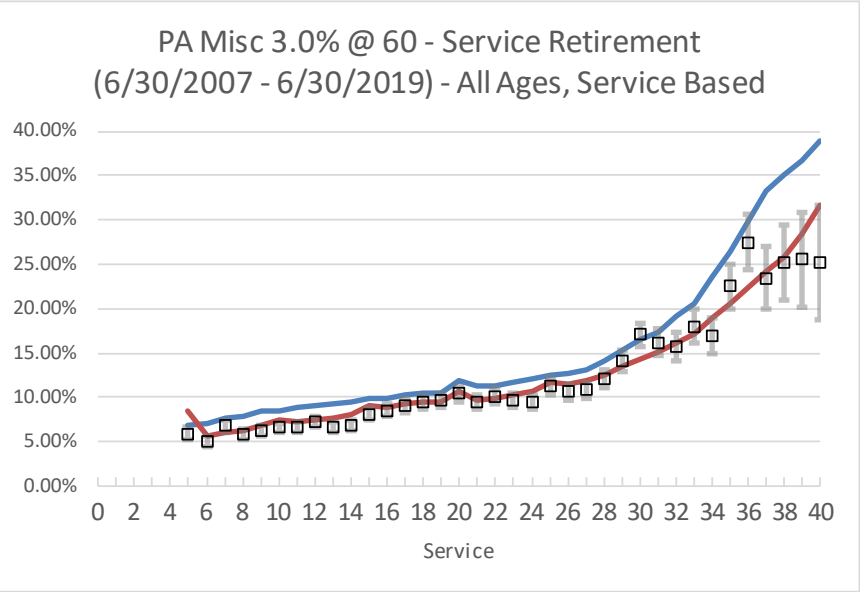


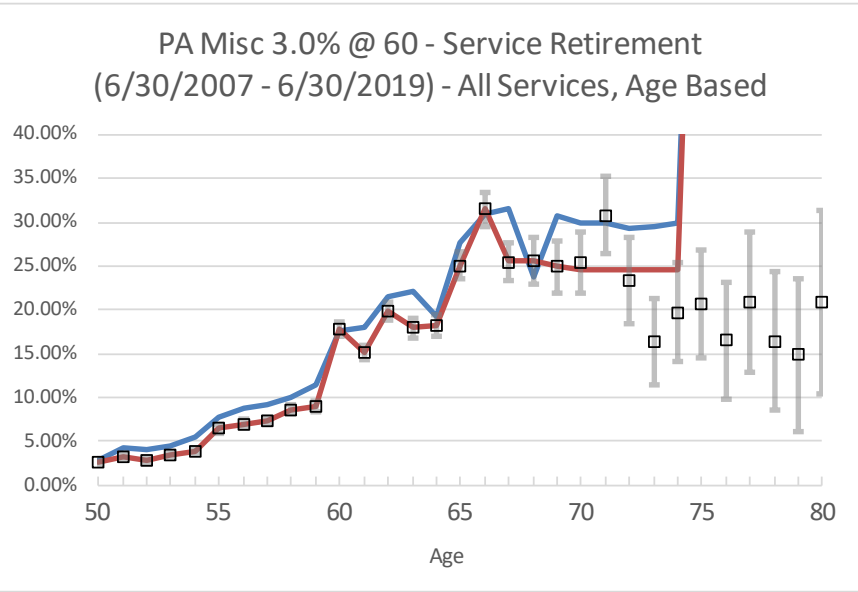


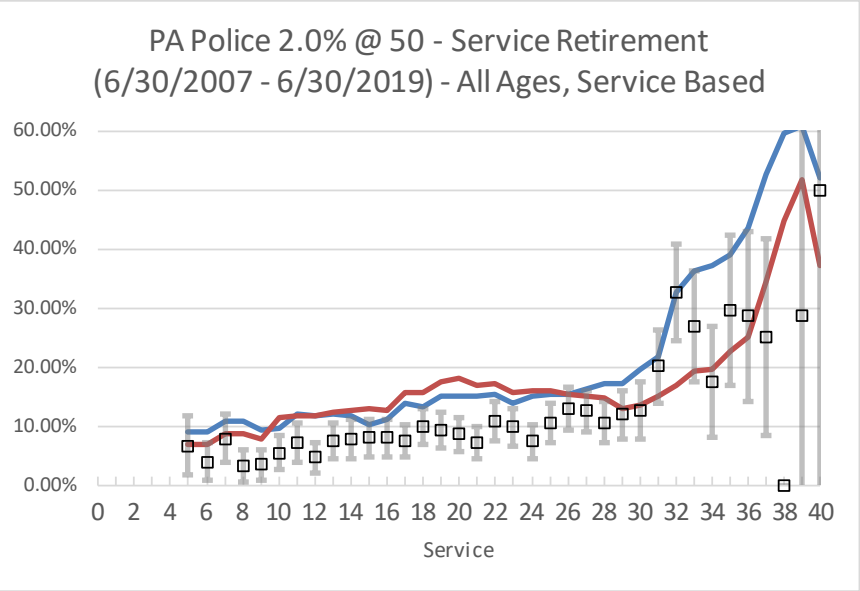


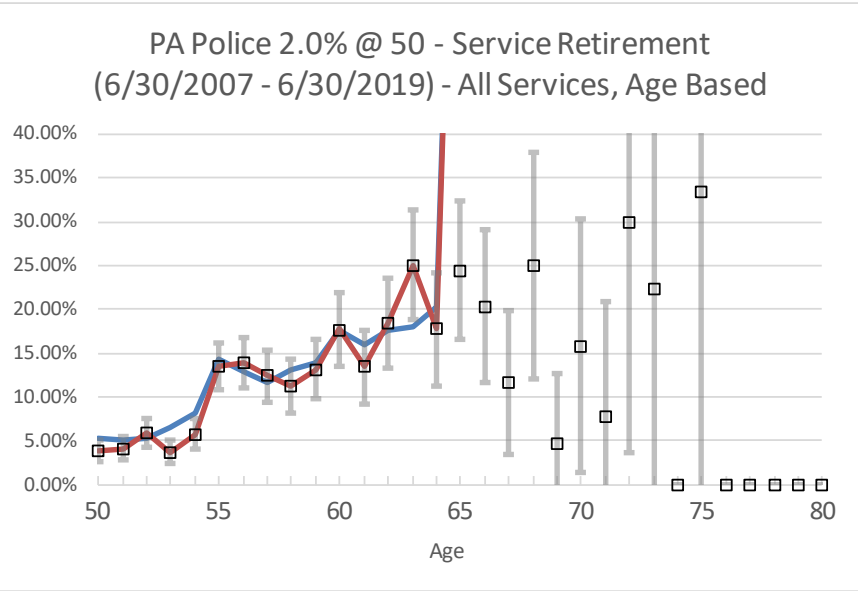


Detailed Analysis – Service Retirement

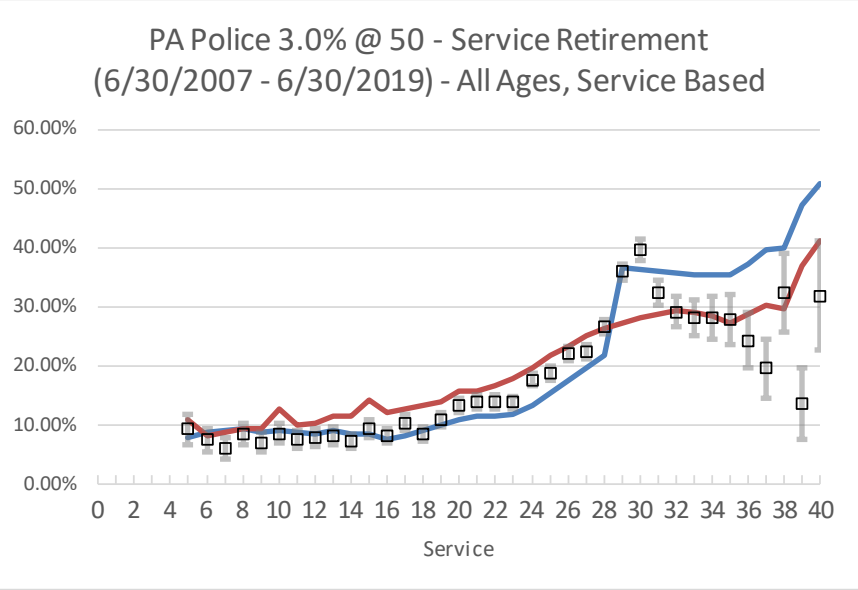


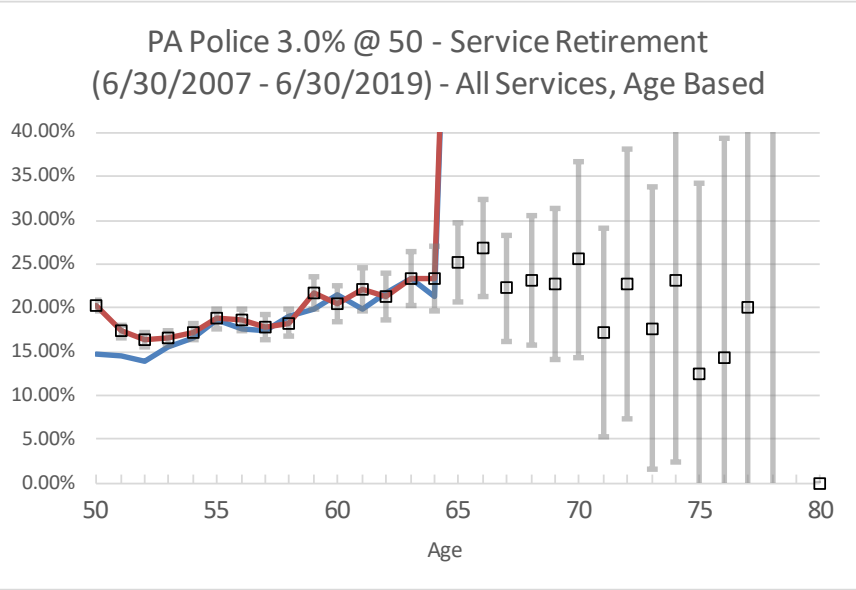


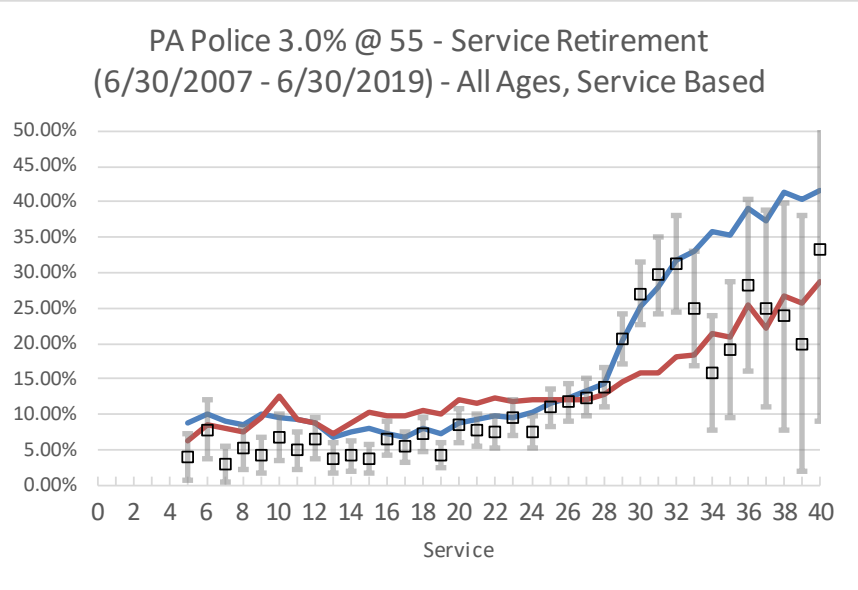


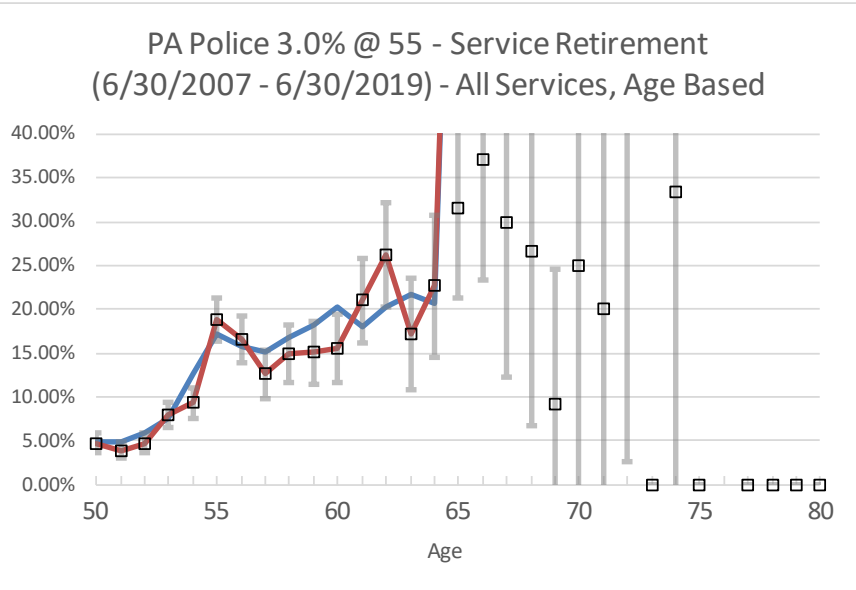


Detailed Analysis – Service Retirement

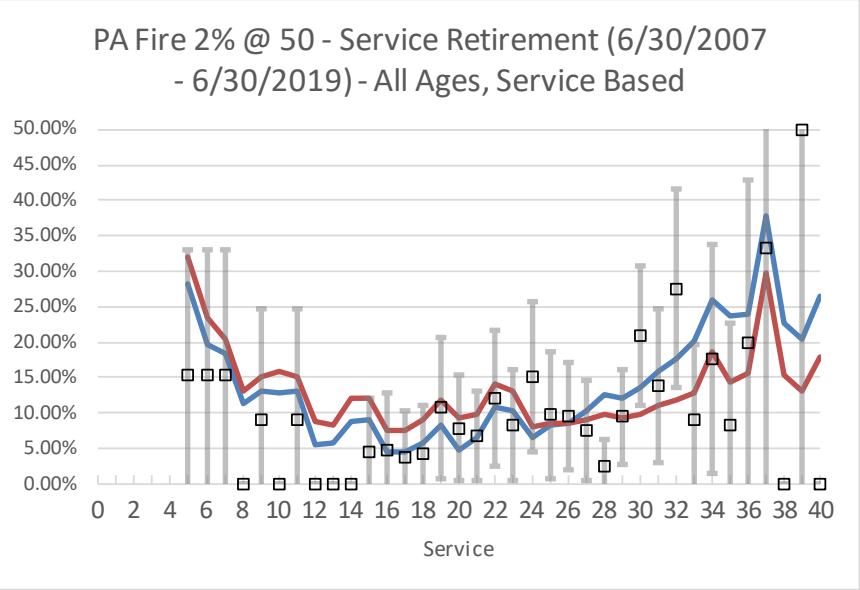


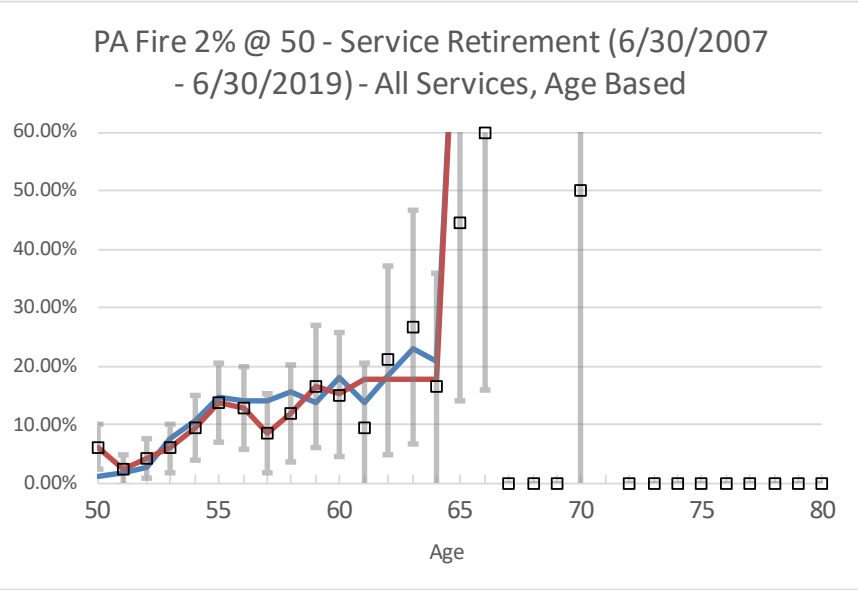


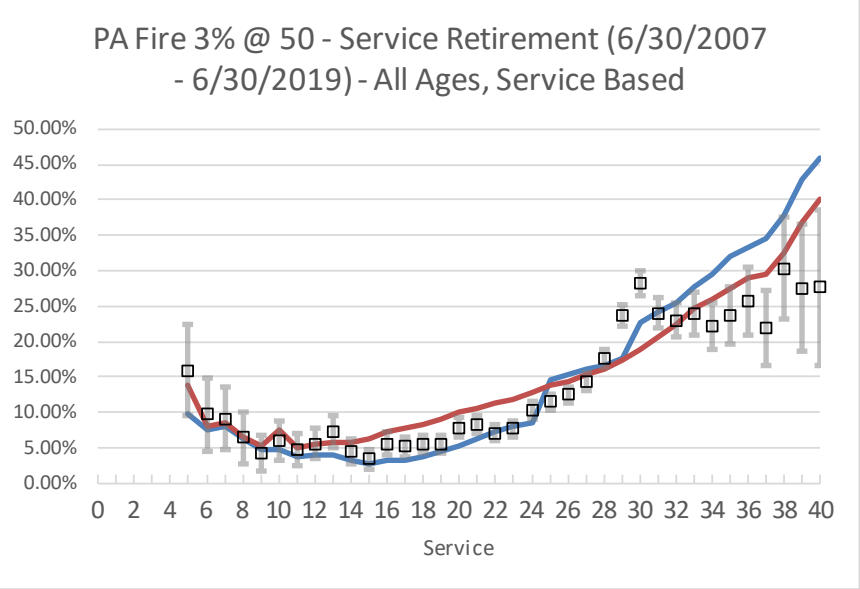


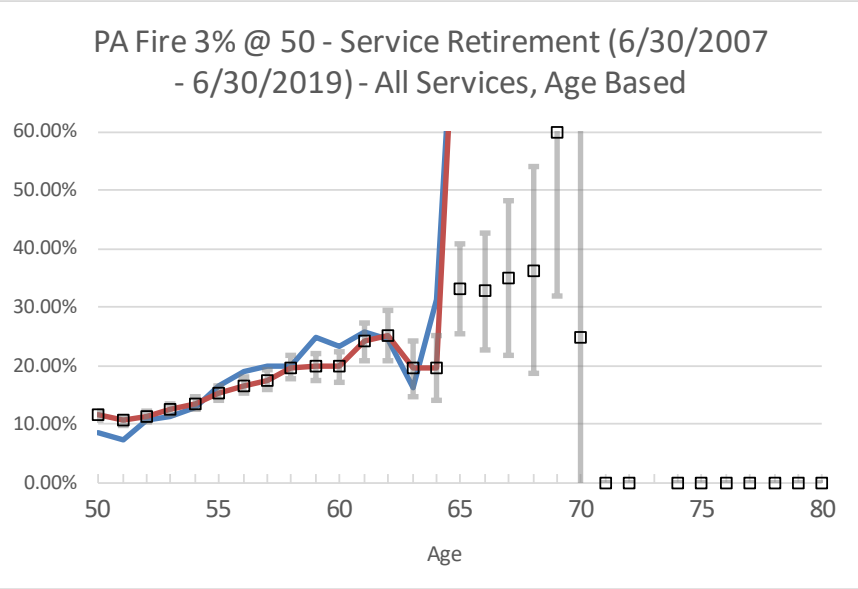


Detailed Analysis – Service Retirement

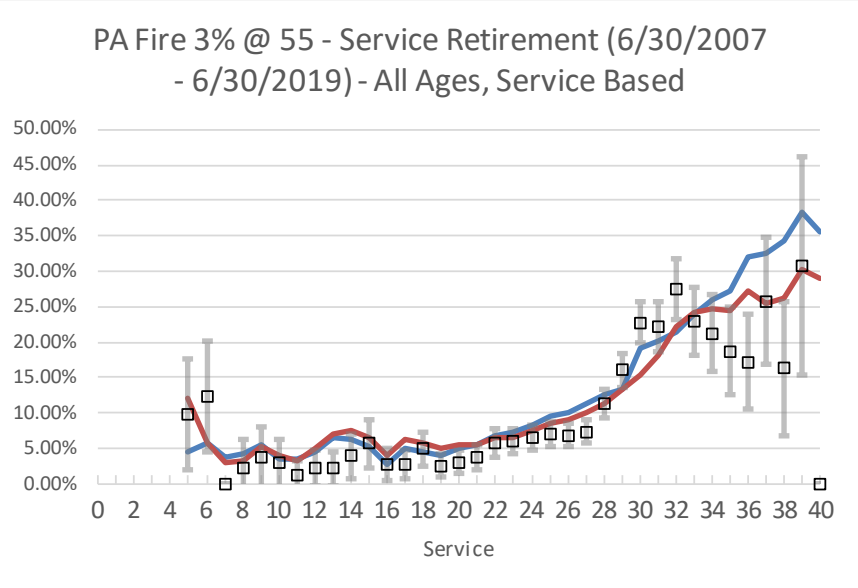


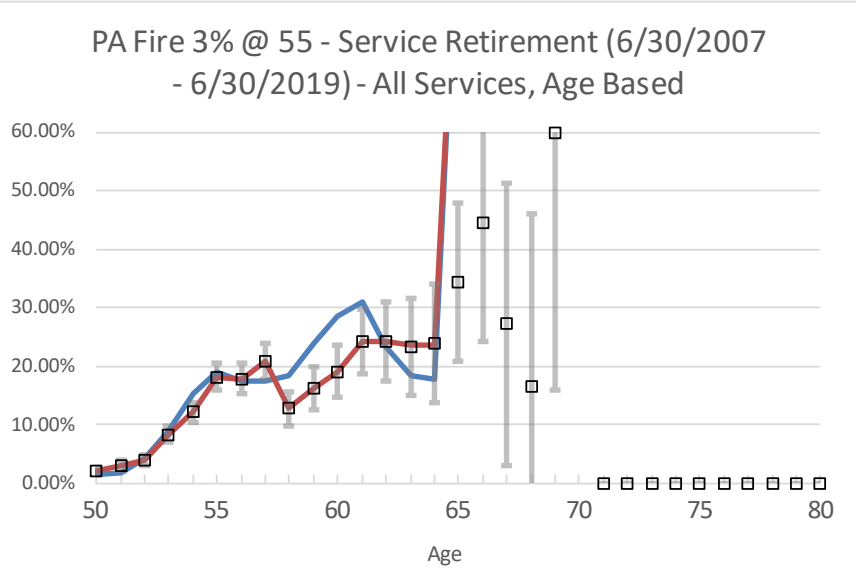






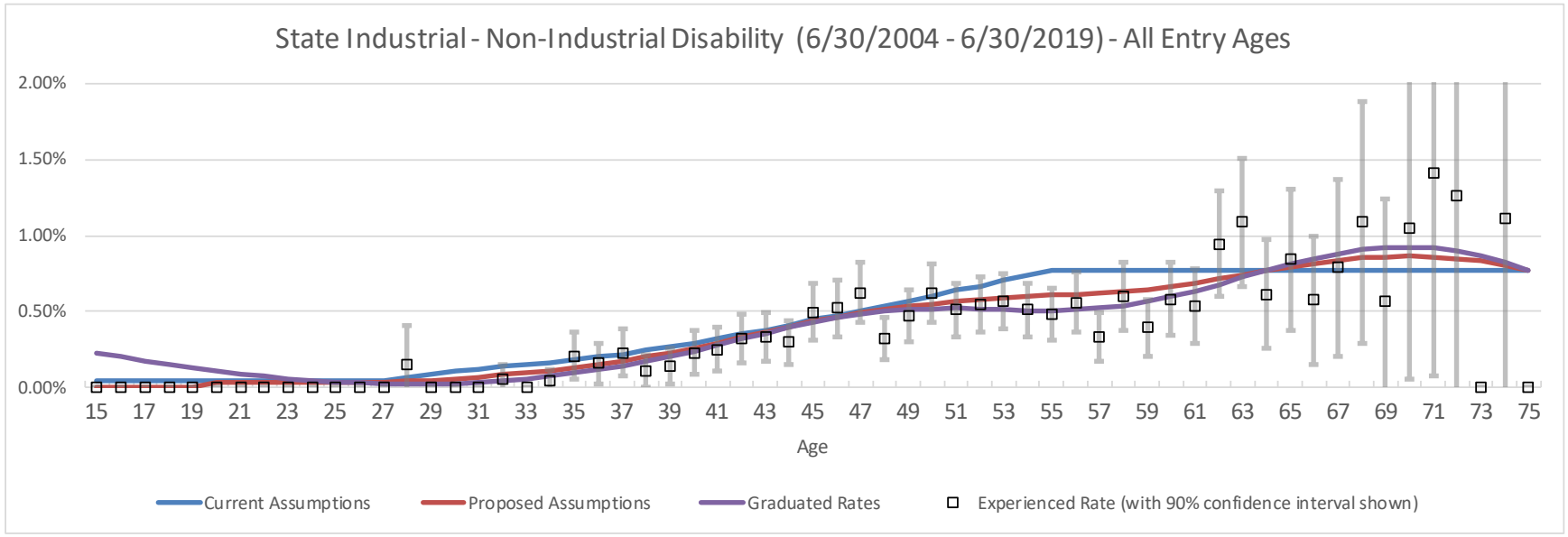
Detailed Analysis – Service Retirement

