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# Mortality Table Development

**American Academy of Actuaries Life Experience Committee / Society of Actuaries Project Oversight Group**

**March 26, 2015**

# Agenda

- Table status
- 2014 VBT and VBT RR Tables
- 2017 CSO
- PBR margins
- GI/SI/Preneed

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# Regulatory Mortality in Development

| Table | Regulatory Use | Status | Request for LATF |
|---|---|---|---|
| 2014 VBT Basic Tables | • AG38<br>• VM-20 Deterministic reserves<br>• VM-20 Stochastic reserves | • Previously exposed in 2014 and comments incorporated | Project to 2015?<br>Re-expose for comment |
| 2014 VBT Relative Risk Tables | | • Beta versions are complete | Project to 2015?<br>Expose for comment |
| 2017 CSO and 2017 CSO Preferred Structure Tables | • Net premium reserves<br>• Tax reserves<br>• Non-forfeiture determination<br>• Basis for 7702/7702A<br>• Cap for universal life cost of insurance charges | • Loading structure and coverage tests complete<br>• Tables currently being tested via impact study | Provide comment on:<br>• Structure of loading<br>• Coverage<br>• Approach to development of preferred structure tables (basic and loaded)<br>• Timing for exposure |
| PBR Margins | VM-20 Deterministic and Stochastic reserves | • Recommendations complete<br>• Reserve impacts of margins currently being testing via impact study | Provide comment on:<br>• Structure/level of margins<br>• Variation by statistical credibility method<br>• Revision to VM-20<br>• Timing for exposure |
| GI/SI/Preneed | CRVM reserves | In progress | Provide comment on:<br>• Timing |

# 2014 VBT and RR Tables

- Requests of LATF
  - Opine on Table Start Date
  - Expose/Re-expose for Comment

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# 2014 VBT and RR Tables

- Incorporated comments and made modifications resulting from prior exposure
- Completed monotonicity and relationship checks for the basic and RR tables
- Finalized preferred wear-off pattern – slight changes from what was previously published

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# 2014 VBT and RR Tables

- VBT Primary Table structure
  - NS/SM/Uni-smoke
  - M/F
  - ANB/ALB
  - Select & Ultimate, Ultimate only
  - Juvenile rates on uni-smoke basis only
- RR Table structure
  - 10 NS/4 SM tables
  - M/F
  - ANB, ALB
  - No juvenile rates or uni-smoke tables
  - Utilizes preferred wear-off pattern that wears off by age 95
  - RR 100 Table same as VBT Primary Table
  - New UCS Calculator

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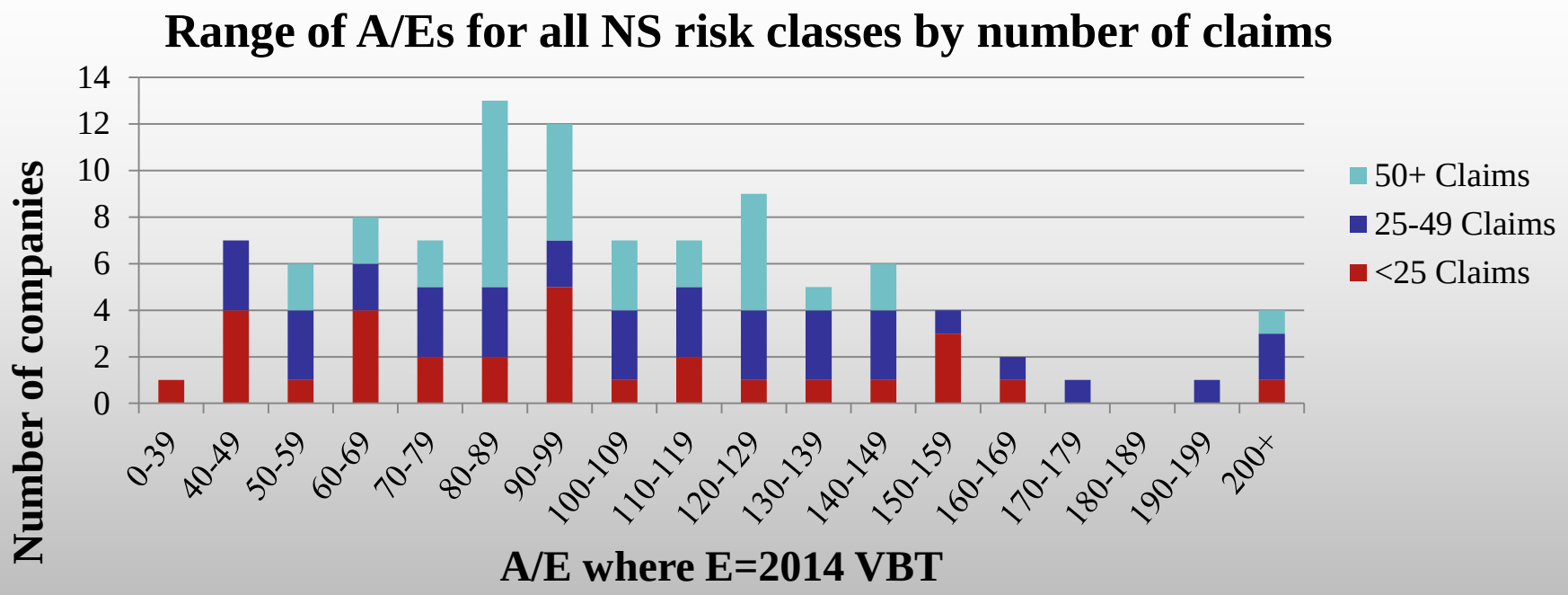
# Determination of Relativity for RR Tables - Nonsmoker