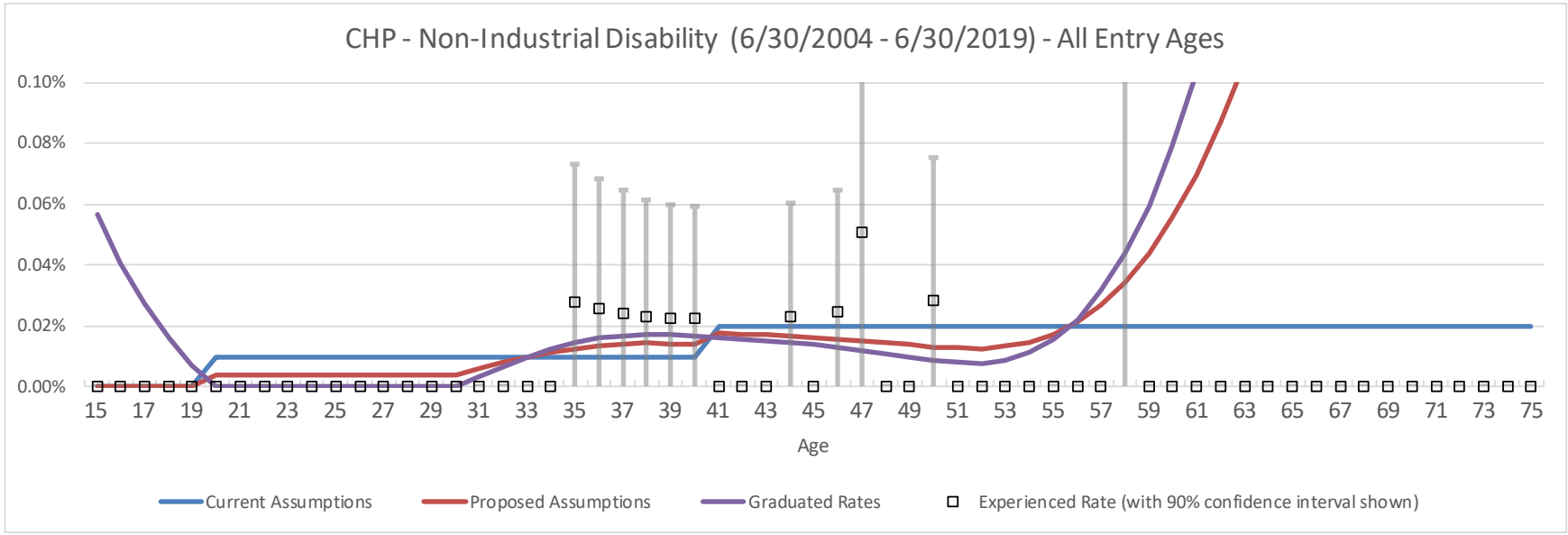




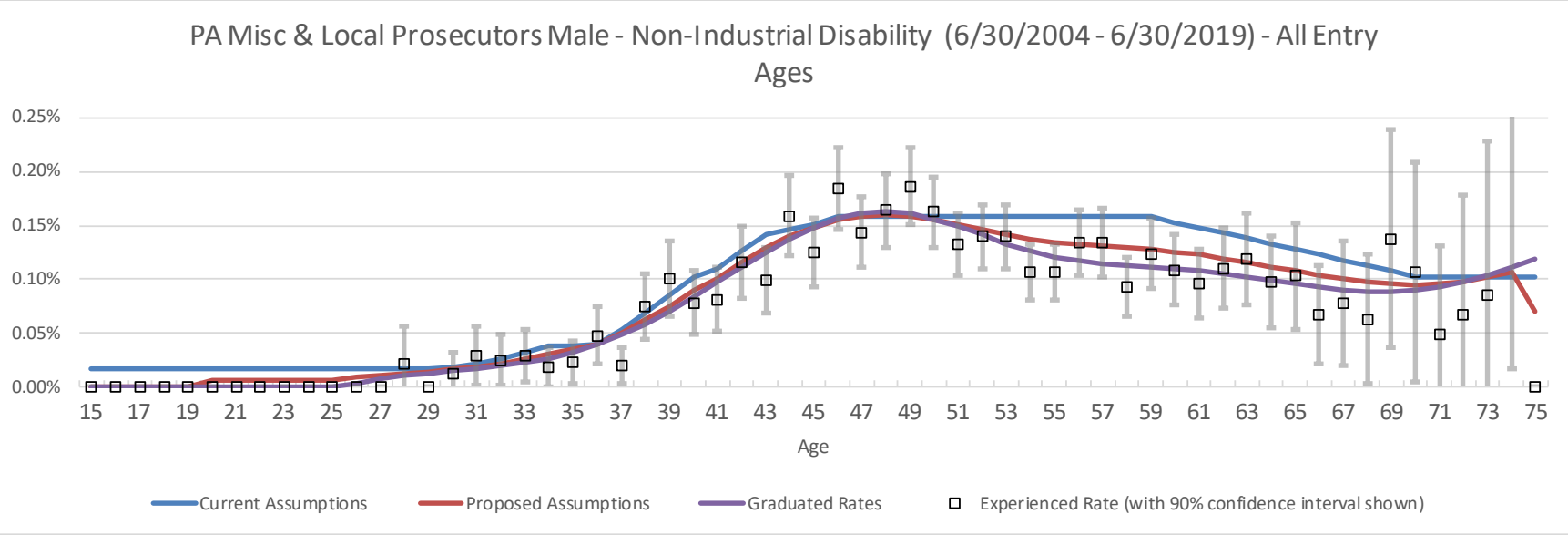
Avg. Current Assumptions | Avg. Proposed Assumptions | Experienced Rate (with 90% confidence interval shown)

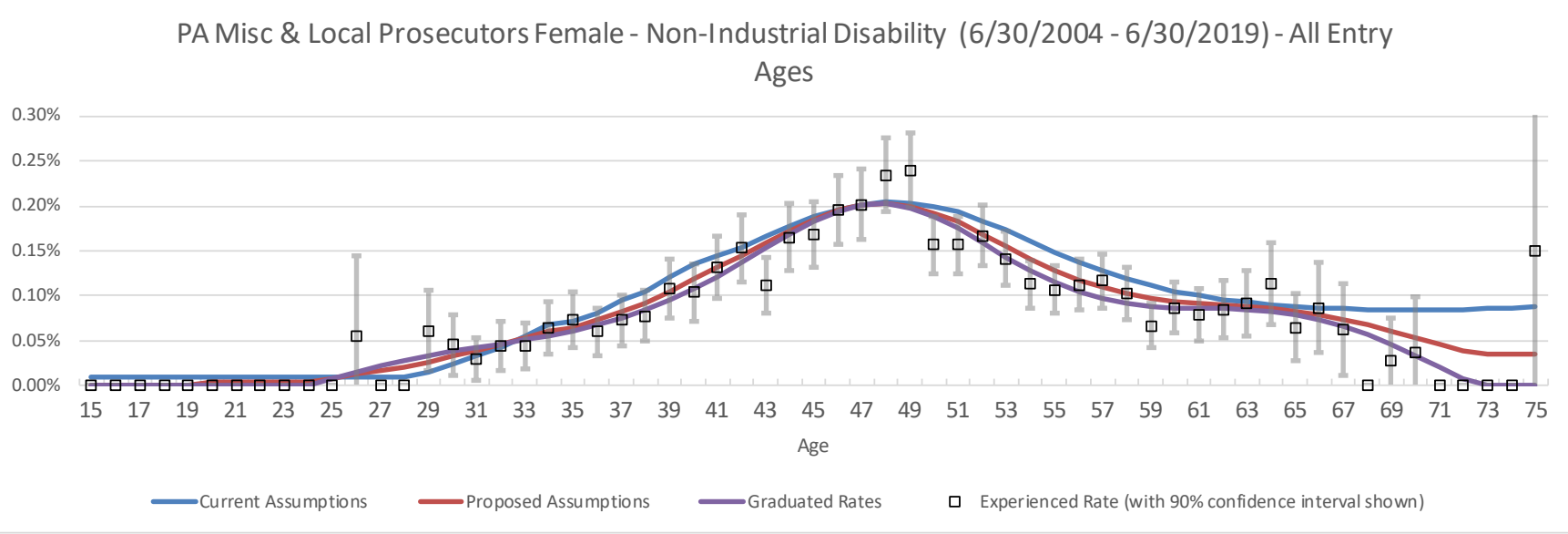
Detailed Analysis – Non-Industrial Disability



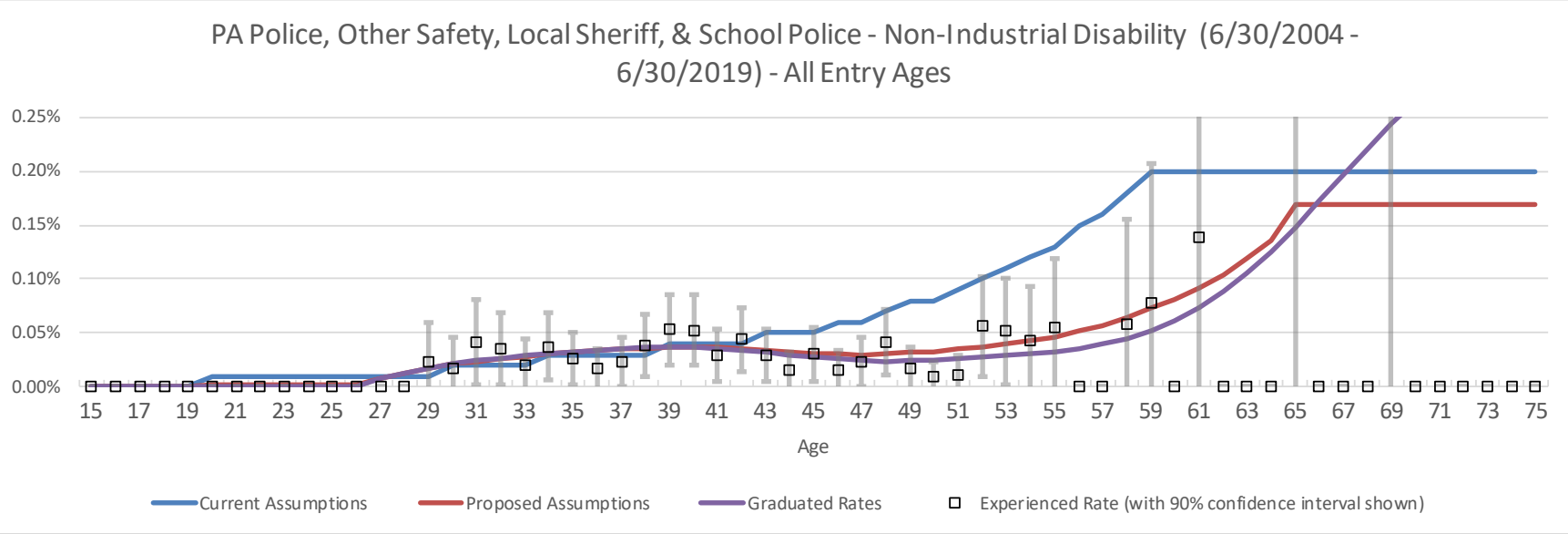


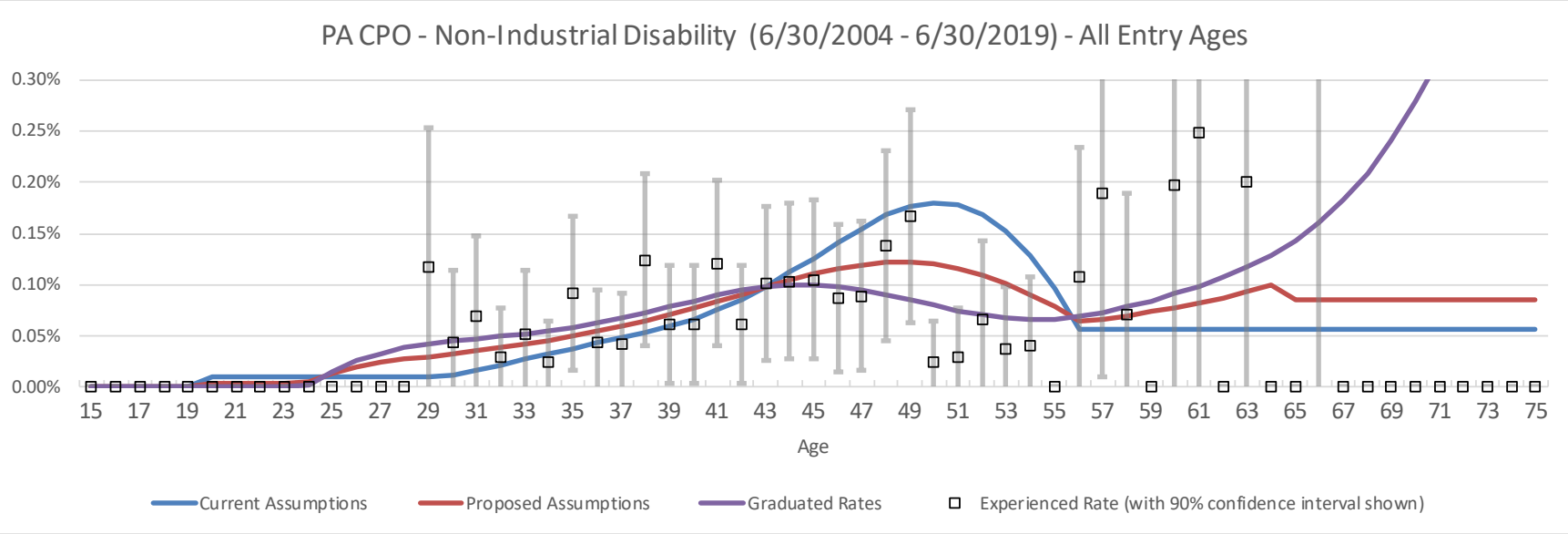
Detailed Analysis – Non-Industrial Disability



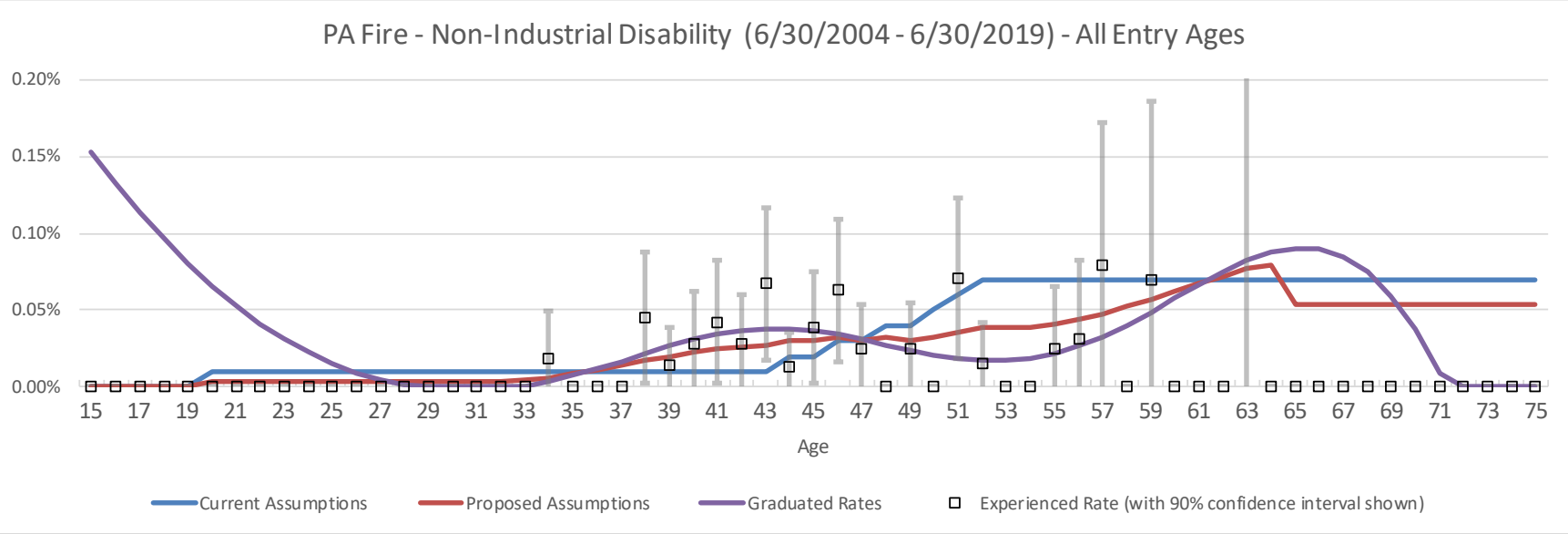


Detailed Analysis – Non-Industrial Disability

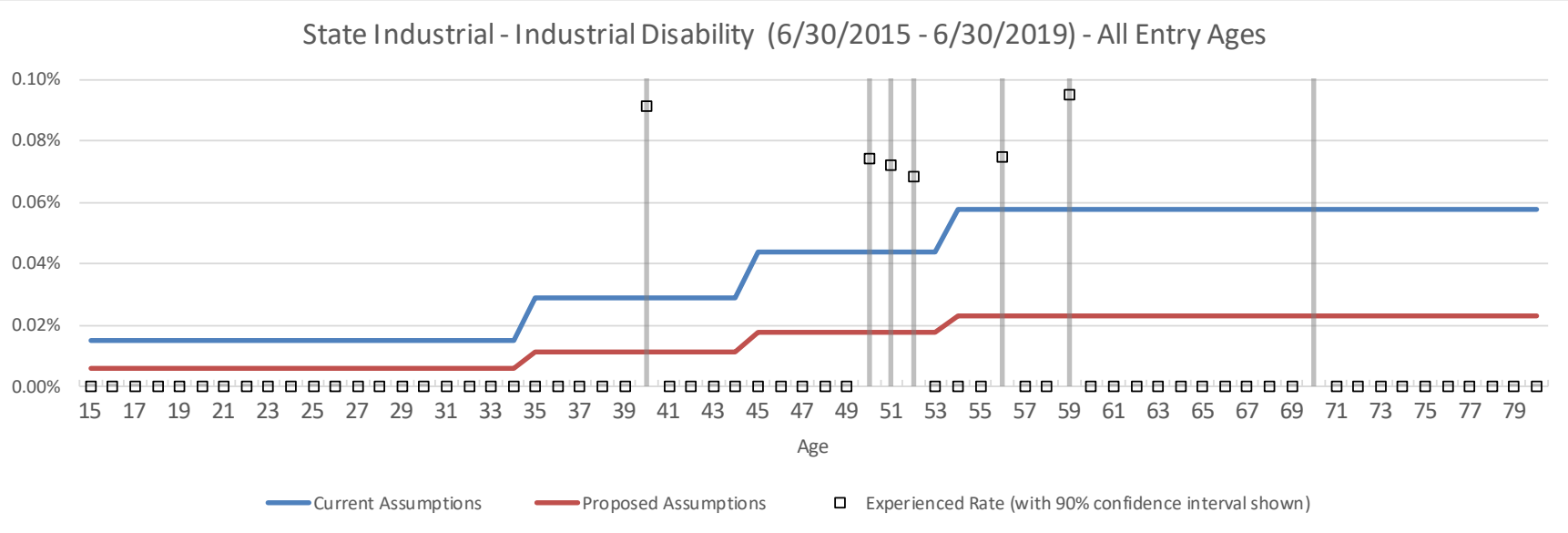


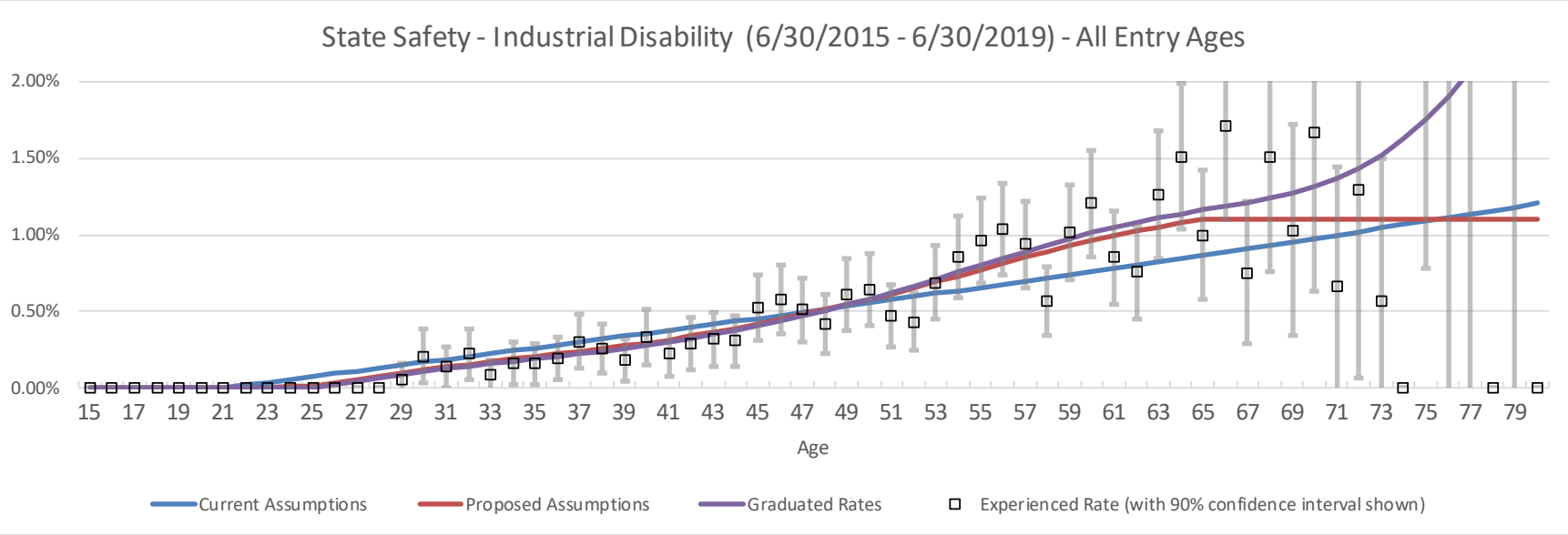


Detailed Analysis – Non-Industrial Disability

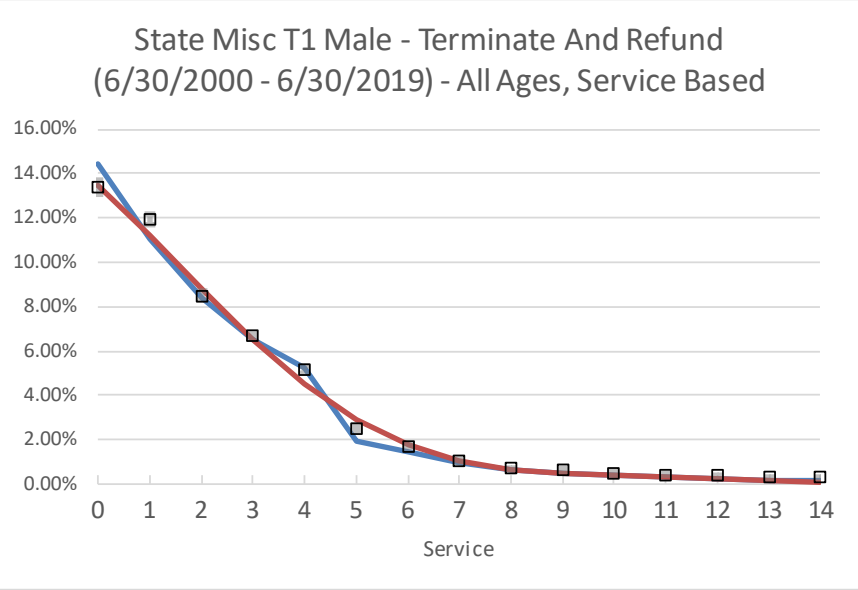


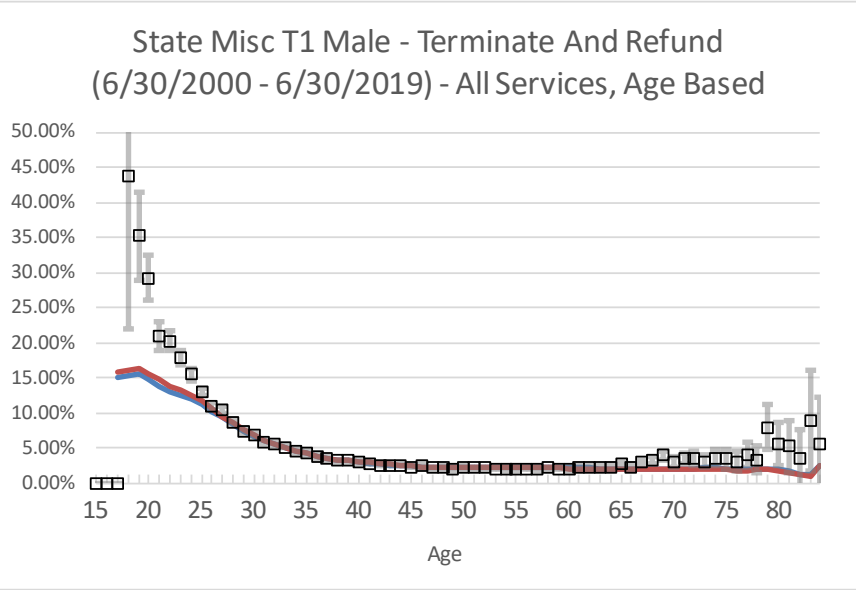
Detailed Analysis – Industrial Disability

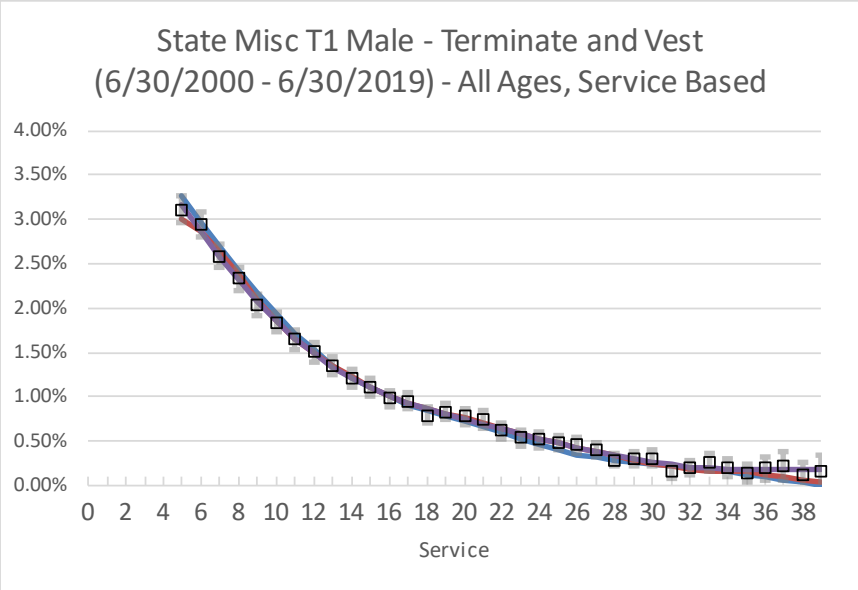


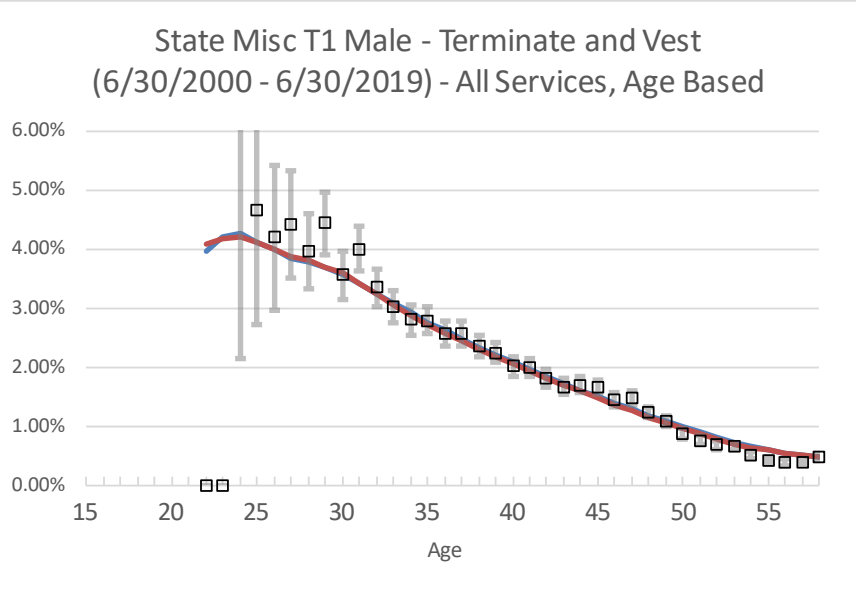


Detailed Analysis – Termination – Refund and Vesting

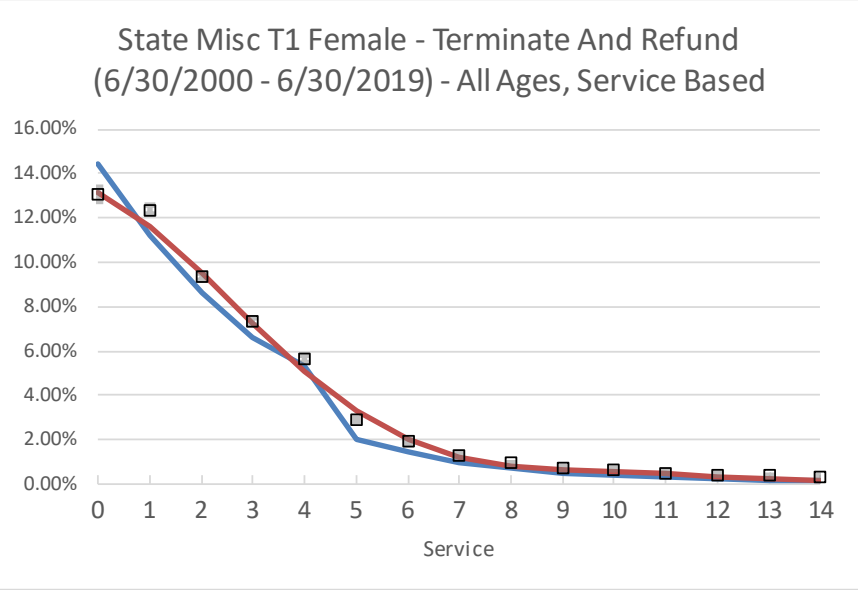


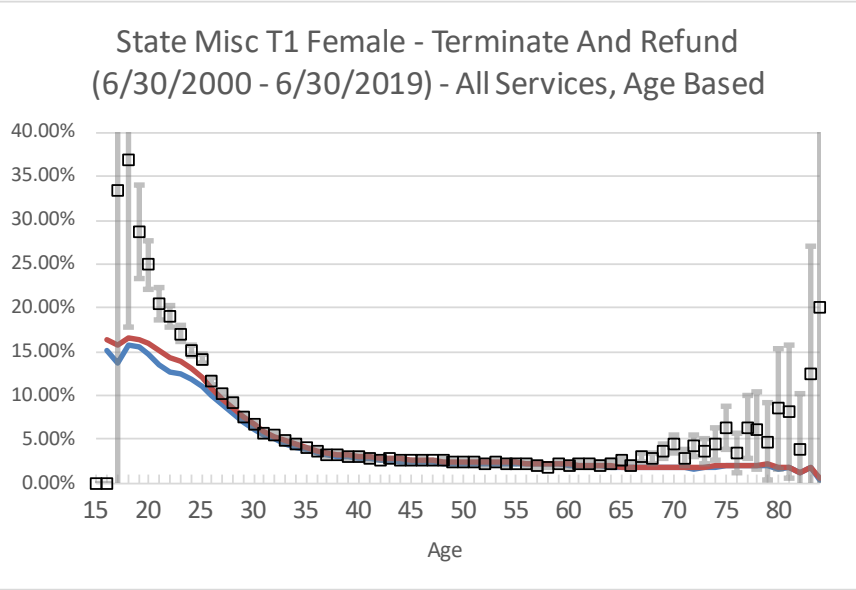


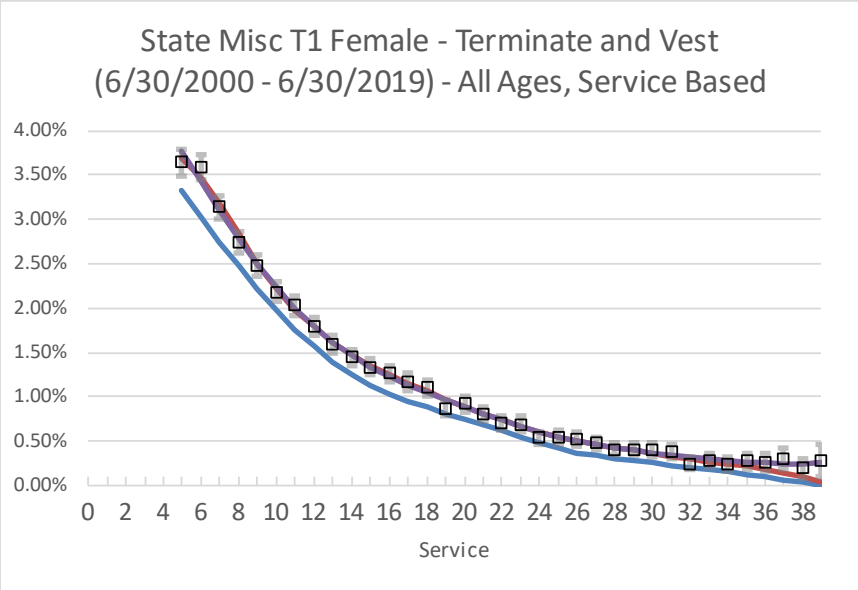


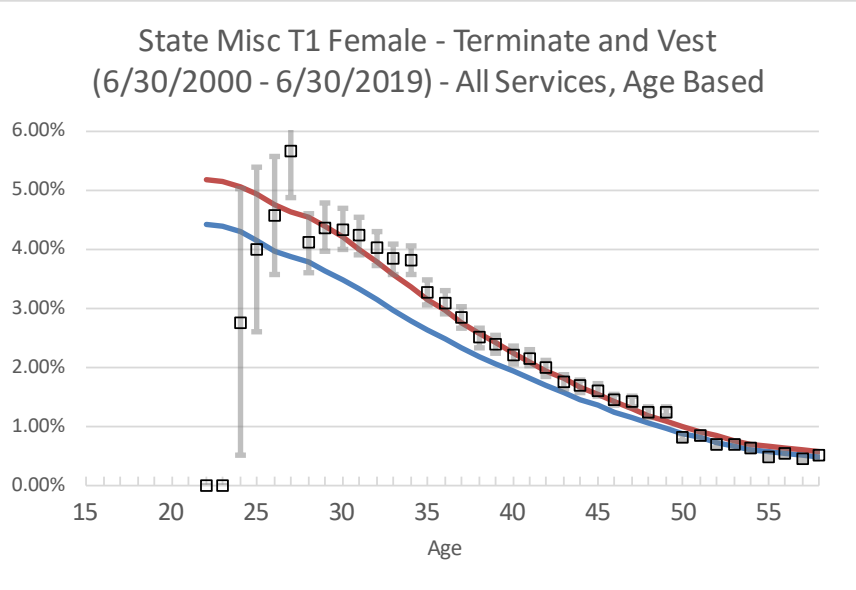


Detailed Analysis – Termination – Refund and Vesting

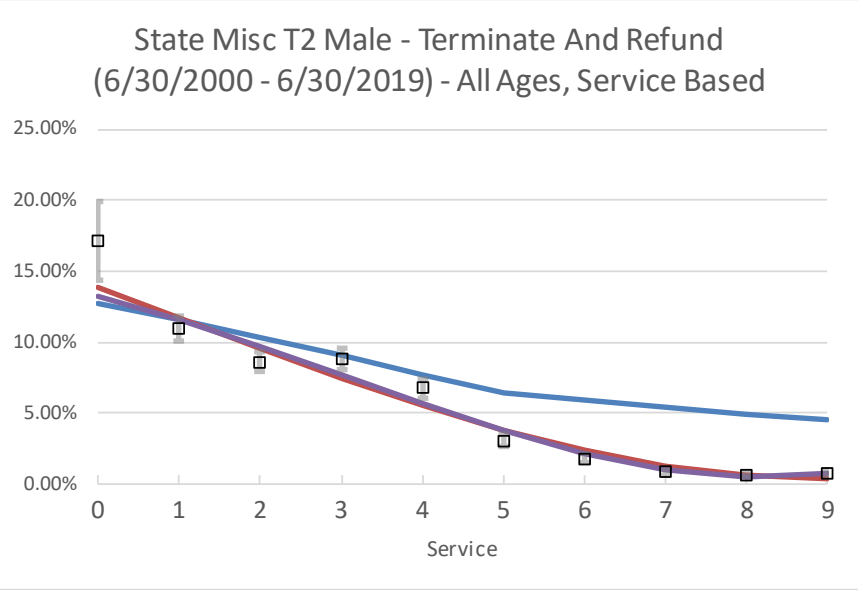


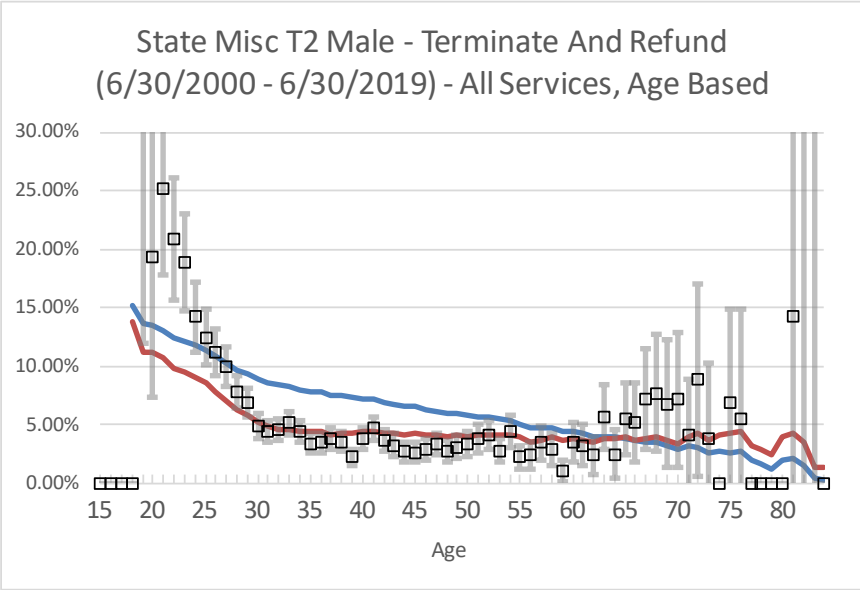


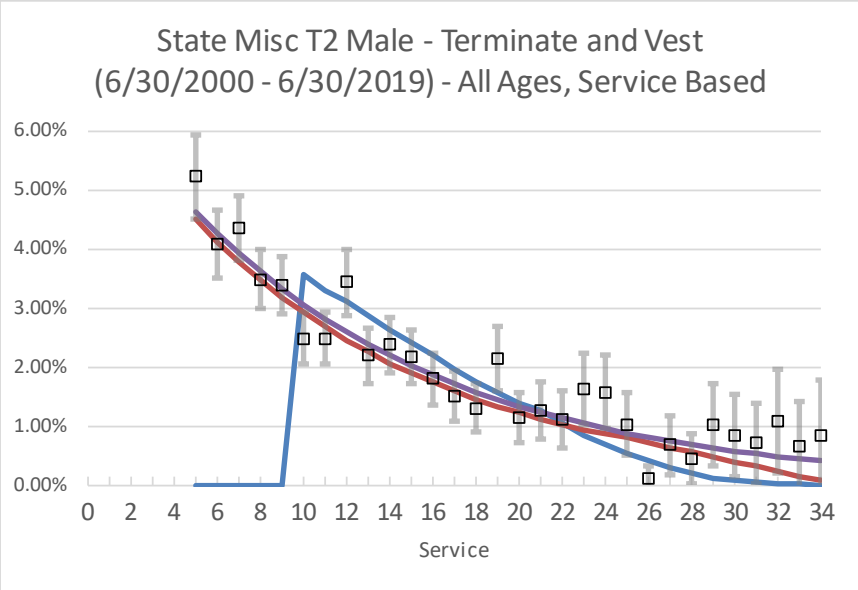


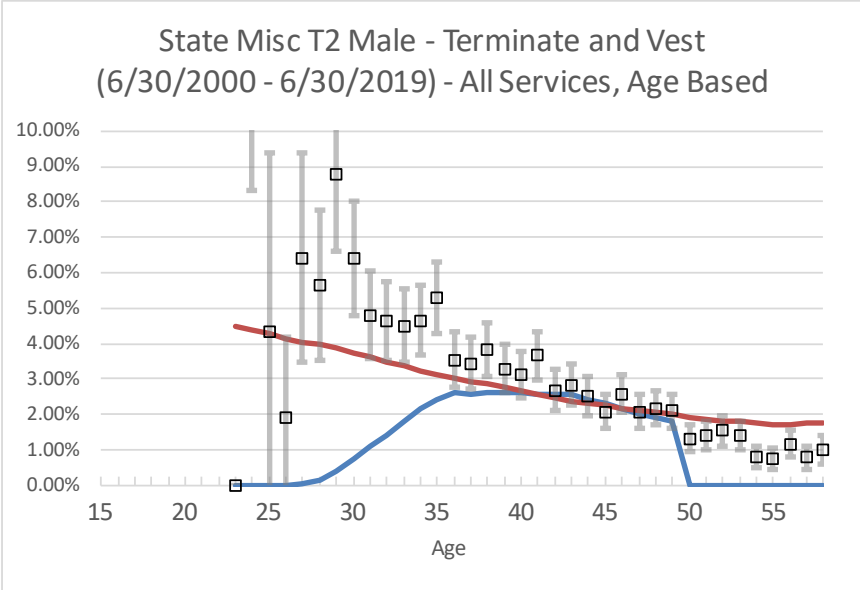


Detailed Analysis – Termination – Refund and Vesting









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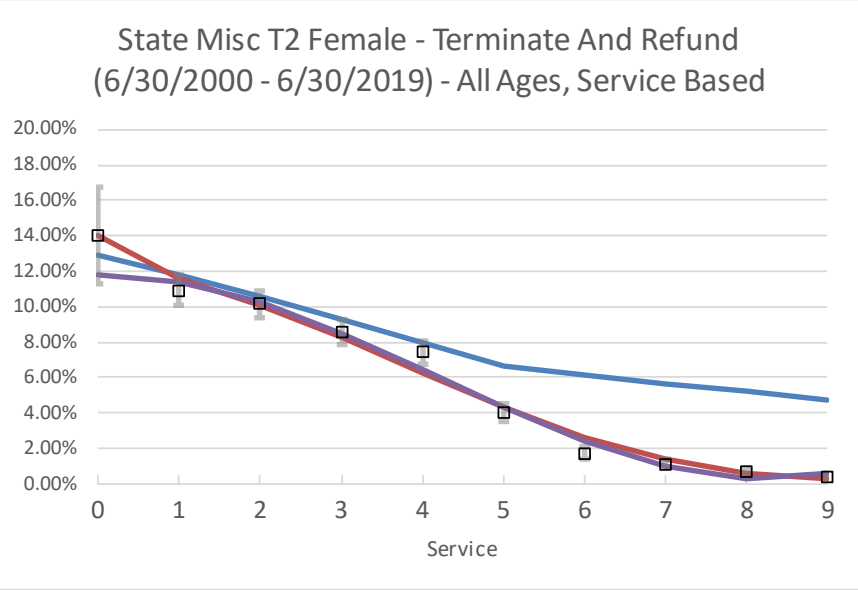

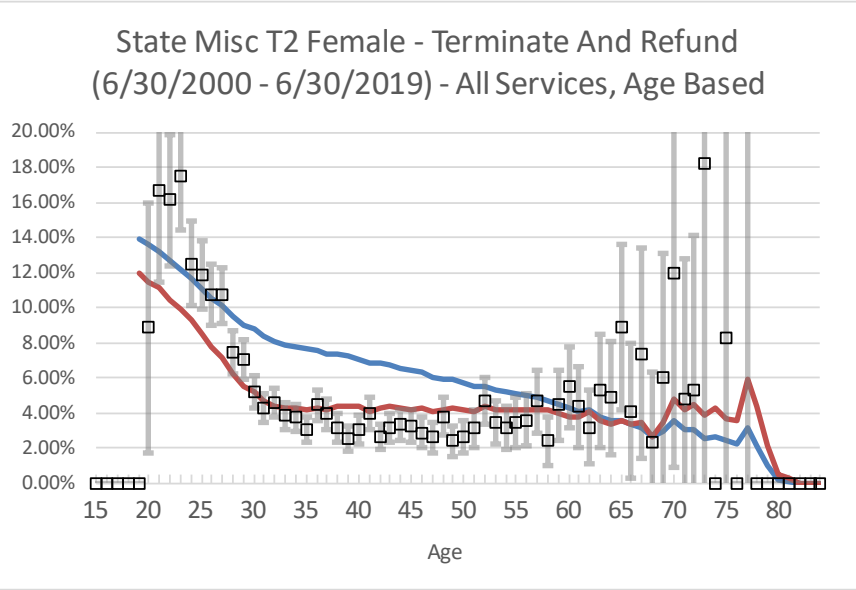

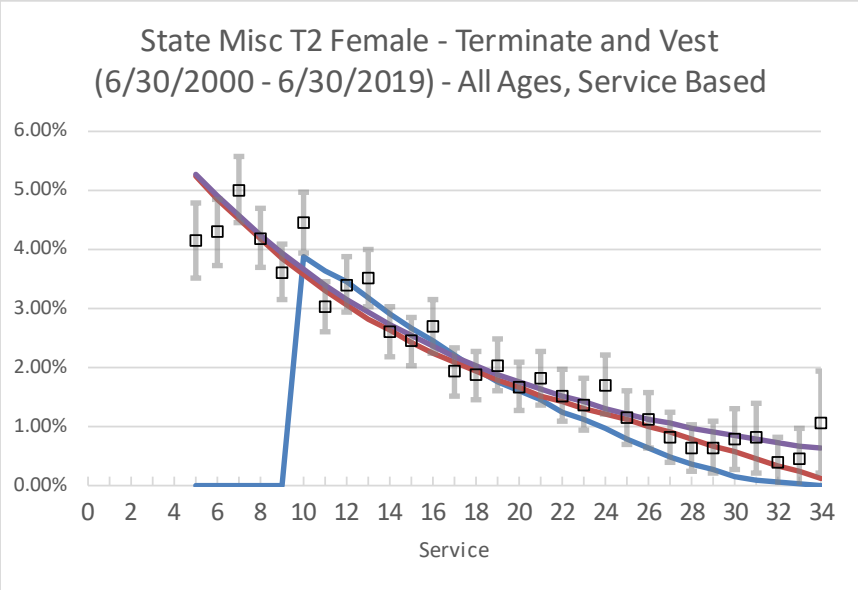

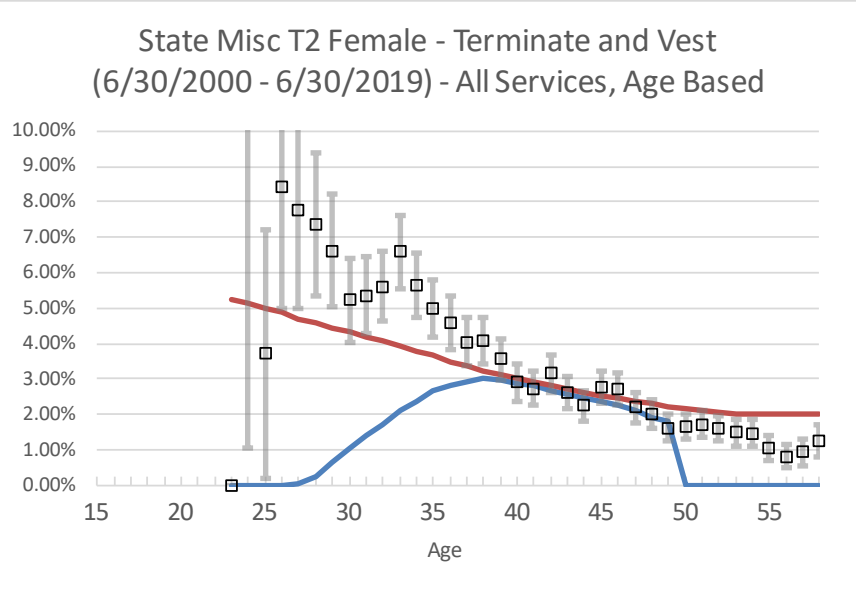

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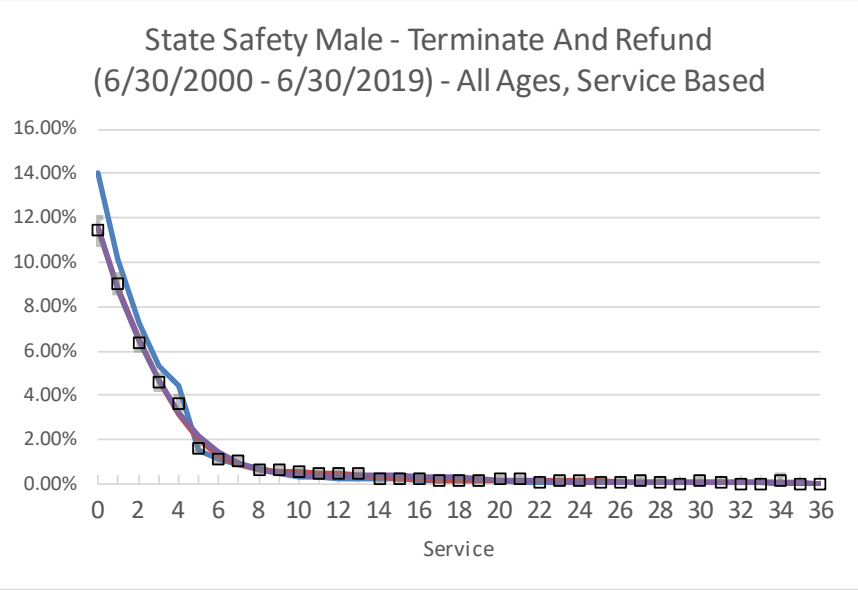