NS = RR 50, 60, 70, 80, 90, 100, 110, 125, 150, 175

E = 2014 VBT adjusted to remove improvement to midpoint of data period for each company

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# Determination of Relativity for RR Tables - Smoker

- Limited data to justify different structure or relativity from that in the 2008 VBT
- SM RR tables = RR 75, RR 100, RR 125, RR 150
- RR 100 = VBT Primary SM


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# Preferred Wear-off Factors – Select Ages

| | Duration | | | | | |
|---|---|---|---|---|---|---|
| **Issue Age** | **1** | **5** | **10** | **15** | **20** | **25** |
| 25 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 2.2% |
| 35 | 0.0% | 0.0% | 0.0% | 2.1% | 5.6% | 11.4% |
| 45 | 0.0% | 1.8% | 5.3% | 11.1% | 19.3% | 29.9% |
| 55 | 0.0% | 5.2% | 14.0% | 25.2% | 39.0% | 55.3% |
| 65 | 0.0% | 11.0% | 27.4% | 46.8% | 66.2% | 81.4% |
| 75 | 0.0% | 22.8% | 51.1% | 72.5% | 94.3% | 100.0% |
| 85 | 0.0% | 27.8% | 82.9% | 100.0% | 100.0% | 100.0% |

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# 2017 CSO SM/NS and Preferred Structure Tables

- Requests of LATF – Opine on:
  - Structure of loading
  - Coverage
  - Approach to development of preferred structure tables (basic and loaded)
  - Timing/process for exposure

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# Considered Four Purposes for a Margin

| Consideration | | Resolution |
|---|---|---|
| 1 | Confidence of experience study | • Not a concern for 2017 CSO (underlying study is credible)<br>• Significantly more data than in prior underlying studies<br>• 439% increase in exposure by amount over data underlying 2001 CSO (52% increase by count) |
| 2 | Variation of individual company's experience relative to the mean | • There is considerable variability by company<br>• For NS risks, the A/E by amount ranges from < 40% to > 200% |
| 3 | Random fluctuation due to smaller exposure | • Not practical to vary loadings by size of company exposure<br>• Purpose of capital and surplus |
| 4 | Unknown variation such as catastrophic events | • Purpose of capital and surplus |


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# 2017 CSO Margin Development

- NAIC LATF guidance:
  - Margins consistent with 2001 CSO
  - To cover the claims or mortality experience from at least 70% - 79% of the contributing companies (in the underlying mortality study)

- Purpose of margin is to cover the variation of an individual company's mortality around the mean (company variation)

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# CSO Margin Structure

- 2001 CSO Margin structure:

$$\frac{0.0056 - 0.00016(x+t) + 0.000008(x+t)^2}{e_{[x]+t}}$$

- Examined using similar structure to determine margin as used for the 2001 CSO
  - This formula results in margins that are extremely high during the select period and for issue ages where there is the most experience
  - Formulaic margin difficult to develop for the large number of tables to load (Select & Ultimate, Ultimate, Non-smoker, Smoker, Preferred Risk Tables, etc.)


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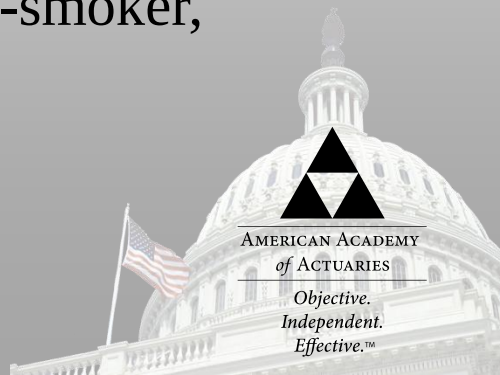

# CSO Margin Structure, cont'd

- Developed % Load that varies by attained age with the following pattern:
  - 23% below age 20, grading down to
  - 17% at age 80, and further grading down to
  - 15% at age 100, and further grading down to
  - 7.5% at age 110 and later