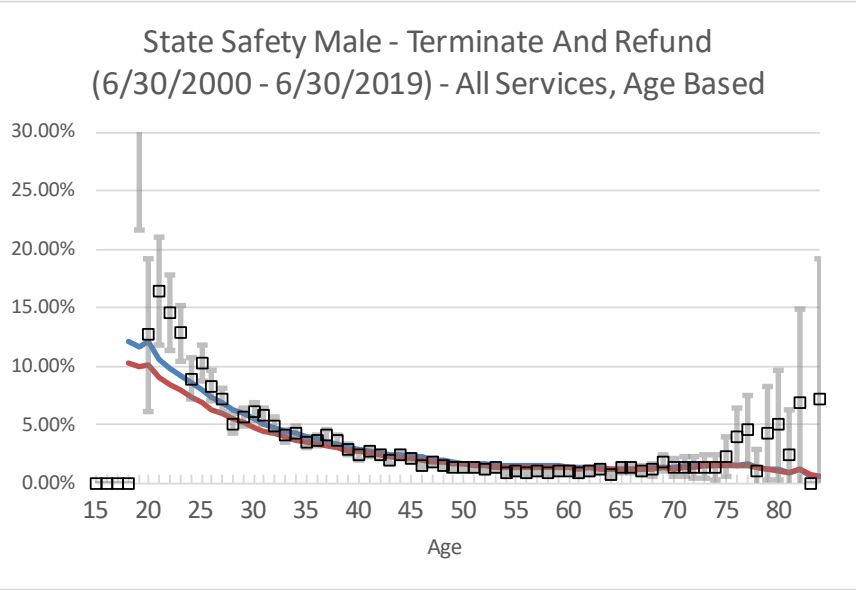

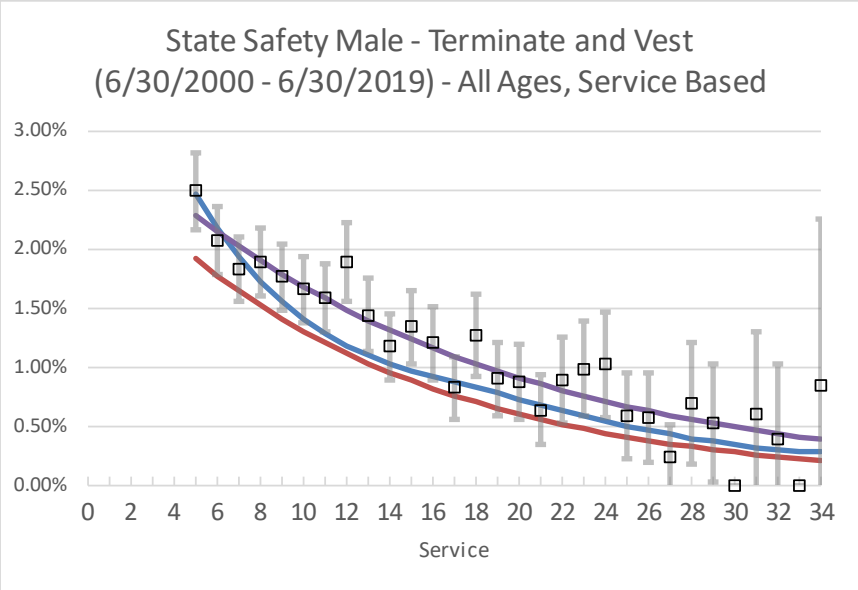

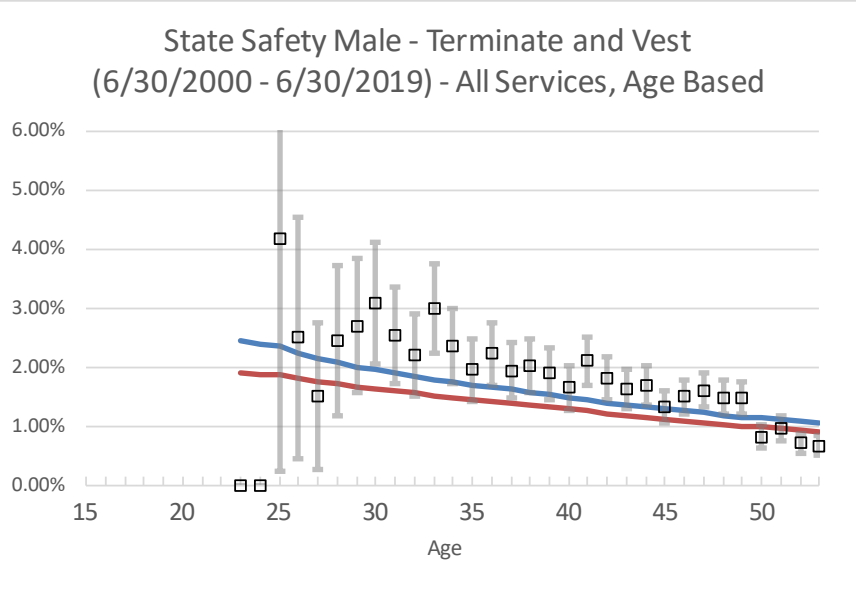

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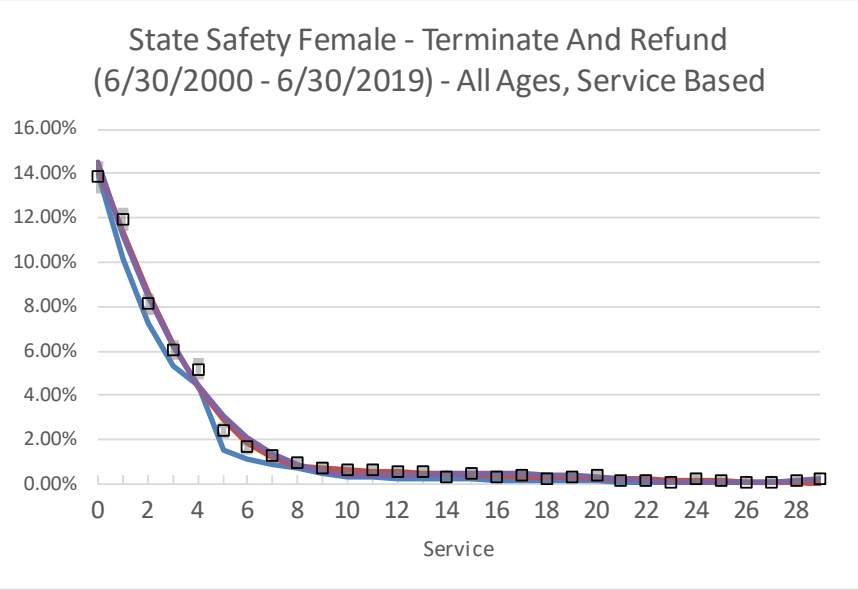
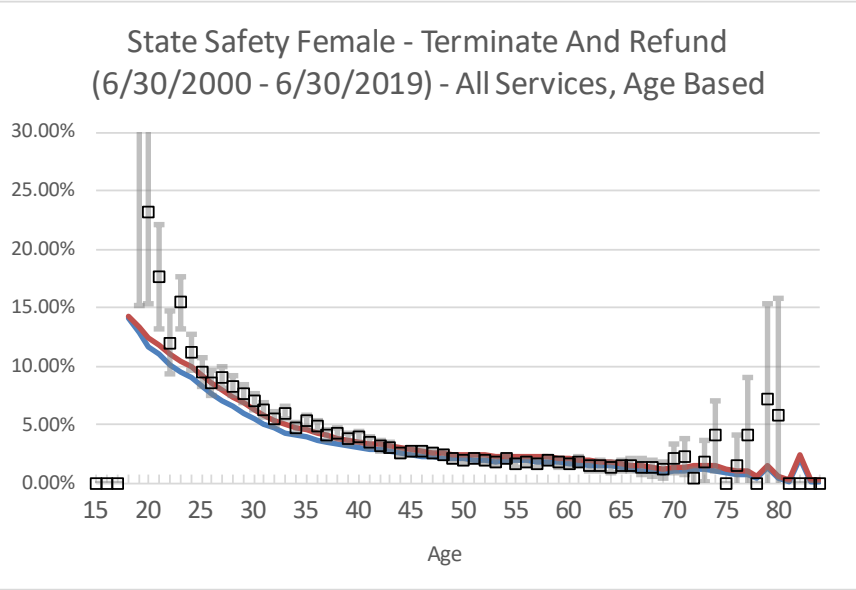
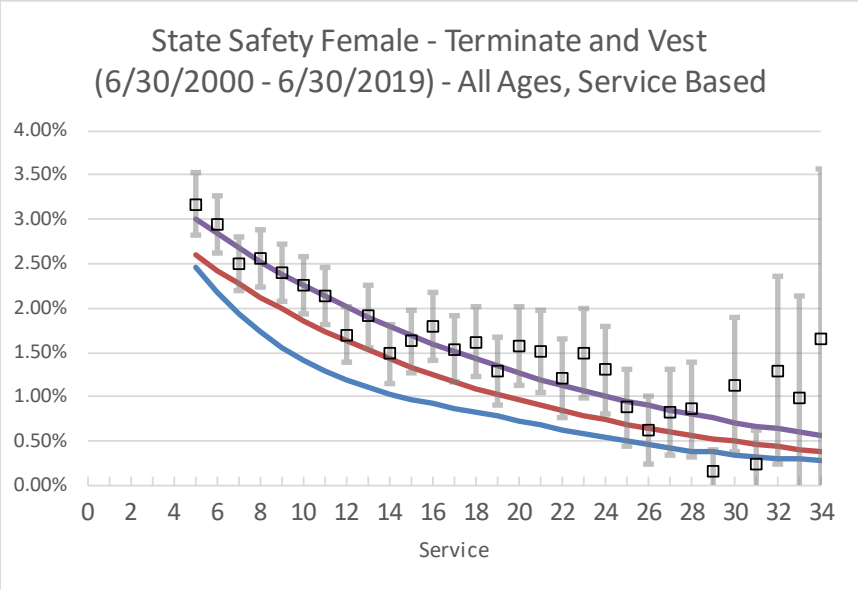
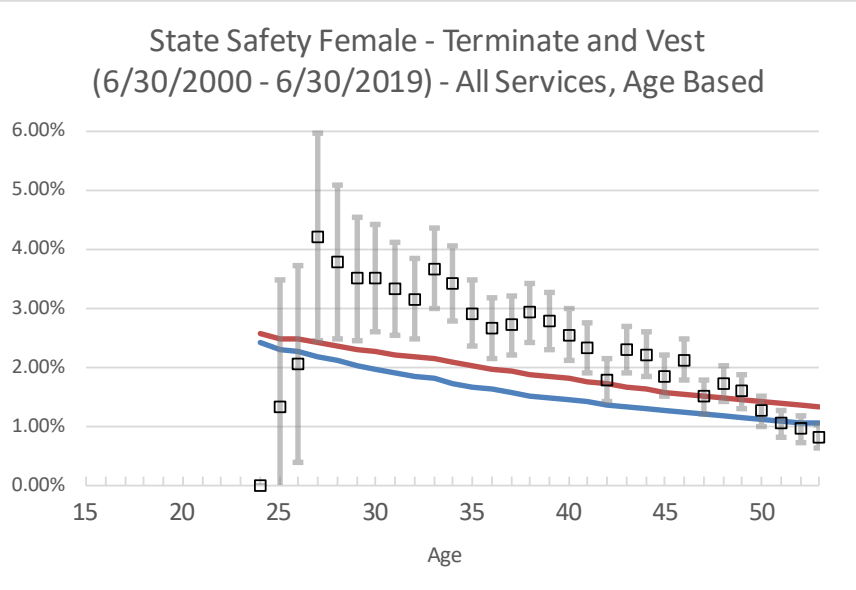
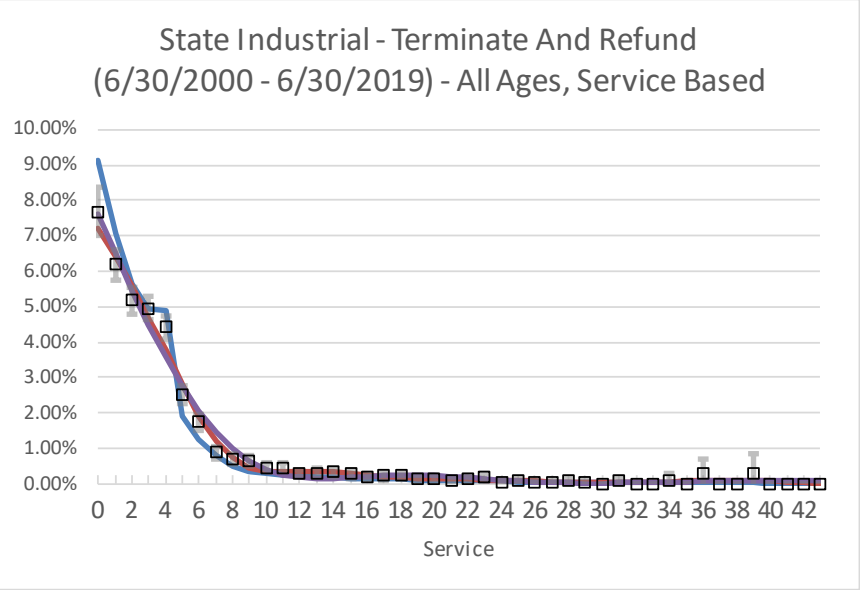


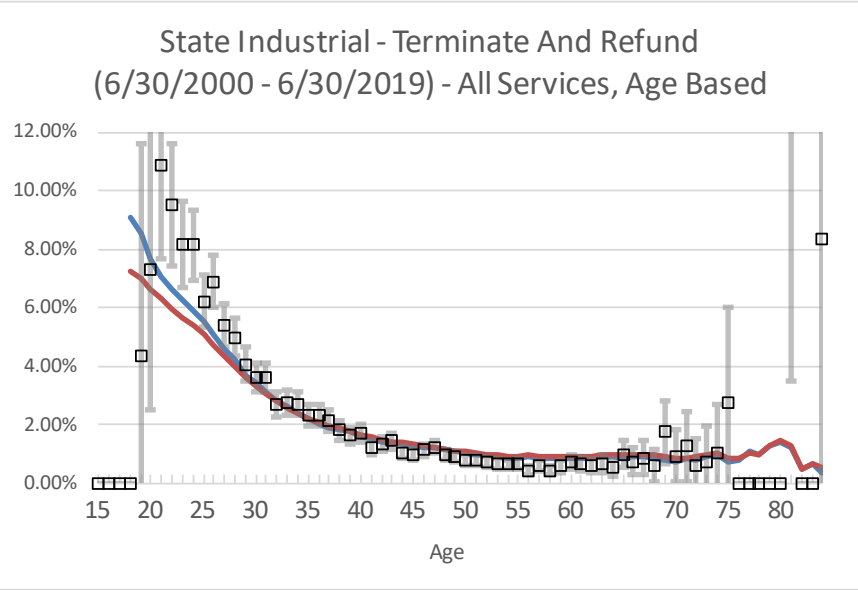


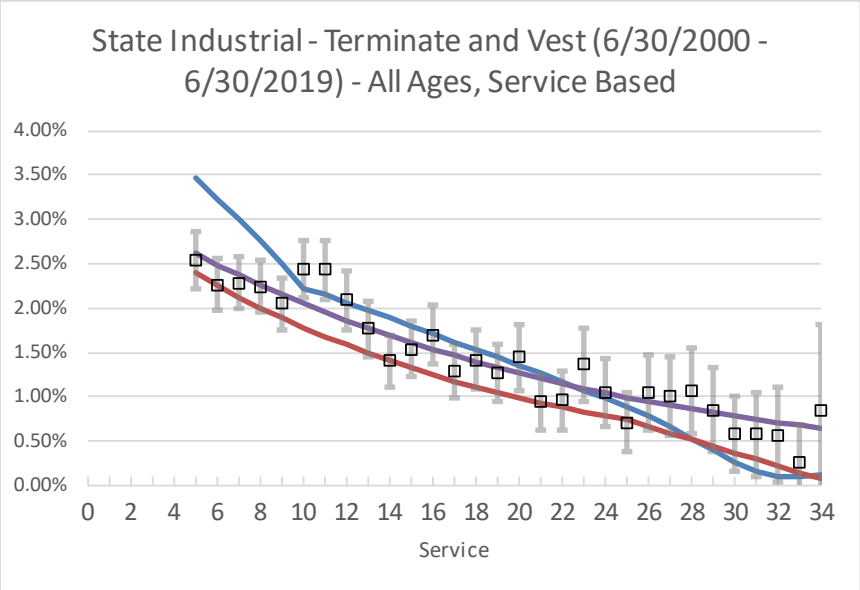


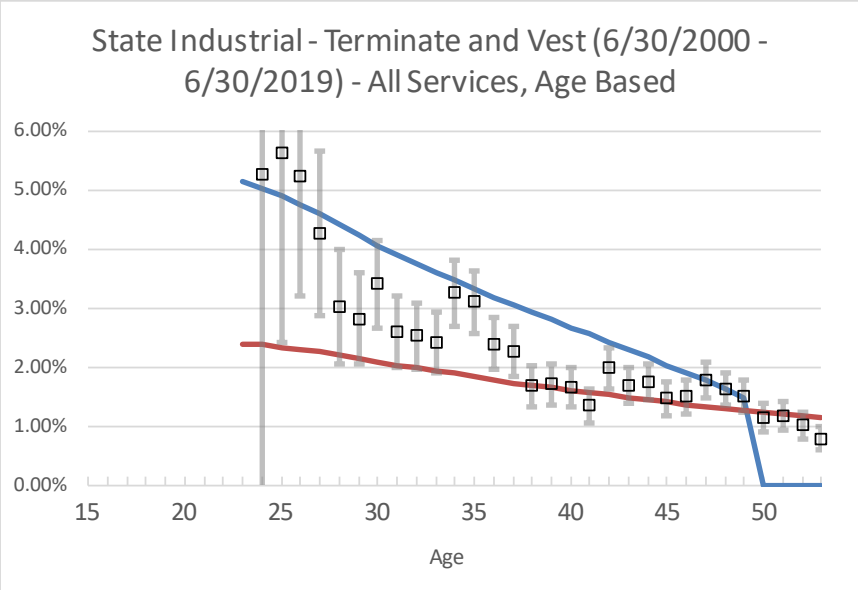


Detailed Analysis – Termination – Refund and Vesting

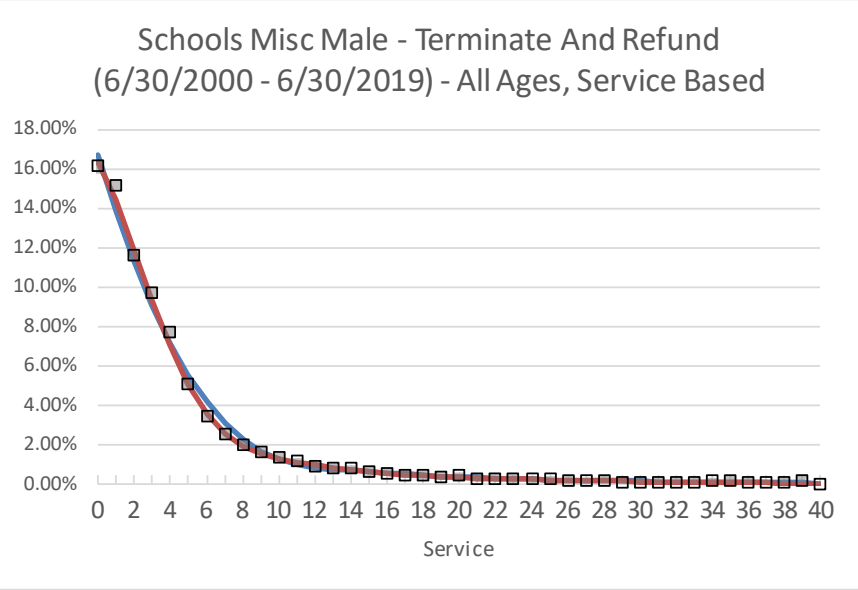


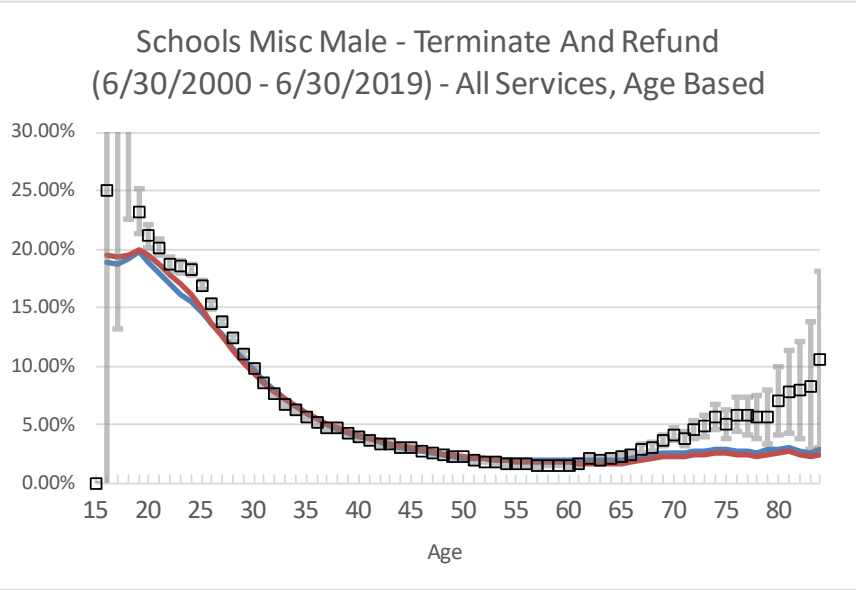


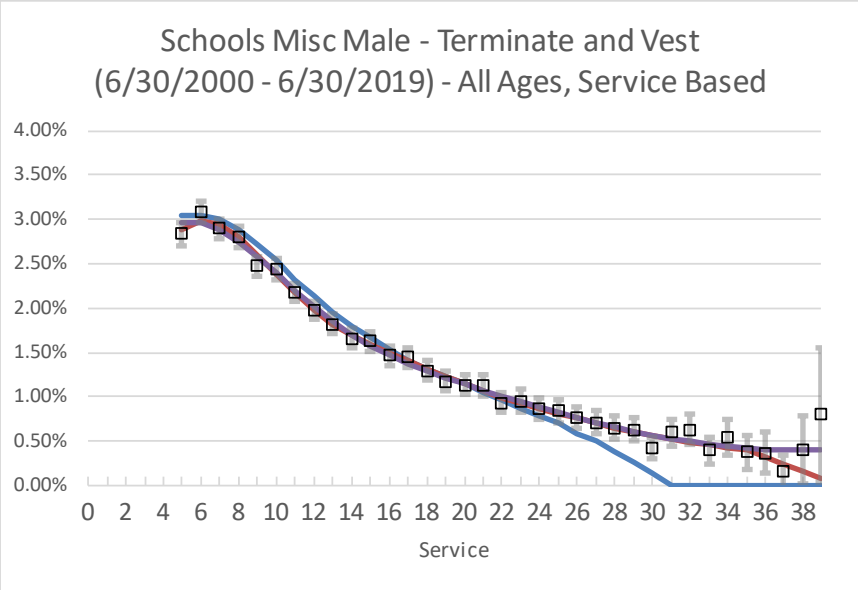


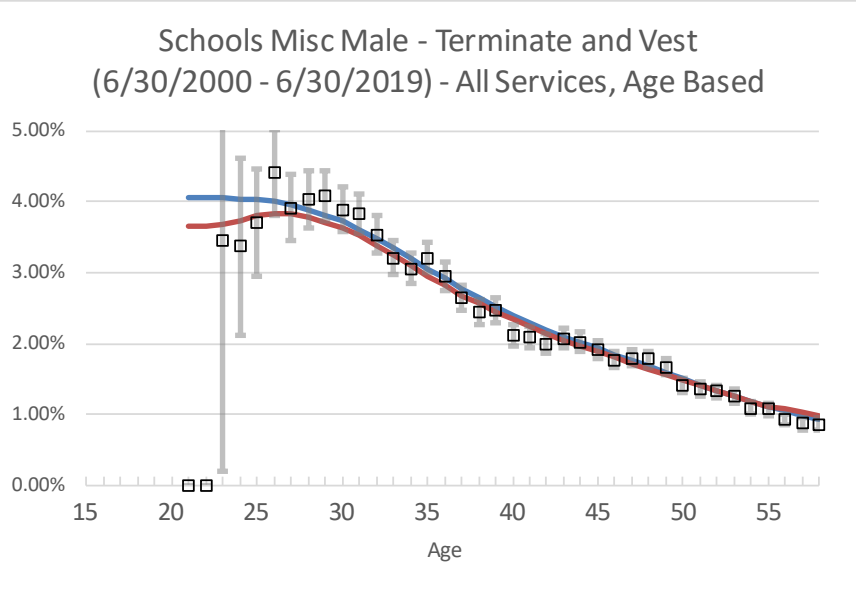


Detailed Analysis – Termination – Refund and Vesting

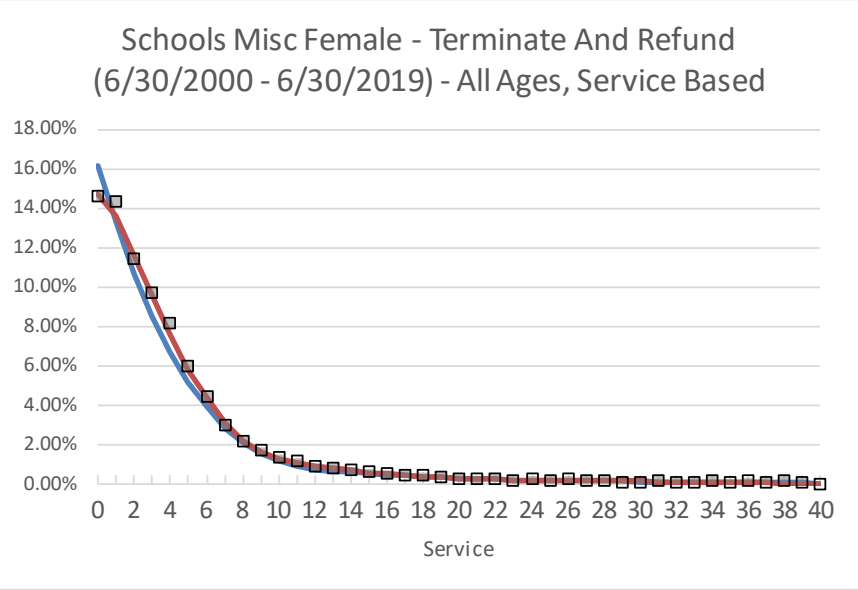


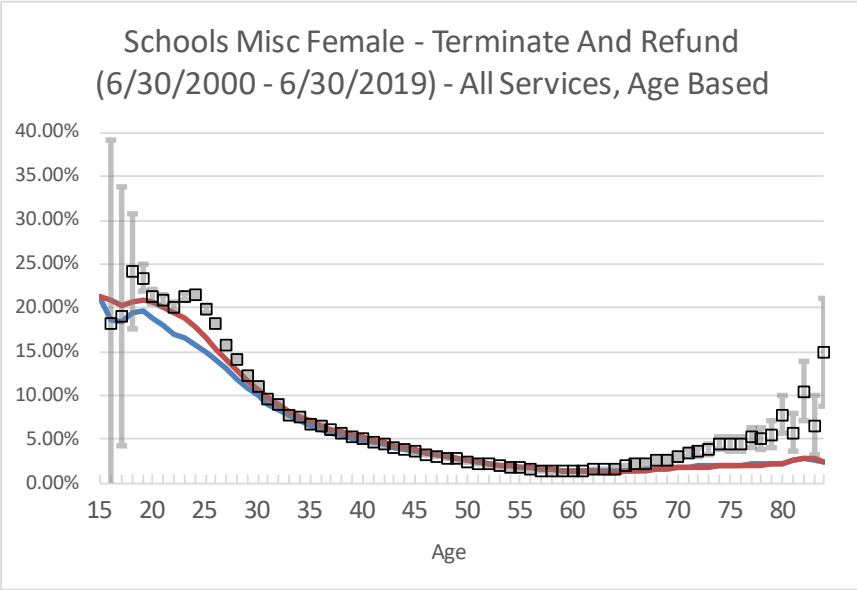


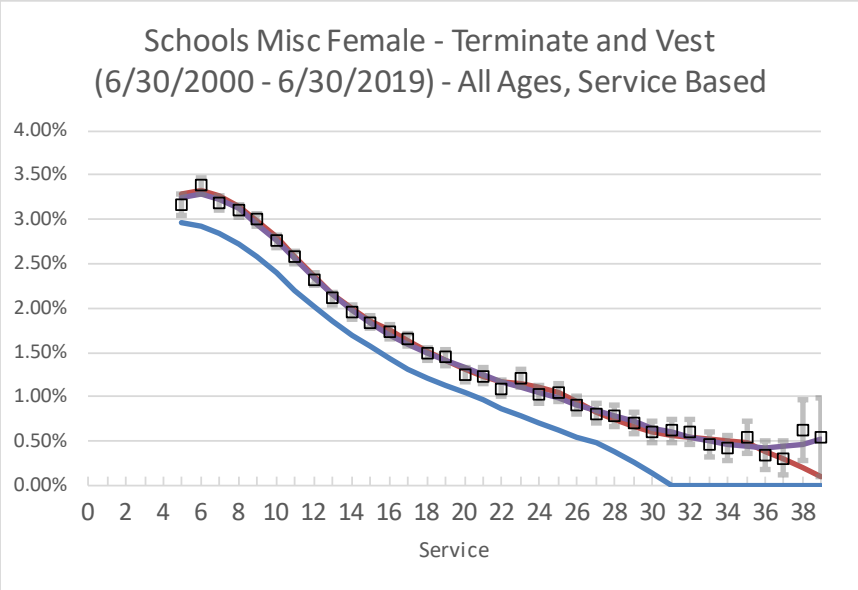


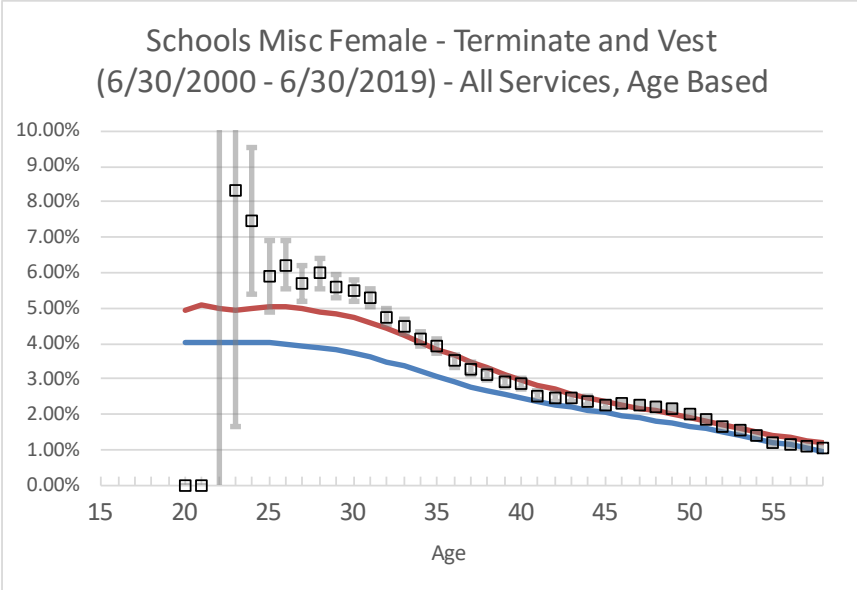


Detailed Analysis – Termination – Refund and Vesting

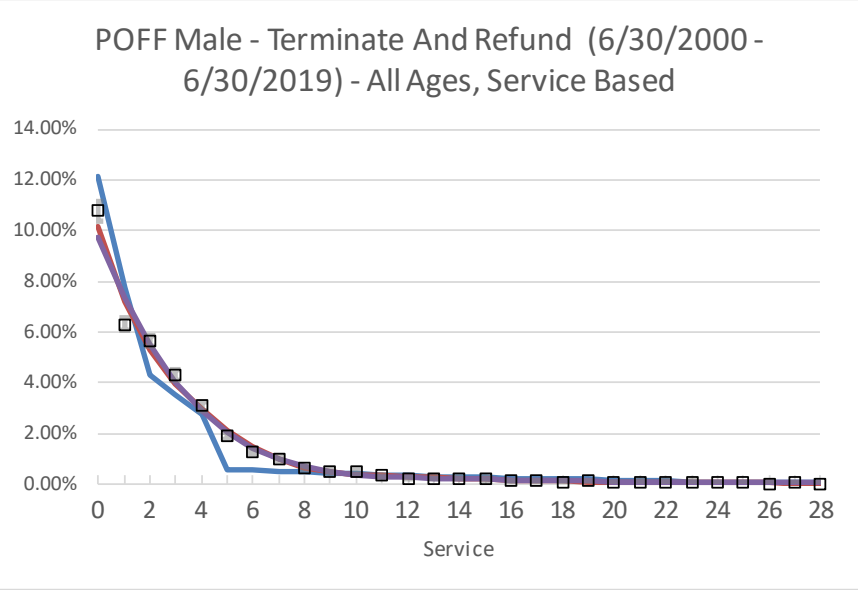


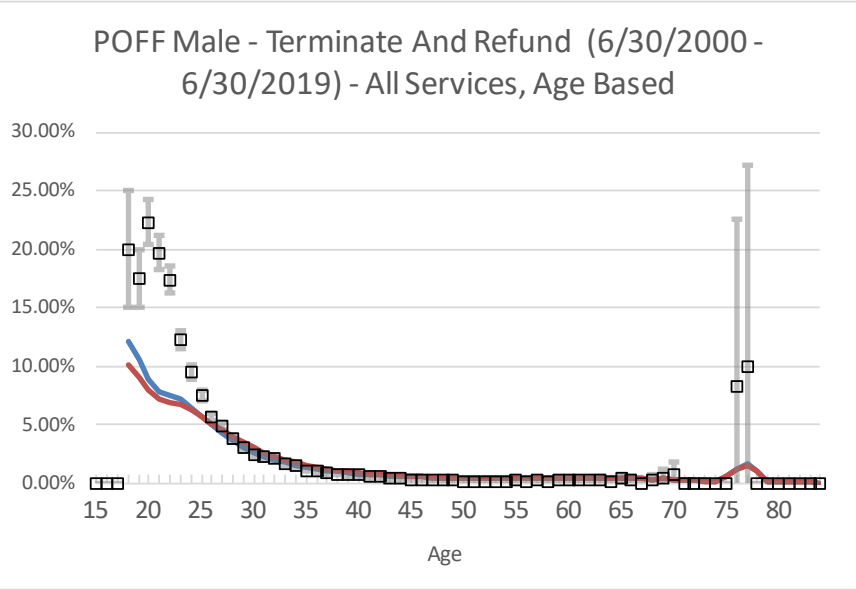


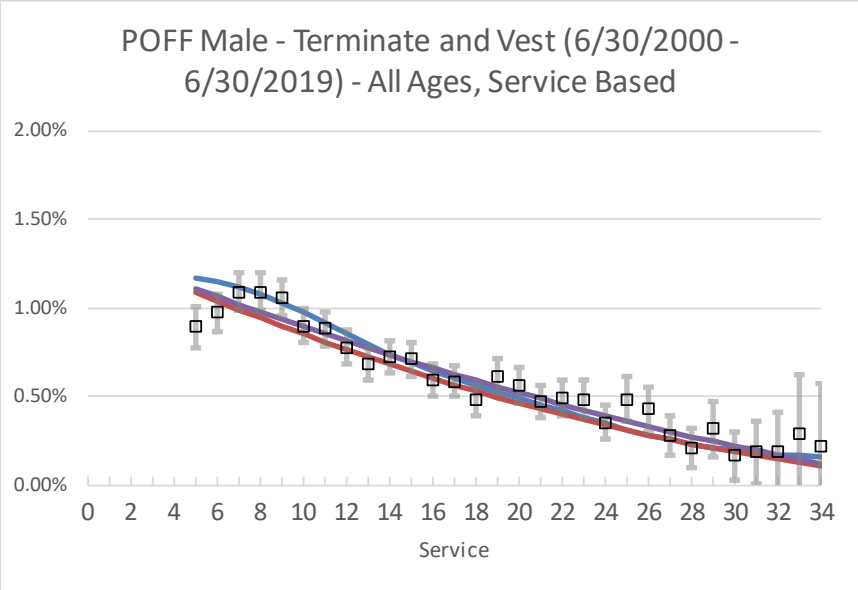


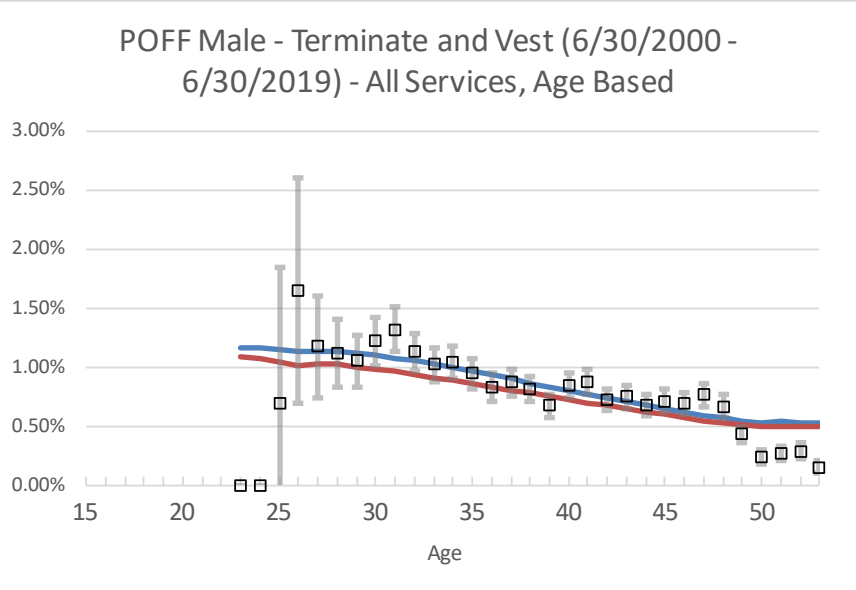


Detailed Analysis – Termination – Refund and Vesting

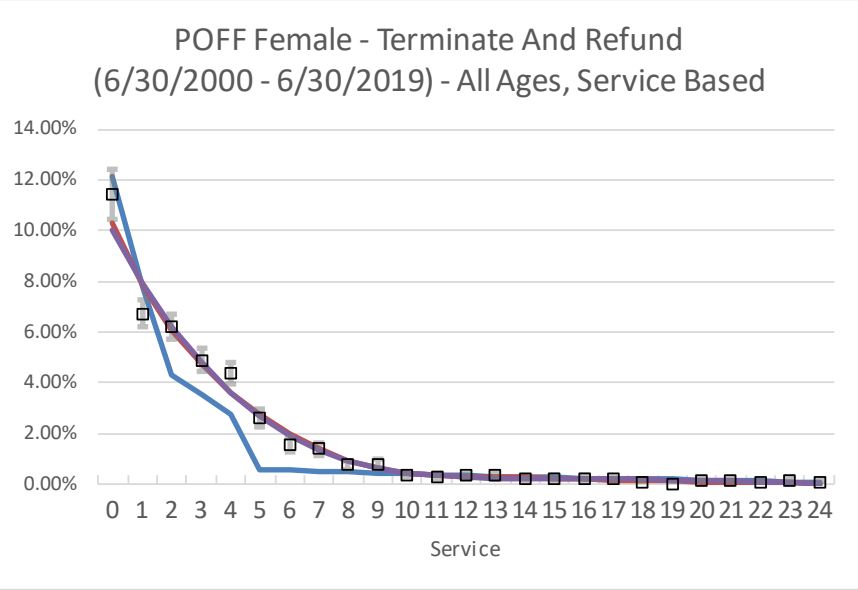


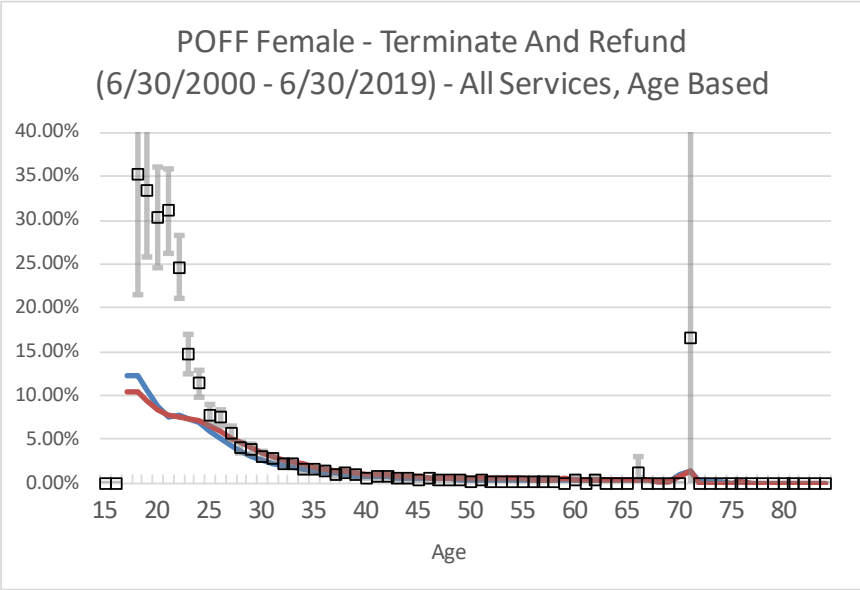


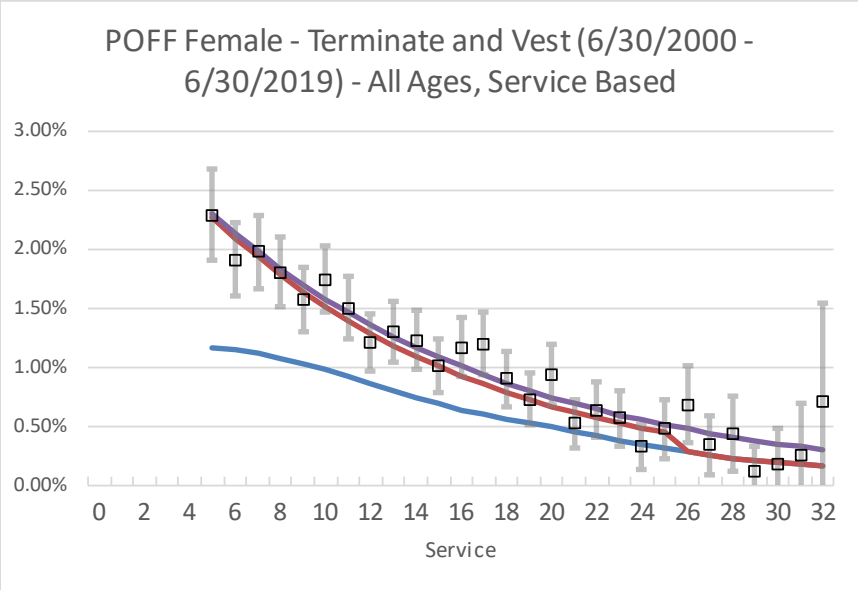


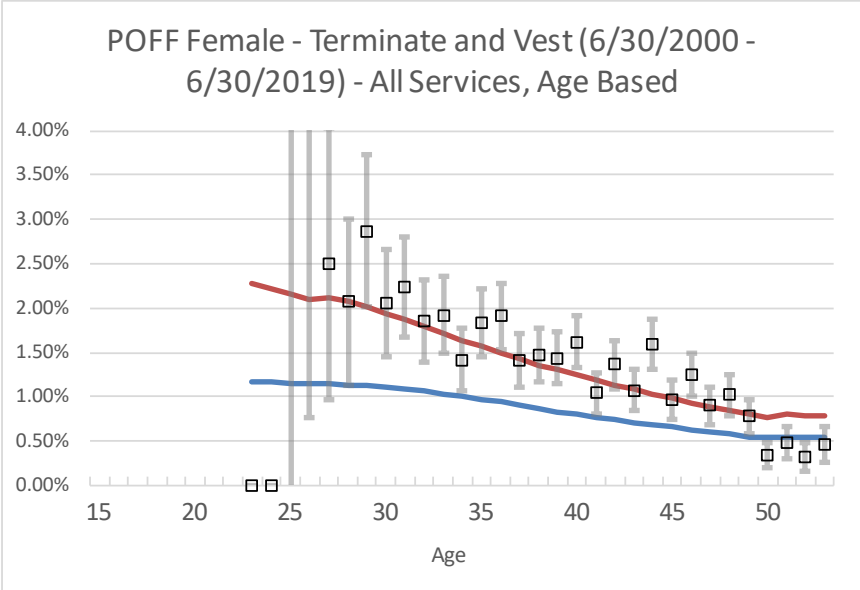


Detailed Analysis – Termination – Refund and Vesting

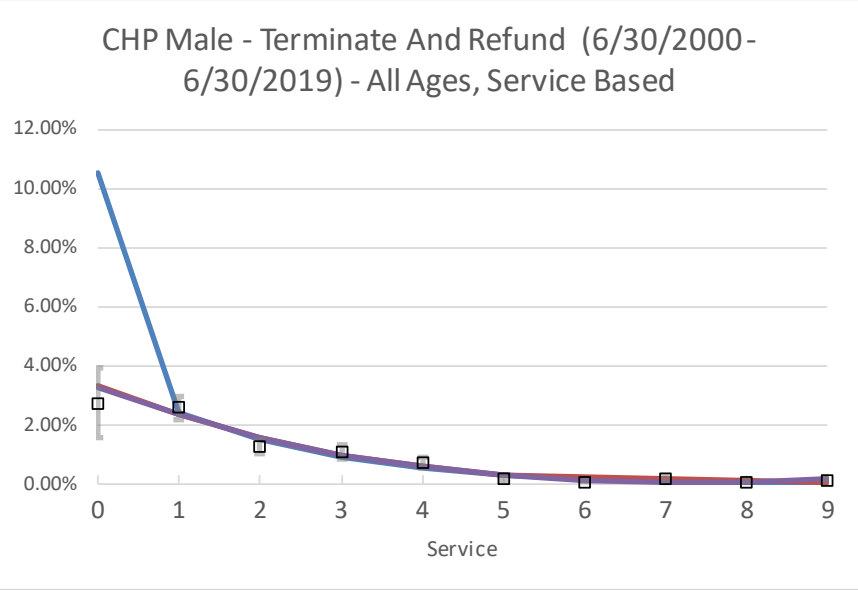


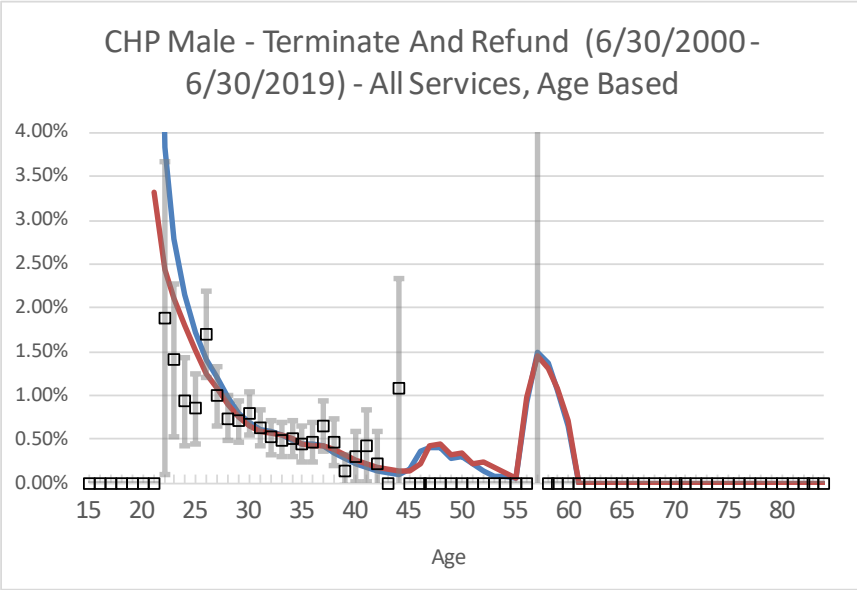


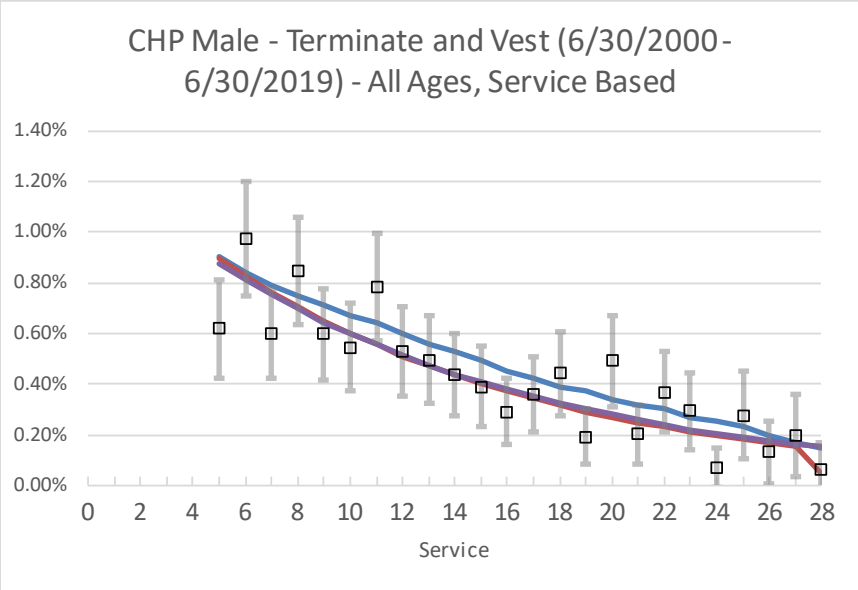


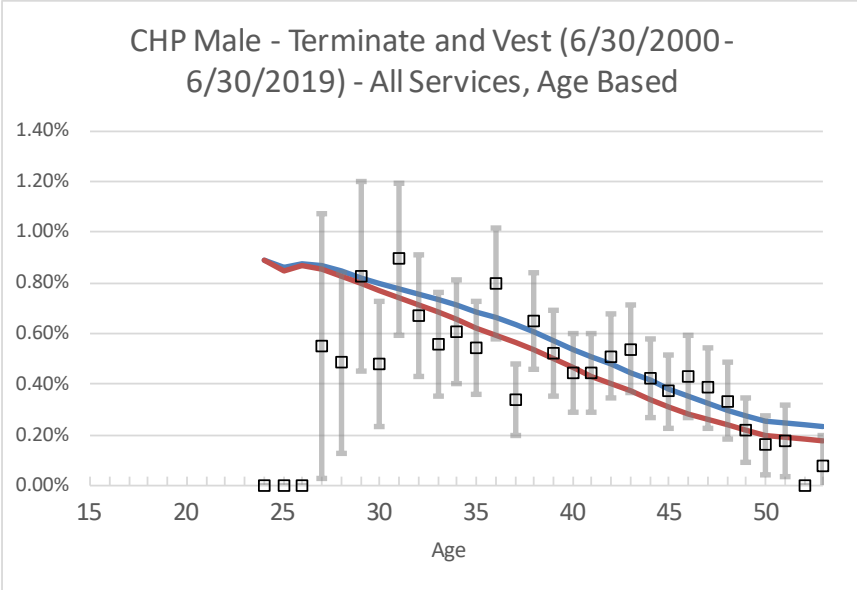


Detailed Analysis – Termination – Refund and Vesting

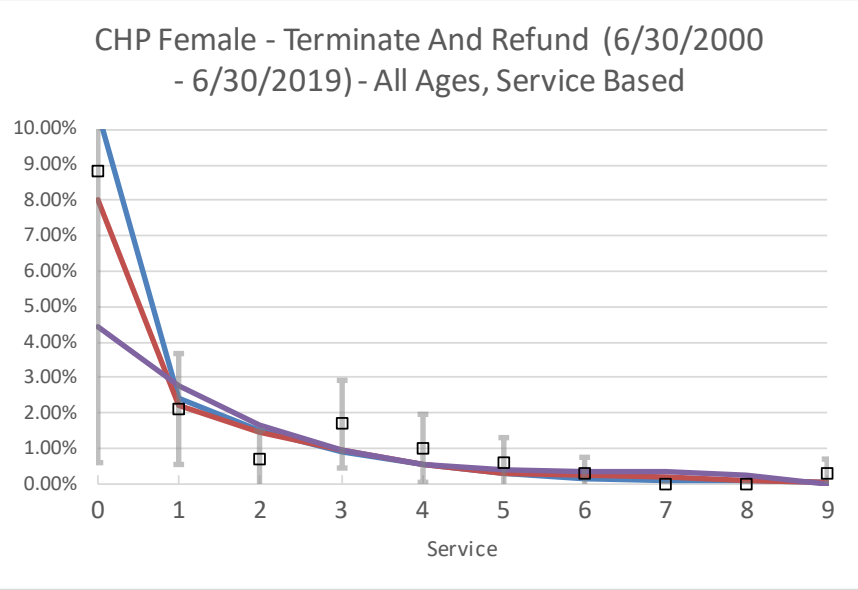


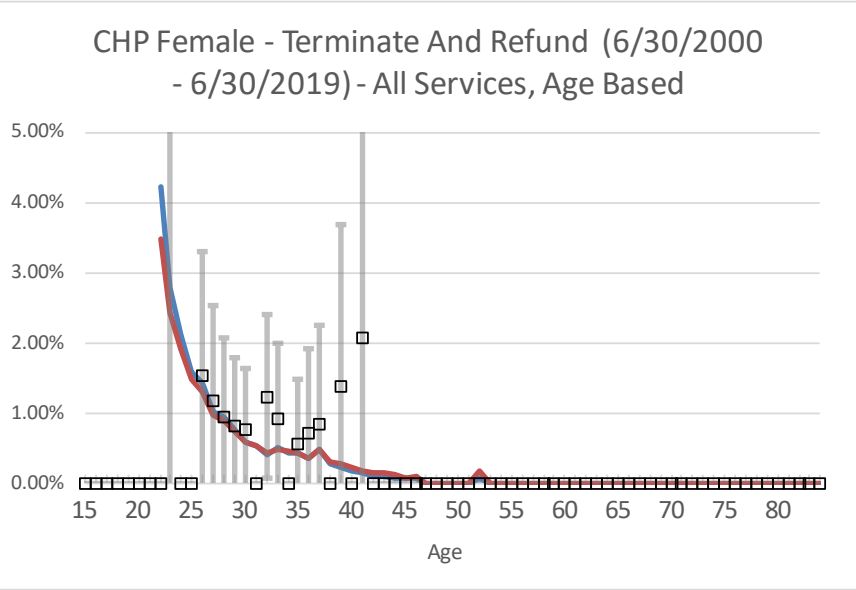


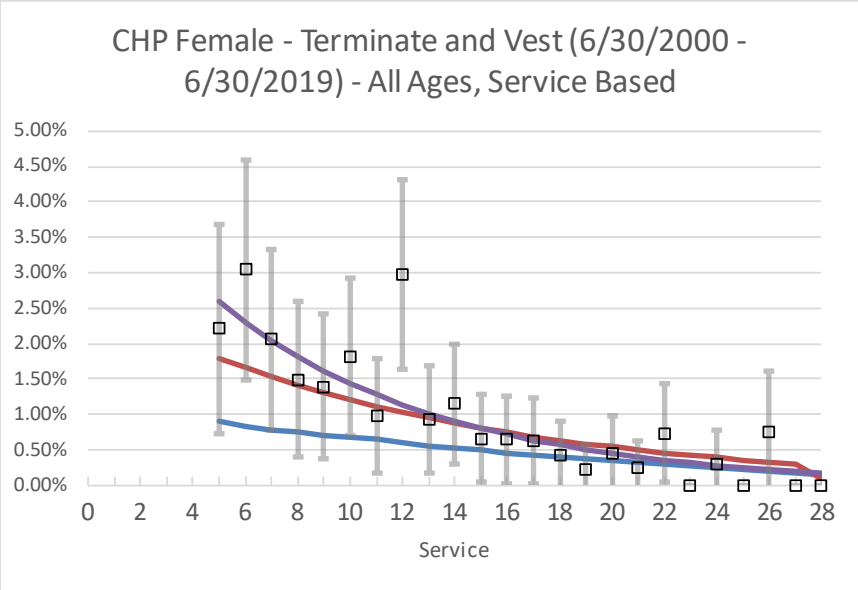


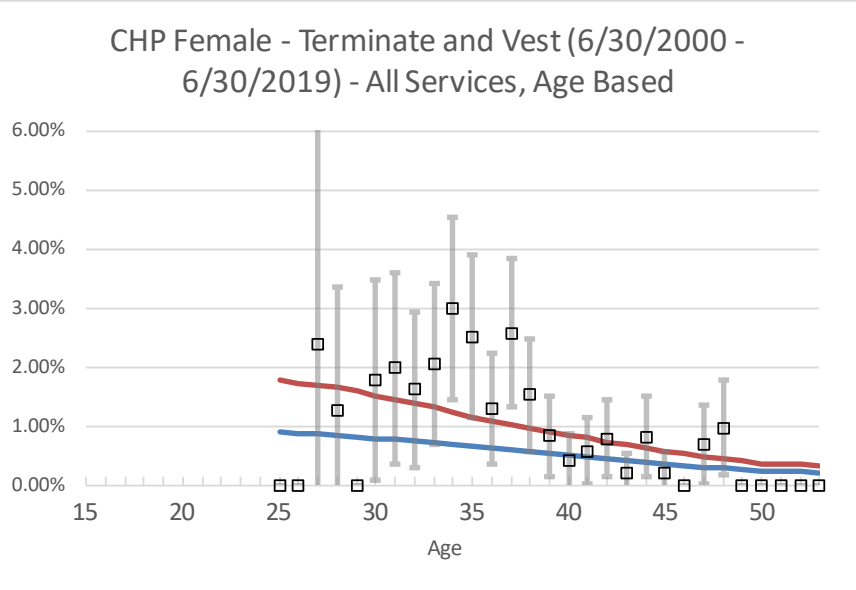


Detailed Analysis – Termination – Refund and Vesting

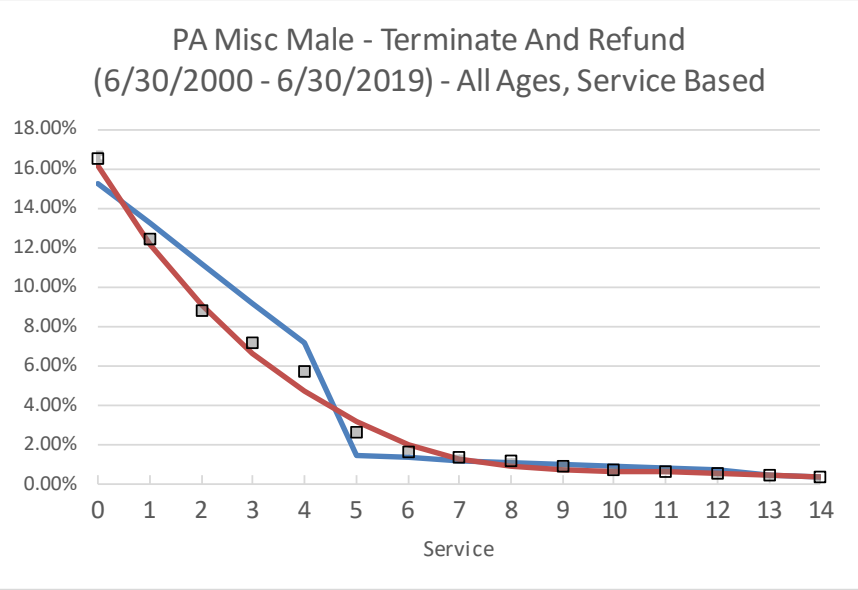


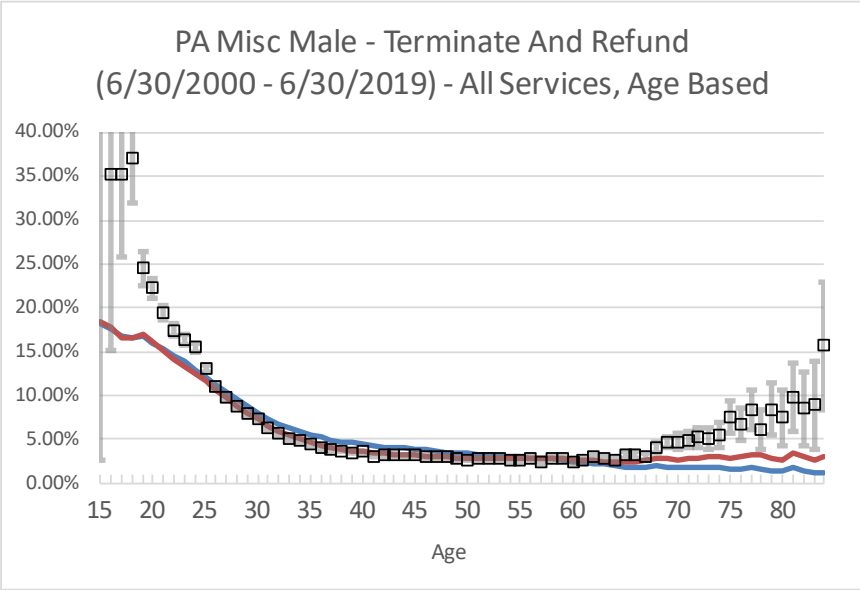


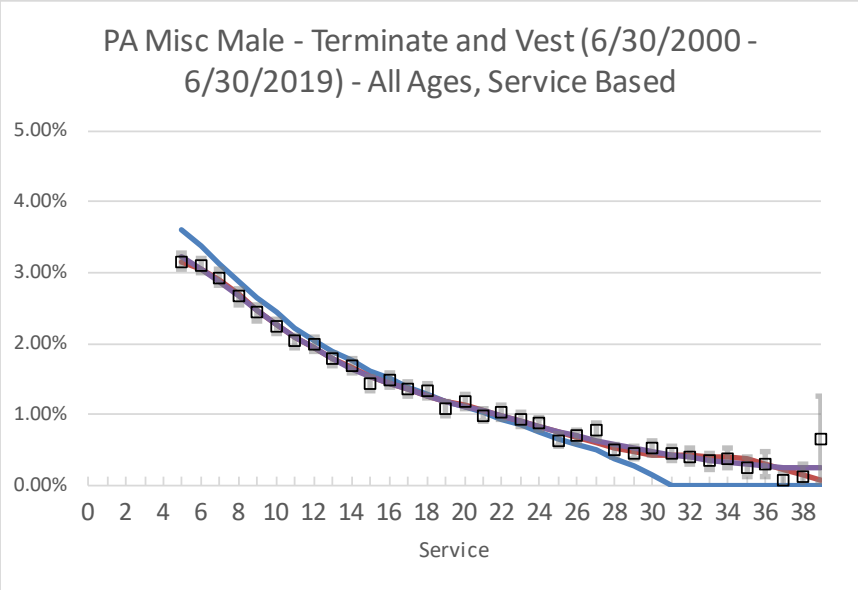


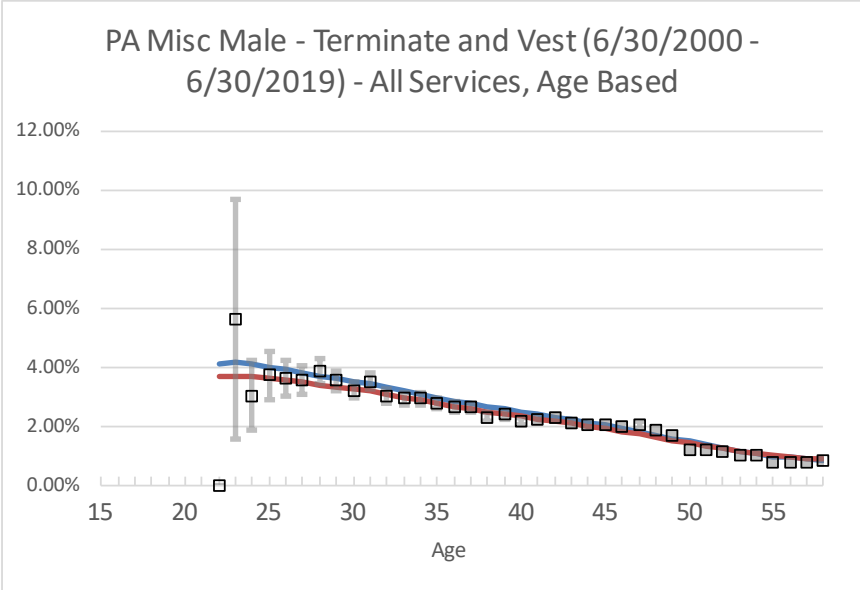


Detailed Analysis – Termination – Refund and Vesting

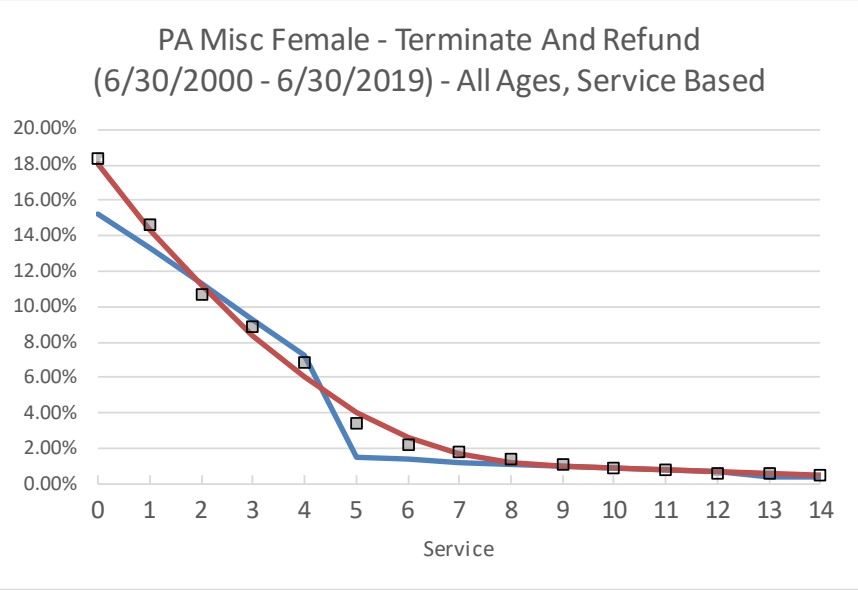


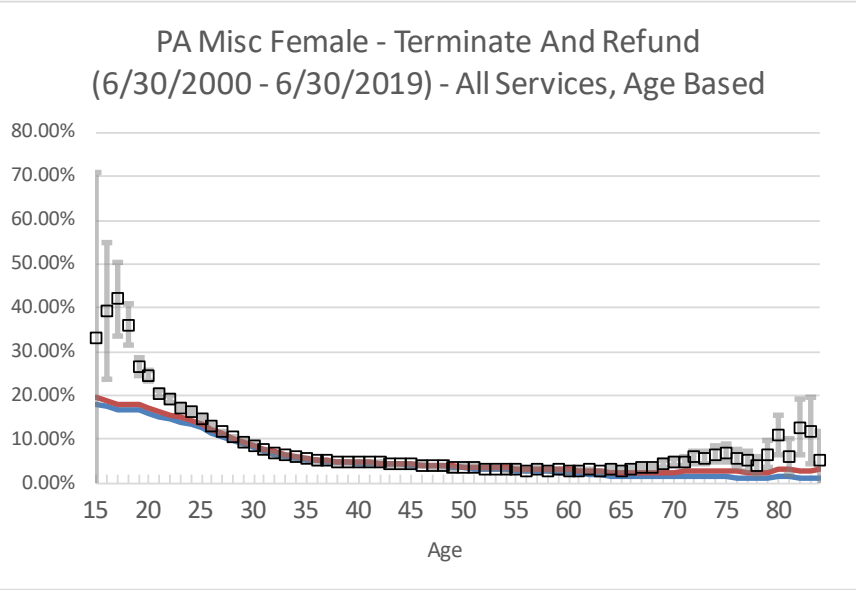


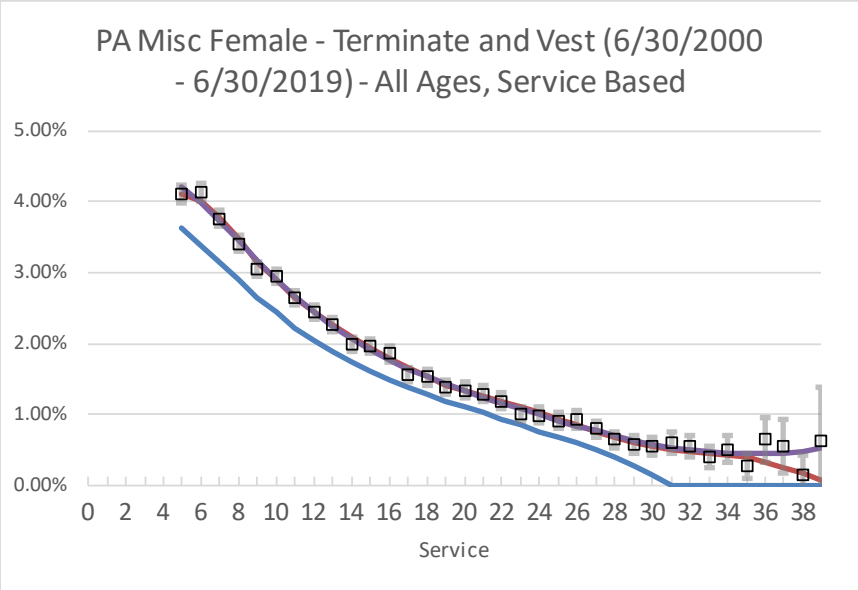


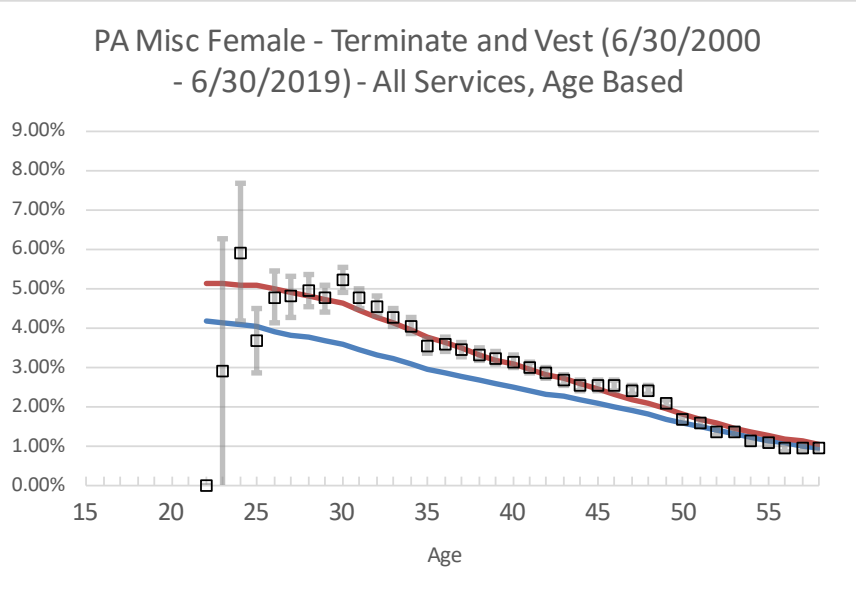


Detailed Analysis – Termination – Refund and Vesting

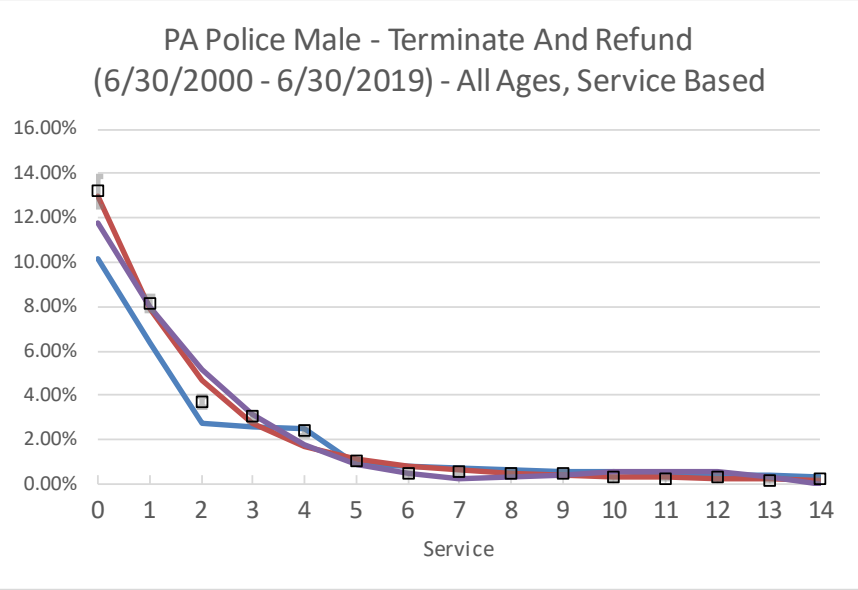


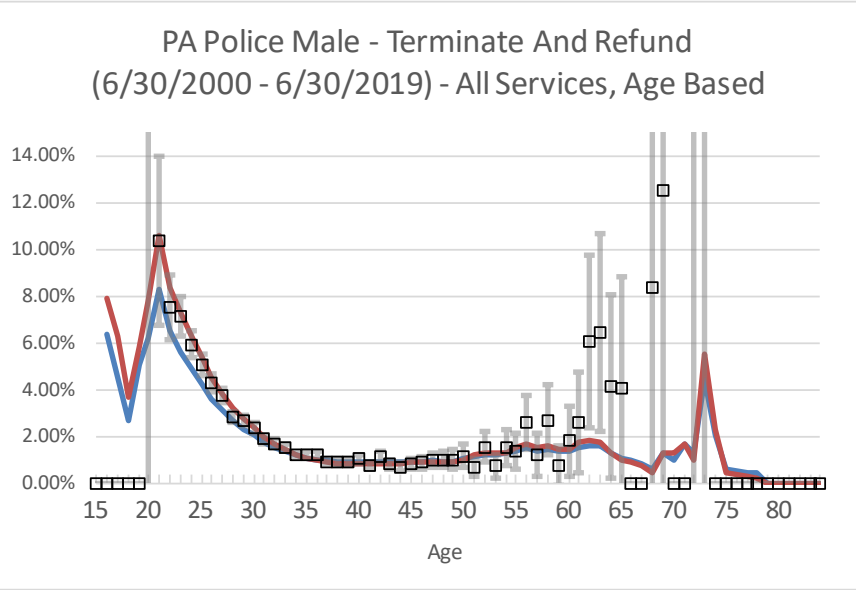


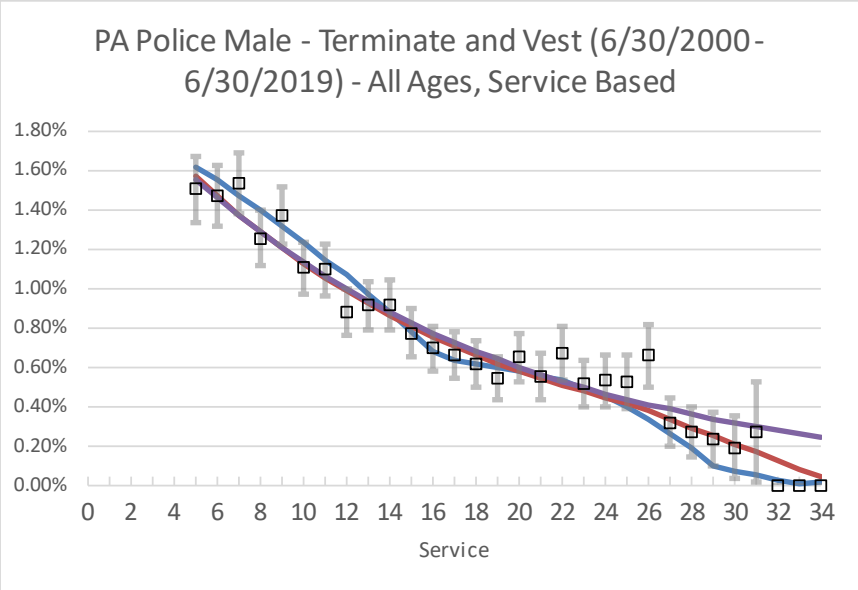


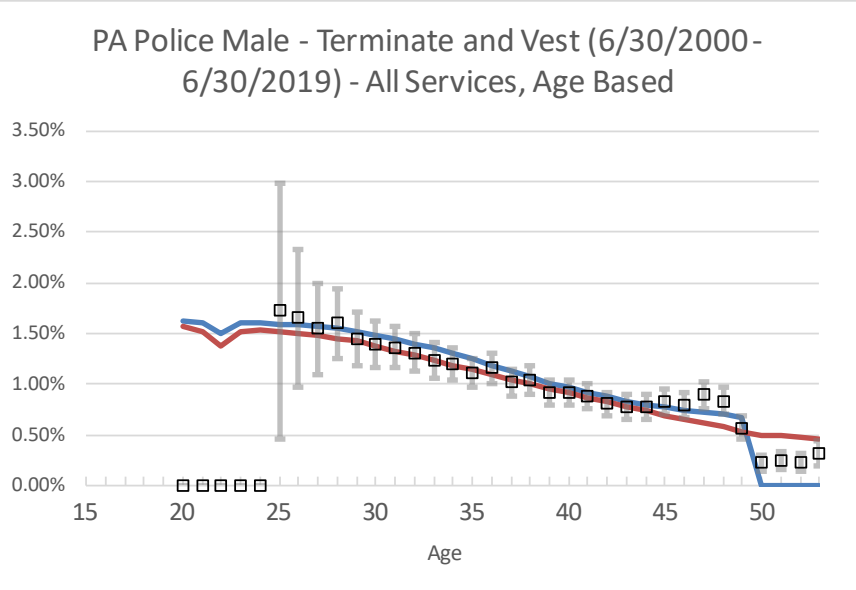


Detailed Analysis – Termination – Refund and Vesting

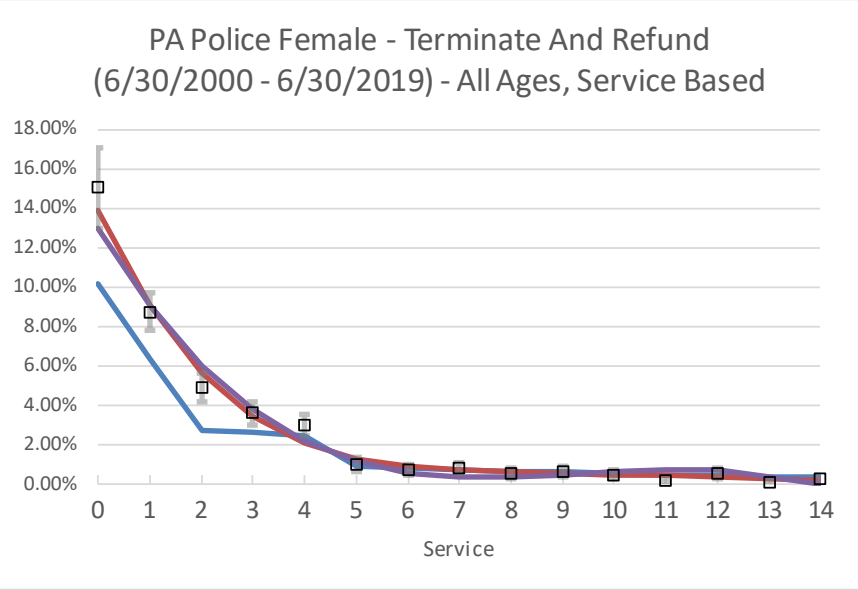


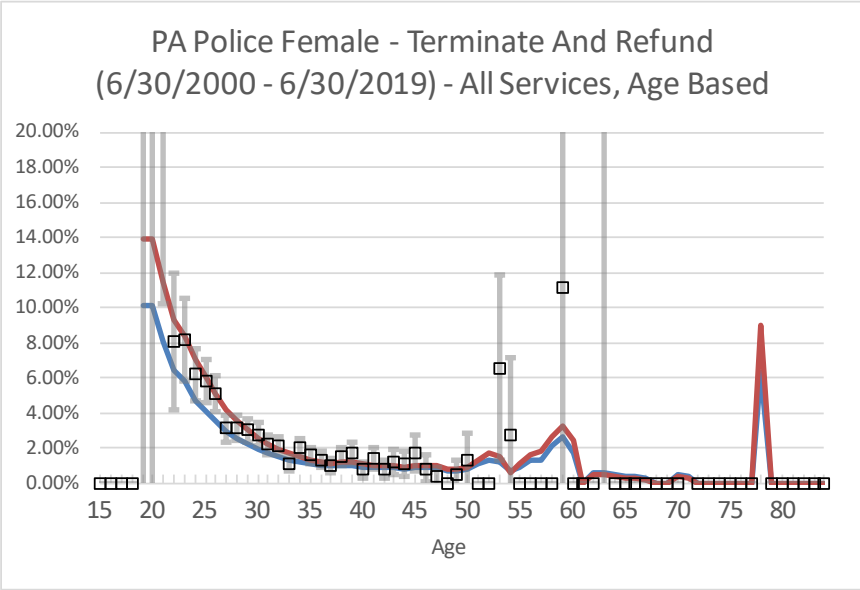


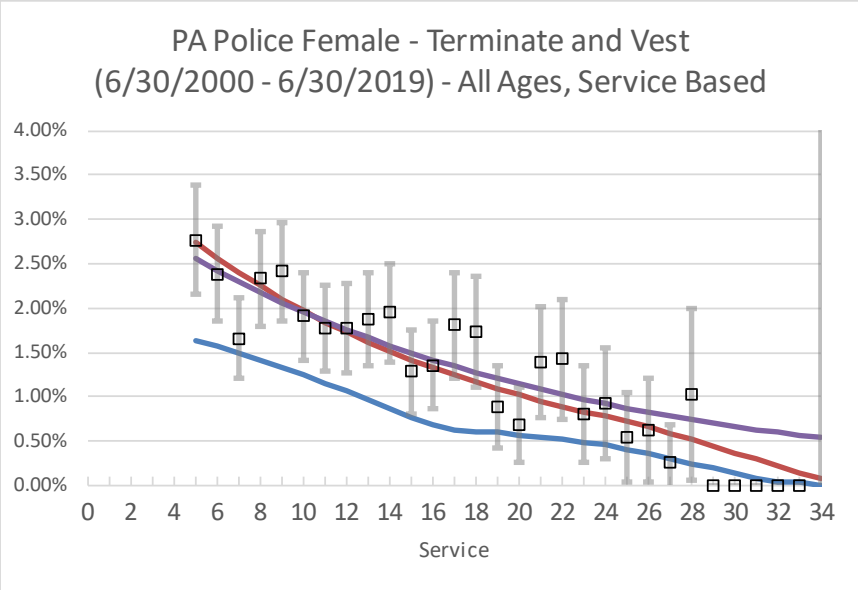


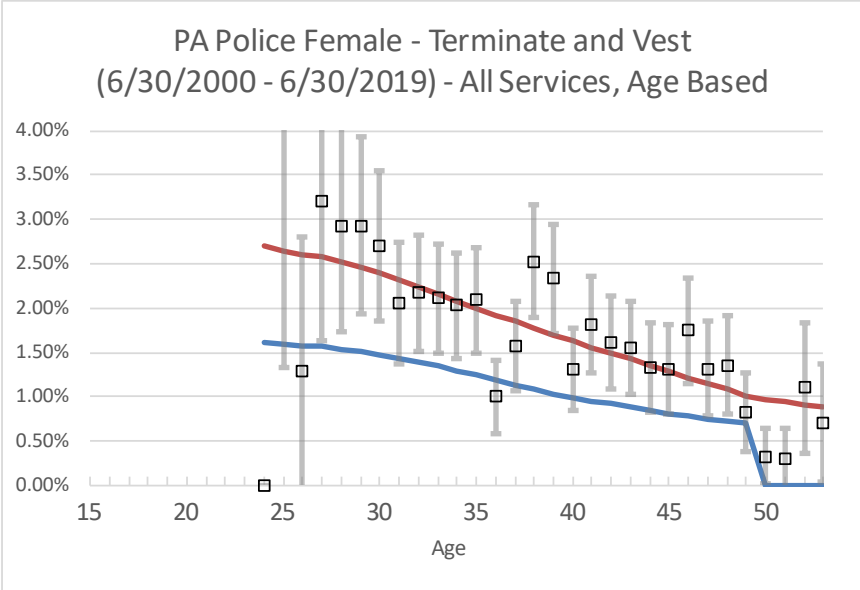


Detailed Analysis – Termination – Refund and Vesting

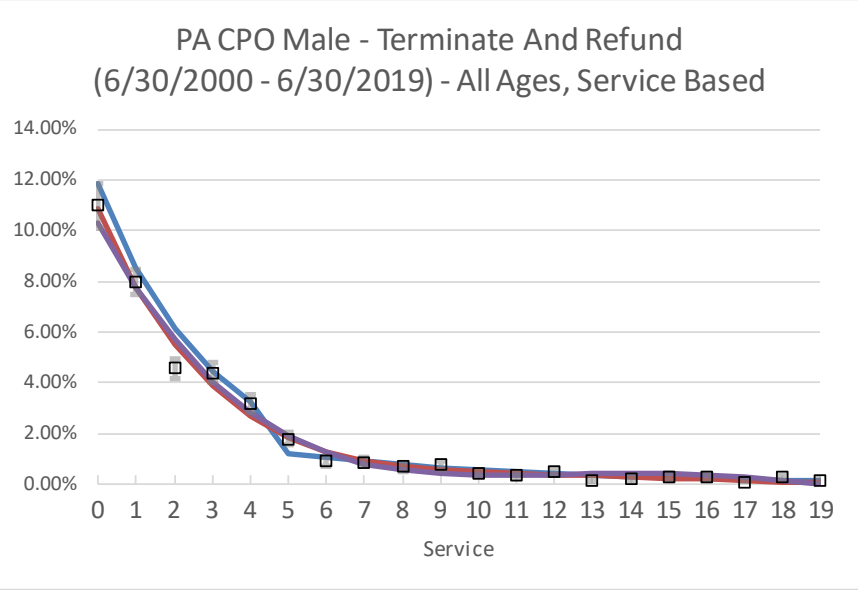


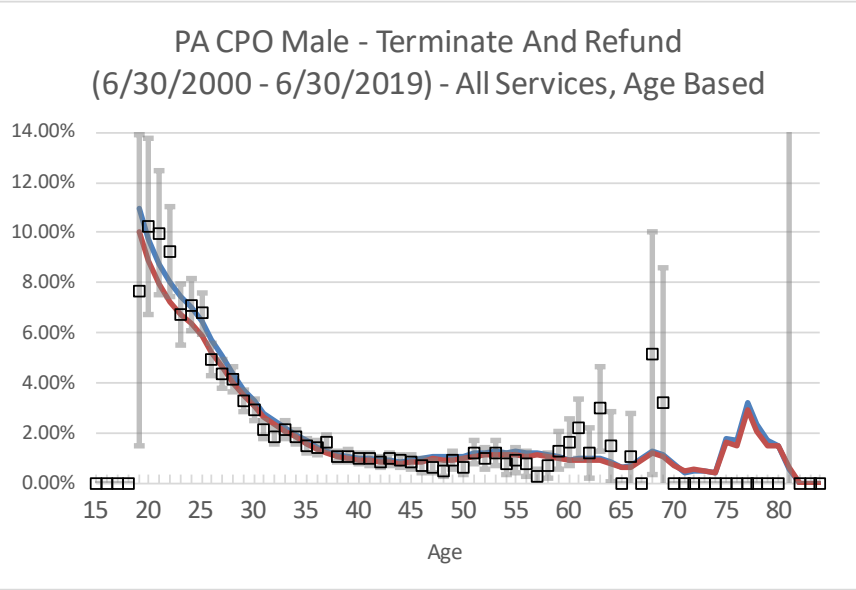


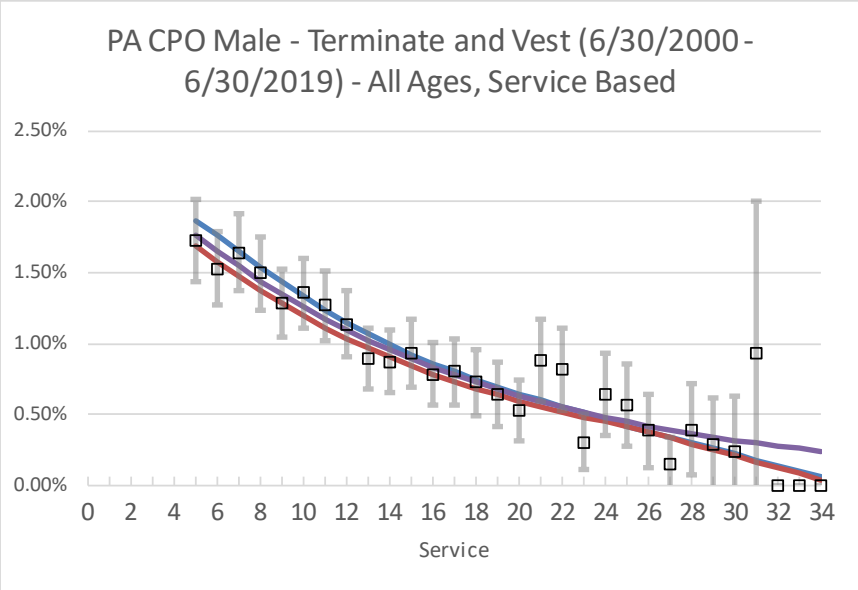


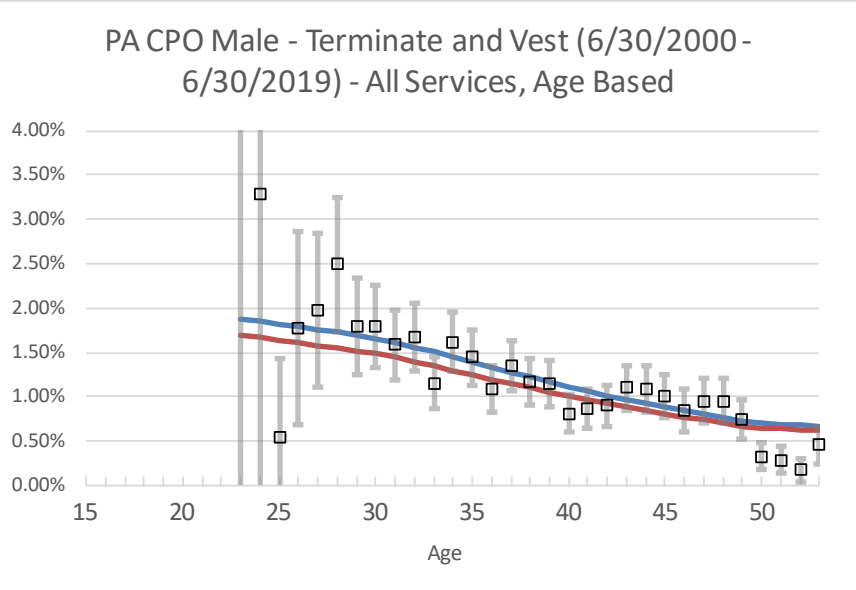


Detailed Analysis – Termination – Refund and Vesting

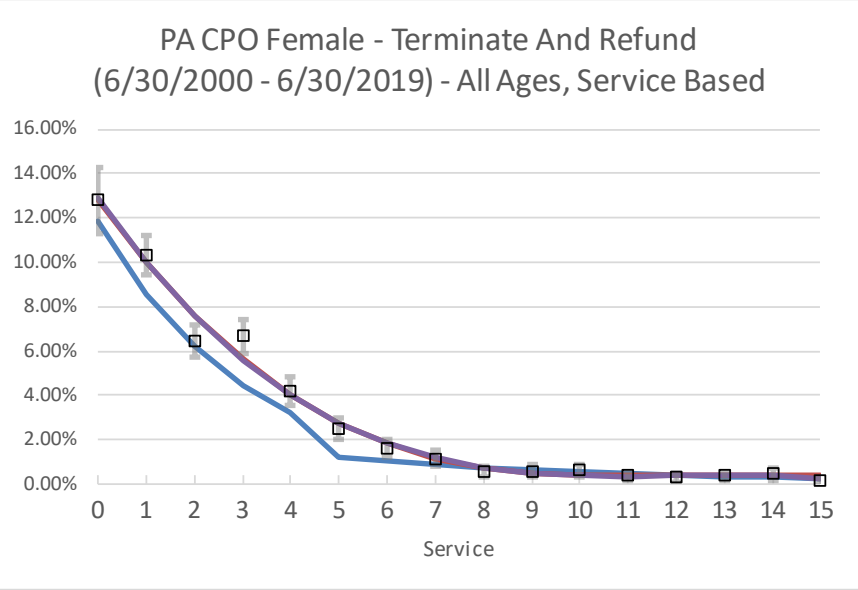


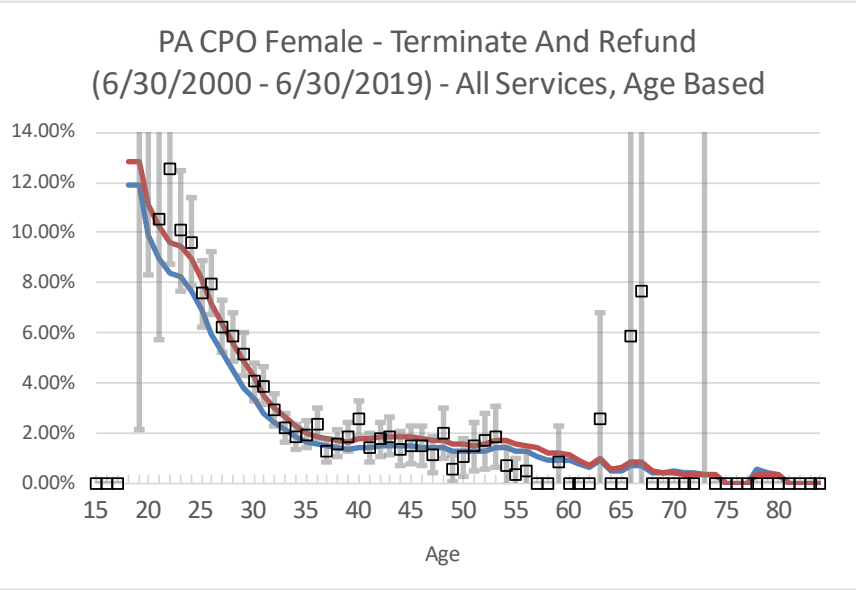


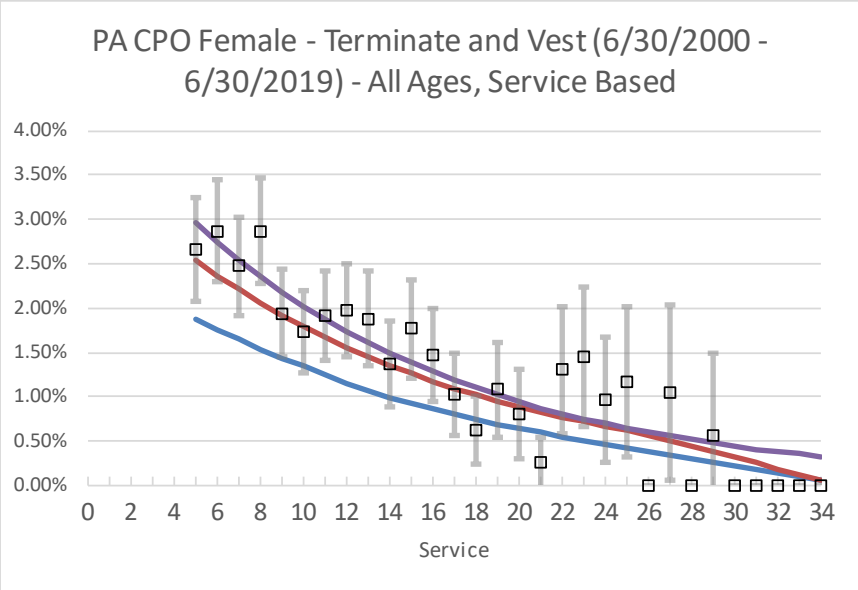


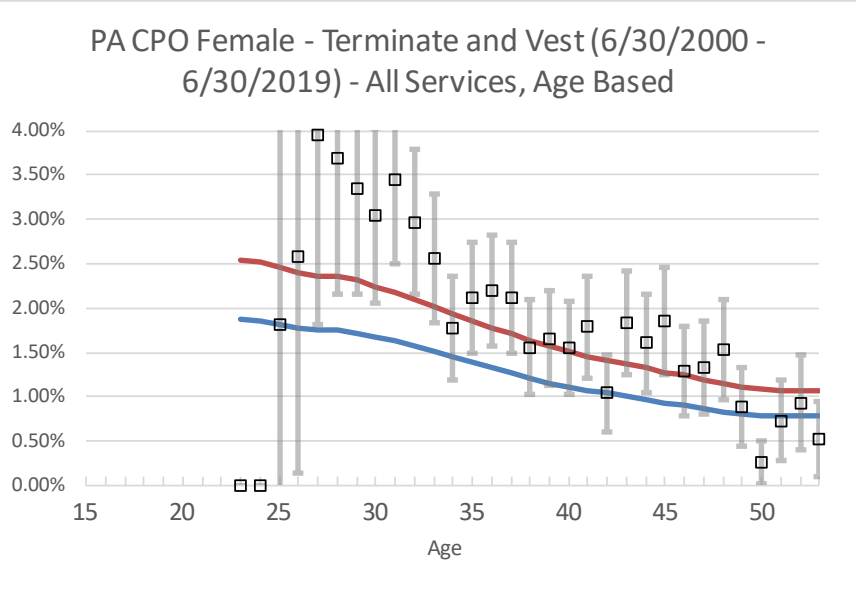


Detailed Analysis – Termination – Refund and Vesting

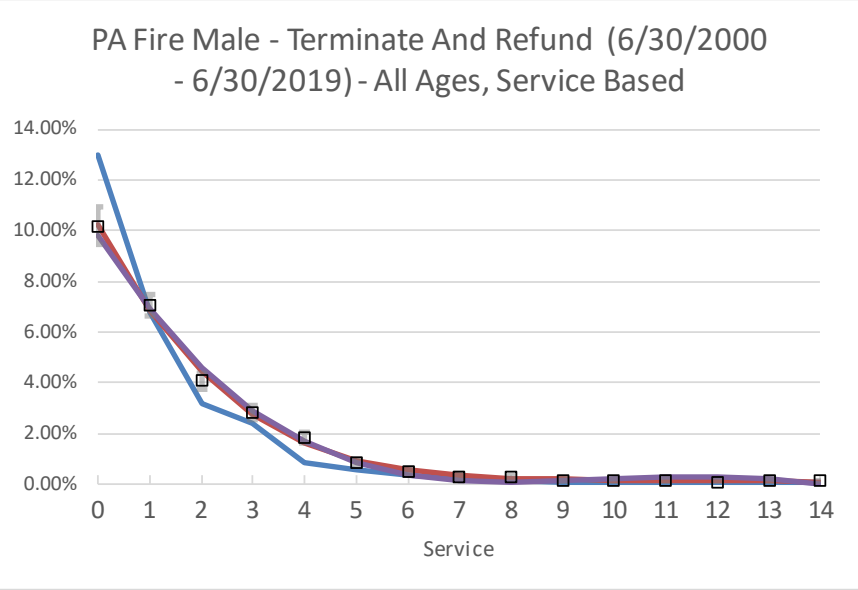


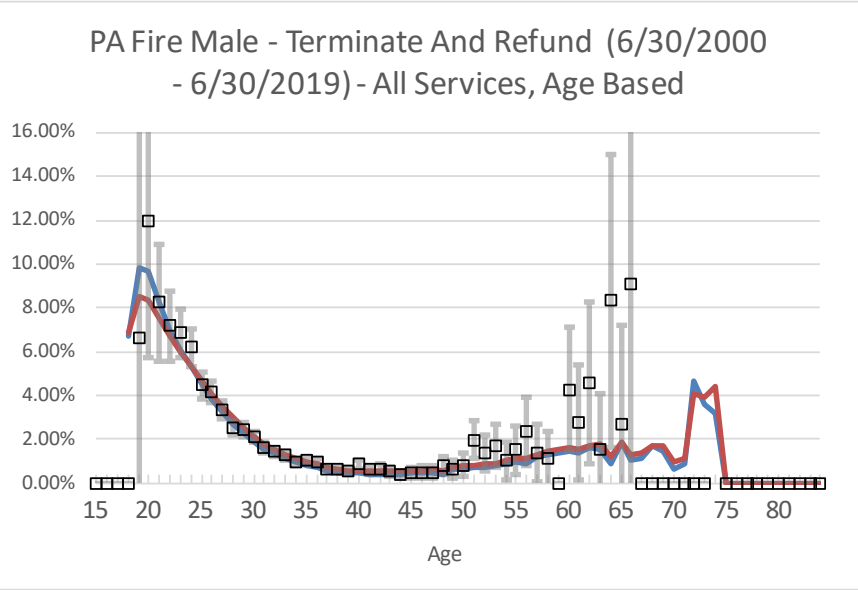


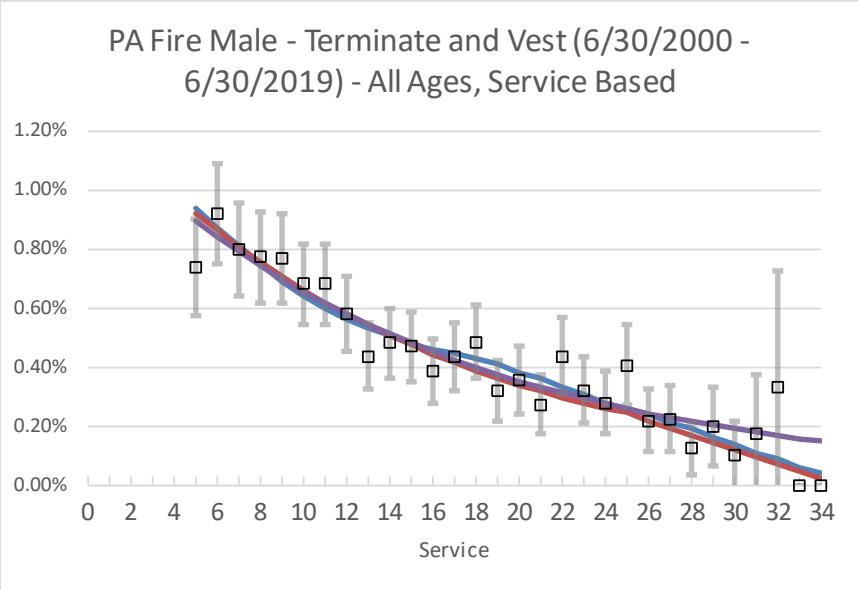


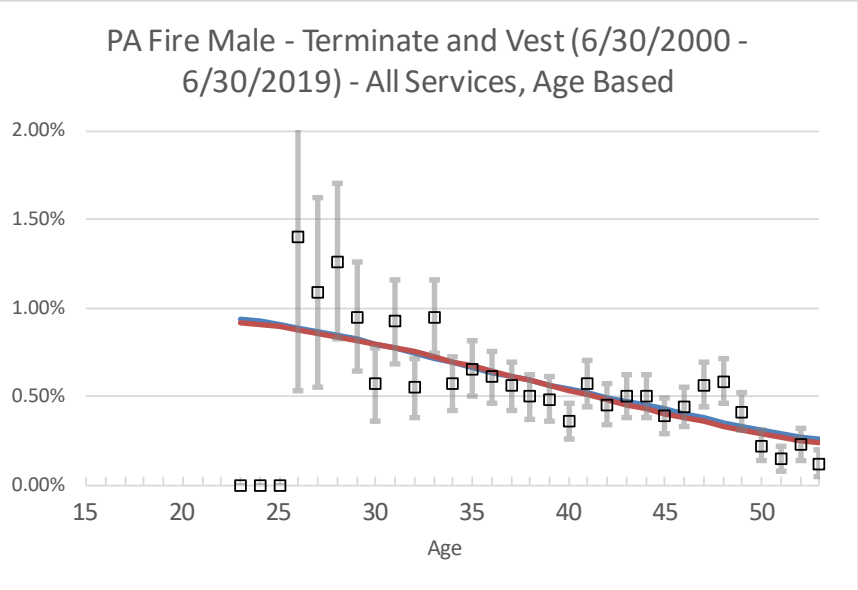


Detailed Analysis – Termination – Refund and Vesting

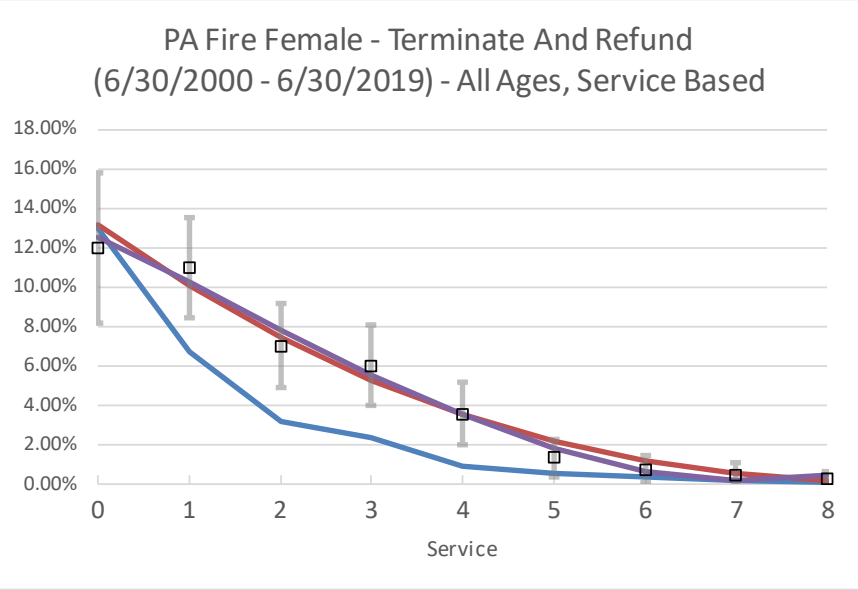


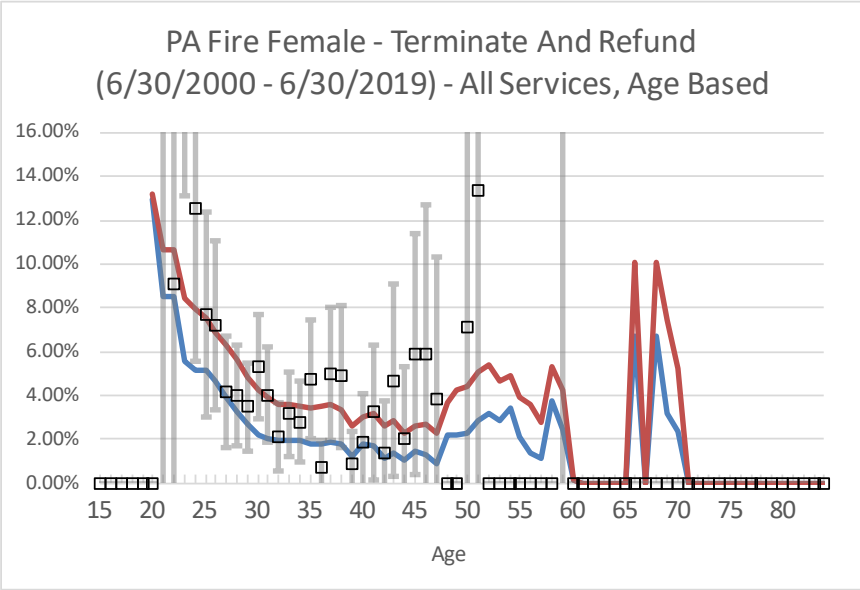


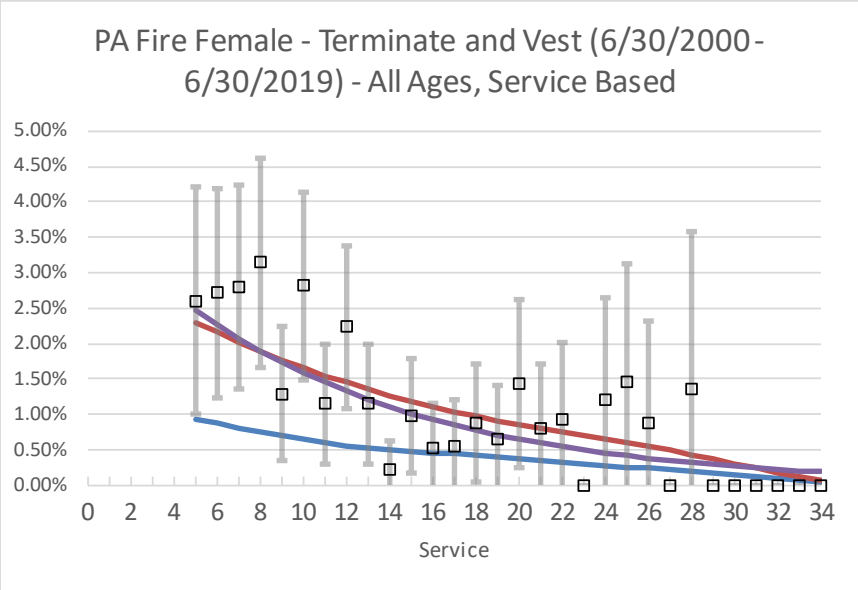


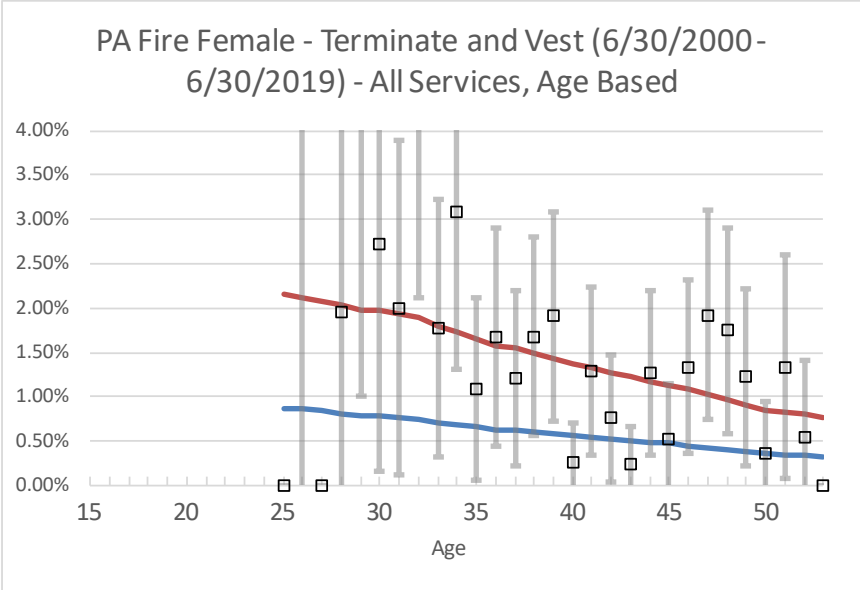


Detailed Analysis – Termination – Refund and Vesting









SECTION V

MATERIALS RECEIVED FROM CALPERS FOR REVIEW

Materials Received from CalPERS for Review
California Highway Patrol Census Data

Date Received	File Name	Additional Summary
3/17/2021	No2.accdb	Access Database - ES_BENEFIT_DTL - CHP Retiree data for valuation years 2015-2019
		ES_BENEFIT_DTL - CHP Retiree data for valuation years 2015-2019
3/17/2021	No3.accdb	Access Databases
		ES_BENEFIT_GROUP - Descriptions of different benefit groups & benefits
		Schema Definition - Descriptions of data elements of other databases
3/17/2021	ES Data for CHP 2000-2019.accdb	
3/22/2021	Data Sent to parallel Audit	Data provided to prior actuary for 2017 Audit of CHP
4/15/2021	ES Data for CHP 2000-2019_v2.accdb	

Materials Received from CalPERS for Review
Merit & Seniority Pay Increases Data

Date Received	File Name	Additional Summary
7/23/2021	2021 Salary Scale Presentation - FINAL.pptx	Salary Scale Presentation
7/23/2021	CHP Salary Scale (2003-2019, only 15-40 EA).xlsm	CHP
7/23/2021	County Peace Officer Salary Scale V1.14 (2003-19).xlsm	County Peace Officers
7/23/2021	PA Fire Salary Scale V 1.14 (2003-19).xlsm	Public Agency Fire
7/23/2021	PA Misc (PUB-MIS, SPR) Salary Scale V 1.14 (2003-19).xlsm	Public Agency Miscellaneous
7/23/2021	PA Police (SPO, SOS, SSH, SSP) V 1.14 (2003-19).xlsm	Public Agency Police
7/23/2021	POFF V 1.14 (2003-19, EA= All).xlsm	POFF