- Results in a percentage load that decreases by age and an absolute load that generally increases by age
- Appears to result in more intuitive pattern in load by age than other methods
- Simple to understand and administer for all the table variations
  - Easier to maintain appropriate relationships between the various tables


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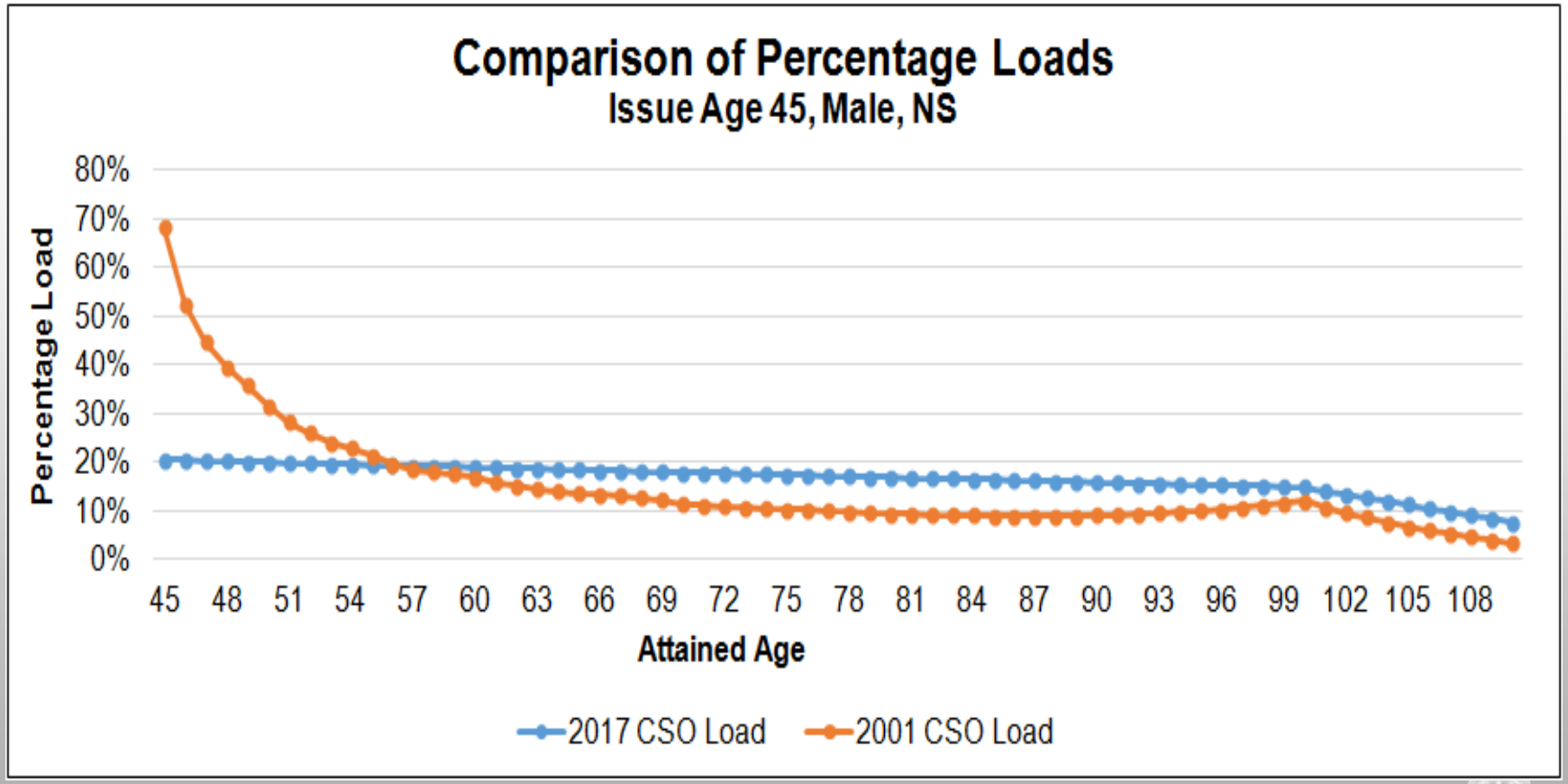
# CSO Margin Structure, cont.

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# CSO Margin Structure, cont'd

- This load covers the mortality* of
  - 70.6% of companies in the study overall
  - 72.5% of companies for males; 76.5% for females
  - 71.6% of the companies for male non-smokers; 74.5% for female non-smokers
  - 74.5% of the companies for male smokers; 78.4% for female smokers
- A company's mortality was covered if its A/E ratio by amount was below 100% where E was the loaded pure experience table before any improvement to 2014 (or 2017)
- Committee believes this covers the guidance suggested by LATF to cover 70%-79% of contributing companies' experience

* The different distributions of business within each company led to variability in which companies and how many companies experience is covered by a particular load.
The coverage percentage varies by age grouping within a particular cohort.