7/23/2021	School Misc Salary Scale V 1.14 (2003-19) with bumps.xlsm	School Miscellaneous
7/23/2021	State Industrial Salary Scale V 1.14 (2003-19).xlsm	State industrial
7/23/2021	State Misc Salary Scale V 1.14 (2003-19).xlsm	State Miscellaneous
7/23/2021	State Safety Salary Scale V 1.14 (2003-19, EA=ALL).xlsm	State Safety
9/21/2021	CHP Salary Scale (2003-2019) (only 15-40 EA, Exclude 08-10)).xlsm	CHP (Excluding 08-10)
9/21/2021	County Peace Officer Salary Scale V1.14 (2003-19) Exclude 08-10.xlsm	County Peace Officers (Excluding 08-10)
9/21/2021	PA Fire Salary Scale V 1.14 (2003-19) Exclude 08-10.xlsm	Public Agency Fire (Excluding 08-10)
9/21/2021	PA Misc (PUB-MIS, SPR) Salary Scale V 1.14 (2003-19) Exclude 08-10.xlsm	Public Agency Miscellaneous (Excluding 08-10)
9/21/2021	PA Police (SPO, SOS, SSH, SSP) V 1.14 (2003-19) Exclude 08-10.xlsm	Public Agency Police (Excluding 08-10)
9/21/2021	POFF V 1.14 (2003-19)(EA= All, Exclude 08-10).xlsm	POFF (Excluding 08-10)
9/21/2021	School Misc Salary Scale V 1.14 (2003-19) with bumps (Exclude 08-10).xlsm	School Miscellaneous (Excluding 08-10)
9/21/2021	State Industrial Salary Scale V 1.14 (2003-19) (Exclude 08-10).xlsm	State industrial (Excluding 08-10)
9/21/2021	State Misc Salary Scale V 1.14 (2003-19) (Exclude 08-10).xlsm	State Miscellaneous (Excluding 08-10)
9/21/2021	State Safety Salary Scale V 1.14 (2003-19) (EA=ALL, Exclude 08-10).xlsm	State Safety (Excluding 08-10)

Materials Received from CalPERS for Review
Mortality Rates Data

Date Received	File Name	Additional Summary
6/16/2021	CPE_F_BW_SR_2015_2019_379704.xlsm	All CPE - Female - Receiving - Post Retirement Mortality (6/30/2015 - 6/30/2019) *(Benefit Weighting)*
6/16/2021	CPE_M_BW_SR_2015_2019_379708.xlsm	All CPE - Male - Receiving - Post Retirement Mortality (6/30/2015 - 6/30/2019) *(Benefit Weighting)*
6/16/2021	CPE_IDR_F_2015_2019_EPM_379741.xlsm	All CPE - Female - Receiving - Post Retirement Mortality-IDR (6/30/2015 - 6/30/2019) *(Head Count Weighting)*
6/16/2021	CPE_IDR_M_2015_2019_EPM_379743.xlsm	All CPE - Male - Receiving - Post Retirement Mortality-IDR (6/30/2015 - 6/30/2019) *(Head Count Weighting)*
6/16/2021	CPE_NIDR_F_2015_2019_EPM_379745.xlsm	All CPE - Female - Receiving - Post Retirement Mortality-NIDR (6/30/2015 - 6/30/2019) *(Head Count Weighting)*
6/16/2021	CPE_NIDR_M_2015_2019_EPM_379746.xlsm	All CPE - Male - Receiving - Post Retirement Mortality-NIDR (6/30/2015 - 6/30/2019) *(Head Count Weighting)*
6/16/2021	Peer Review DD&NDD Safety F.xlsm	All Safety F - Duty and Non-Duty Death Combined (6/30/2004 - 6/30/2019)
6/16/2021	Peer Review DD&NDD Safety M.xlsm	All Safety M - Duty and Non-Duty Death Combined (6/30/2004 - 6/30/2019)
6/16/2021	Peer Review NDD Misc F.xlsm	All Misc F - Non-Duty Death (6/30/2004 - 6/30/2019)
6/16/2021	Peer Review of NDD Misc M.xlsm	All Misc M - Non-Duty Death (6/30/2004 - 6/30/2019)
6/16/2021	Final Proposed Post Retirement Mortality Rates.xlsx	Proposed mortality rates (at implied base year of 2017)
6/16/2021	Peer Review Mortality Improvement Projection.xlsx	Review of proposed mortality rates with MP 2020
6/16/2021	peer review table comparison.xlsb.xlsx	Review of current/proposed assumptions vs. various published mortality tables
6/16/2021	Proposed Mortality Rates_20210427.pptx	Proposed Mortality Rates Presentation
9/22/2021	CPE_SR_M_BW_2015_2019_379708_ Upd_PubG2010_Proj.xlsm	All CPE - Male - Receiving - Post Retirement Mortality (6/30/2015 - 6/30/2019) (Benefit Weighting)
9/22/2021	CPE_IDR_M_2015_2019_EPM_379743_ Upd_Pub2010_Proj.xlsm	All CPE - Male - Receiving - Post Retirement Mortality-IDR (6/30/2015 - 6/30/2019) (Head Count Weighting)
9/22/2021	CPE_NIDR_M_2015_2019_EPM_379746_ Upd_Pub2010_Proj.xlsm	All CPE - Male - Receiving - Post Retirement Mortality-NIDR (6/30/2015 - 6/30/2019) (Head Count Weighting)

Materials Received from CalPERS for Review
Retirement Rates Data

Date Received	File Name	Additional Summary
7/23/2021	CHP 07132021.xlsm	CHP - Service Retirement (6/30/2007 - 6/30/2019)
7/23/2021	PA Fire 2@50 07132021 Final.xlsm	PA Fire 2% @ 50 - Service Retirement (6/30/2007 - 6/30/2019)
7/23/2021	PA Fire 3@50 07132021.xlsm	PA Fire 3% @ 50 - Service Retirement (6/30/2007 - 6/30/2019)
7/23/2021	PA Fire 3@55 07132021.xlsm	PA Fire 3% @ 55 - Service Retirement (6/30/2007 - 6/30/2019)
7/23/2021	PA Misc 2.5@55 07132021.xlsm	PA Misc 2.5% @ 55 - Service Retirement (6/30/2007 - 6/30/2019)
7/23/2021	PA Misc 2.7@55 07132021.xlsm	PA Misc 2.7% @ 55 - Service Retirement (6/30/2007 - 6/30/2019)
7/23/2021	PA Misc 2@55 07132021.xlsm	PA Misc 2.0% @ 55 - Service Retirement (6/30/2007 - 6/30/2019)
7/23/2021	PA Misc 2@60 07132021.xlsm	PA Misc 2.0% @ 60 - Service Retirement (6/30/2007 - 6/30/2019)
7/23/2021	PA Misc 3@60 07132021.xlsm	PA Misc 3.0% @ 60 - Service Retirement (6/30/2007 - 6/30/2019)
7/23/2021	PA Police 2@50 07132021.xlsm	PA Police 2.0% @ 50 - Service Retirement (6/30/2007 - 6/30/2019)
7/23/2021	PA Police 3@50 07132021.xlsm	PA Police 3.0% @ 50 - Service Retirement (6/30/2007 - 6/30/2019)
7/23/2021	PA Police 3@55 07132021.xlsm	PA Police 3.0% @ 55 - Service Retirement (6/30/2007 - 6/30/2019)
7/23/2021	POFF 07132021.xlsm	POFF - Service Retirement (6/30/2007 - 6/30/2019)
7/23/2021	Schools 07132021.xlsm	Schools - Service Retirement (6/30/2007 - 6/30/2019)
7/23/2021	State Industrial 07132021.xlsm	State Industrial - Service Retirement (6/30/2007 - 6/30/2019)
7/23/2021	State Misc 07132021.xlsm	State Miscellaneous - Service Retirement (6/30/2007 - 6/30/2019)
7/23/2021	State Safety 07132021.xlsm	State Safety - Service Retirement (6/30/2007 - 6/30/2019)
8/22/2021	PA Fire 2@50 07132021 Final v2.xlsm	PA Fire 2% @ 50 - Service Retirement (6/30/2007 - 6/30/2019) (Revised)
8/22/2021	PA Fire 3@50 07132021 v2.xlsm	PA Fire 3% @ 50 - Service Retirement (6/30/2007 - 6/30/2019) (Revised)
8/22/2021	PA Misc 3@60 07132021 v2.xlsm	PA Misc 3.0% @ 60 - Service Retirement (6/30/2007 - 6/30/2019) (Revised)

Materials Received from CalPERS for Review
Disability Rates Data

Date Received	File Name	Additional Summary
4/30/2021	Template for Presentation.pptx	Industrial Disability Presentation
4/30/2021	CHP REDO.xlsm	CHP - Non-Duty Disability (6/30/2004 - 6/30/2019)
4/30/2021	Final Rates Ind 4yr80%.xlsm	State Industrial - Duty Disability (6/30/2015 - 6/30/2019)
4/30/2021	State Industrial1.xlsm	State Industrial - Non-Duty Disability (6/30/2004 - 6/30/2019)
4/30/2021	State Safety 4yr 80%.xlsm	State Safety - Duty Disability (6/30/2015 - 6/30/2019)
4/30/2021	PA CPO1.xlsm	PA CPO - Non-Duty Disability (6/30/2004 - 6/30/2019)
4/30/2021	PA Fire1.xlsm	PA Fire - Non-Duty Disability (6/30/2004 - 6/30/2019)
4/30/2021	PA Misc & Local Prosecutors F1.xlsm	PA Misc & Local Prosecutors F - Non-Duty Disability (6/30/2004 - 6/30/2019)
4/30/2021	PA Misc & Local Prosecutors M1.xlsm	PA Misc & Local Prosecutors M - Non-Duty Disability (6/30/2004 - 6/30/2019)
4/30/2021	PA Police, Other Safety, Local Sheriff, & School Police1.xlsm	PA Police, Other Safety, Local Sheriff, & School Police - Non-Duty Disability (6/30/2004 - 6/30/2019)
5/3/2021	Template for Presentation-IDR.pptx	Industrial Disability Presentation
5/3/2021	Template for Presentation-NIDR.pptx	Non-Industrial Disability Presentation
5/27/2021	IDR Presentation Revised.pptx	Industrial Disability Presentation *(Revised)*
5/27/2021	Ind 40% current.xlsm	State Industrial - Duty Disability (6/30/2015 - 6/30/2019) *(Revised)*
5/27/2021	State Safety 4yr 80% level at 65.xlsm	State Safety - Duty Disability (6/30/2015 - 6/30/2019) *(Revised)*

Materials Received from CalPERS for Review
Termination Rates Data

Date Received	File Name	Additional Summary
6/22/2021	2021 Term Refund Presentation - FINAL.pptx	Termination Refund Rates Study Presentation (FYE 2001-2019)
6/22/2021	2021 Term Vest Presentation.pptx	Termination Vested Rates Study Presentation (1 of 4)
6/22/2021	2021 Term Vest Presentation 2.pptx	Termination Vested Rates Study Presentation (2 of 4)
6/22/2021	2021 Term Vest Presentation 3.pptx	Termination Vested Rates Study Presentation (3 of 4)
6/22/2021	2021 Term Vest Presentation 4.pptx	Termination Vested Rates Study Presentation (4 of 4)
6/22/2021	Peace Officers - Firefighters Female Term Refund Rates.xlsm	POFF F - Terminate And Refund (6/30/2000 - 6/30/2019)
6/22/2021	Peace Officers - Firefighters Female Term Vest Rates 2000-2019.xlsm	POFF F - Terminate and Vest (6/30/2000 - 6/30/2019)
6/22/2021	Peace Officers - Firefighters Male Term Refund Rates.xlsm	POFF M - Terminate And Refund (6/30/2000 - 6/30/2019)
6/22/2021	Peace Officers - Firefighters Male Term Vest Rates 2000-2019.xlsm	POFF M - Terminate and Vest (6/30/2000 - 6/30/2019)
6/22/2021	School Misc Female Term Refund Rates.xlsm	Schools Misc F - Terminate And Refund (6/30/2000 - 6/30/2019)
6/22/2021	Schools Misc Female Term Vest Rates.xlsm	Schools Misc F - Terminate and Vest (6/30/2000 - 6/30/2019)
6/22/2021	School Misc Male Term Refund Rates.xlsm	Schools Misc M - Terminate And Refund (6/30/2000 - 6/30/2019)
6/22/2021	Schools Misc Male Term Vest Rates.xlsm	Schools Misc M - Terminate and Vest (6/30/2000 - 6/30/2019)
6/22/2021	State Industrial Term Refund Rates FINAL.xlsm	SIF - Terminate And Refund (6/30/2000 - 6/30/2019) *(timestamp 6/6/2021)*
6/22/2021	State Industrial Term Vest Females.xlsm	State Industrial F - Terminate and Vest (6/30/2000 - 6/30/2019) *(no proposed rates by gender)*
6/22/2021	State Industrial Term Vest Males.xlsm	State Industrial M - Terminate and Vest (6/30/2000 - 6/30/2019) *(no proposed rates by gender)*
6/22/2021	State Industrial Term Vest Rates.xlsm	State Industrial - Terminate and Vest (6/30/2000 - 6/30/2019) *(proposed rates for both F & M)*

Materials Received from CalPERS for Review
Termination Rates Data

Date Received	File Name	Additional Summary
6/22/2021	State Misc Tier 1 Female Term Refund Rates.xlsm	State Misc T1 F - Terminate And Refund (6/30/2000 - 6/30/2019)
6/22/2021	State Misc Tier 1 Females Term Vest Rates.xlsm	State Misc T1 F - Terminate and Vest (6/30/2000 - 6/30/2019)
6/22/2021	State Misc Tier 1 Male Term Refund Rates.xlsm	State Misc T1 M - Terminate And Refund (6/30/2000 - 6/30/2019)
6/22/2021	State Misc Tier 1 Males Term Vest Rates.xlsm	State Misc T1 M - Terminate and Vest (6/30/2000 - 6/30/2019)
6/22/2021	State Misc Tier 2 Female Term Refund Rates.xlsm	State Misc T2 F - Terminate And Refund (6/30/2000 - 6/30/2019)
6/22/2021	State Misc Tier 2 Females Term Vest Rates.xlsm	State Misc T2 F - Terminate and Vest (6/30/2000 - 6/30/2019)
6/22/2021	State Misc Tier 2 Male Term Refund Rates.xlsm	State Misc T2 M - Terminate And Refund (6/30/2000 - 6/30/2019)
6/22/2021	State Misc Tier 2 Males Term Vest Rates.xlsm	State Misc T2 M - Terminate and Vest (6/30/2000 - 6/30/2019)
6/22/2021	State Safety Female Term Refund Rates.xlsm	State Safety F - Terminate And Refund (6/30/2000 - 6/30/2019)
6/22/2021	State Safety Female Term Vest Rates 2000-2019.xlsm	State Safety F - Terminate and Vest (6/30/2000 - 6/30/2019)
6/22/2021	State Safety Male Term Refund Rates.xlsm	State Safety M - Terminate And Refund (6/30/2000 - 6/30/2019)
6/22/2021	State Safety Male Term Vest Rates 2000-2019.xlsm	State Safety M - Terminate and Vest (6/30/2000 - 6/30/2019)
6/22/2021	California Highway Patrol Females Term Refund.xlsm	CHP F - Terminate And Refund (6/30/2000 - 6/30/2019)
6/22/2021	CHP Female Term Vest Rates.xlsm	CHP F - Terminate and Vest (6/30/2000 - 6/30/2019)
6/22/2021	California Highway Patrol Male Term Refund Rates.xlsm	CHP M - Terminate And Refund (6/30/2000 - 6/30/2019)
6/22/2021	CHP Male Term Vest Rates.xlsm	CHP M - Terminate and Vest (6/30/2000 - 6/30/2019)

Materials Received from CalPERS for Review
Termination Rates Data

Date Received	File Name	Additional Summary
6/22/2021	PA County Peace Officers Female Term Vest Rates.xlsm	PA CPO F - Terminate And Refund (6/30/2000 - 6/30/2019)
6/22/2021	PA County Peace Officer Females Term Vest Rates.xlsm	PA CPO F - Terminate and Vest (6/30/2000 - 6/30/2019)
6/22/2021	PA County Peace Officers Male Term Vest Rates.xlsm	PA CPO M - Terminate And Refund (6/30/2000 - 6/30/2019)
6/22/2021	PA County Peace Officer Males Term Vest Rates.xlsm	PA CPO M - Terminate and Vest (6/30/2000 - 6/30/2019)
6/22/2021	PA Fire Female Term Refund Rates.xlsm	PA Fire F - Terminate And Refund (6/30/2000 - 6/30/2019)
6/22/2021	PA Fire Females Term Vest Rates.xlsm	PA Fire F - Terminate and Vest (6/30/2000 - 6/30/2019)
6/22/2021	PA Fire Male Term Refund Rates.xlsm	PA Fire M - Terminate And Refund (6/30/2000 - 6/30/2019)
6/22/2021	PA Fire Males Term Vest Rates.xlsm	PA Fire M - Terminate and Vest (6/30/2000 - 6/30/2019)
6/22/2021	PA Misc Female Term Refund Rates.xlsm	PUB-MIS and SPR - Terminate And Refund (6/30/2000 - 6/30/2019)
6/22/2021	PA Misc Females Term Vest Rates.xlsm	PUB-MIS and SPR - Terminate and Vest (6/30/2000 - 6/30/2019)
6/22/2021	PA Misc Male Term Refund Rates.xlsm	PUB-MIS and SPR Males - Terminate And Refund (6/30/2000 - 6/30/2019)
6/22/2021	PA Misc Males Term Vest Rates.xlsm	PUB-MIS and SPR Males - Terminate and Vest (6/30/2000 - 6/30/2019)
6/22/2021	PA Police Female Term Refund Rates.xlsm	SPO, SOS, SSH, SSP Females - Terminate And Refund (6/30/2000 - 6/30/2019)
6/22/2021	PA Police Females Term Vest Rates.xlsm	SPO, SOS, SSH, SSP Females - Terminate and Vest (6/30/2000 - 6/30/2019)
6/22/2021	PA Police Male Term Refund Rates.xlsm	SPO, SOS, SSH, SSP Males - Terminate And Refund (6/30/2000 - 6/30/2019)
6/22/2021	PA Police Males Term Vest Rates.xlsm	SPO, SOS, SSH, SSP Males - Terminate and Vest (6/30/2000 - 6/30/2019)
8/17/2021	PA Fire Females Term Vest Rates.xlsm	PA Fire F - Terminate and Vest (6/30/2000 - 6/30/2019) *(Revised)*

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October 25, 2021

Mr. Scott Terando
Chief Actuary
California Public Employees' Retirement System
Lincoln Plaza North
400 Q Street
Sacramento, CA 95811

Re: Report of the Comprehensive Review of the 2021 Experience Study of the California Public Employees' Retirement System

Dear Mr. Terando:

Gabriel, Roeder, Smith & Company is pleased to present this report of a Comprehensive Review of the 2021 Experience Study of the California Public Employees' Retirement System.

Enclosed are the 3 bound copies of the final report.

Sincerely,
Gabriel, Roeder, Smith and Company

Brian B. Murphy, FSA, EA, MAAA, FCA, PhD

BBM:mdd
Enclosures