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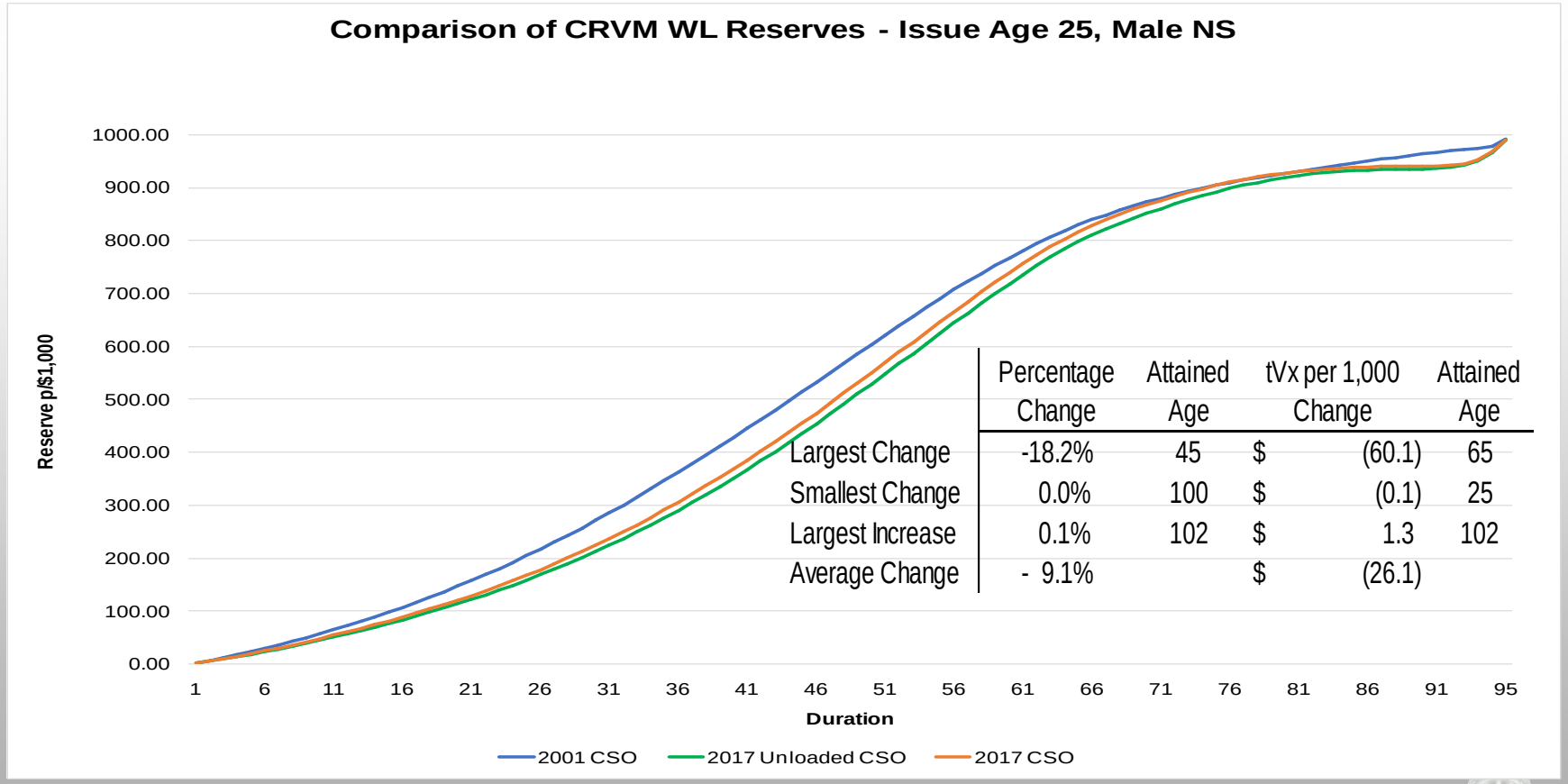
# Whole Life Reserve Comparisons
# CRVM Mean Reserves* - Male NS, Issue Age 25




| | Percentage Change | Attained Age | tVx per 1,000 Change | Attained Age |
|---|---|---|---|---|
| Largest Change | -18.2% | 45 | $ (60.1) | 65 |
| Smallest Change | 0.0% | 100 | $ (0.1) | 25 |
| Largest Increase | 0.1% | 102 | $ 1.3 | 102 |
| Average Change | - 9.1% | | $ (26.1) | |

* Ultimate Table, 4.5% Interest Rate, Fully Continuous

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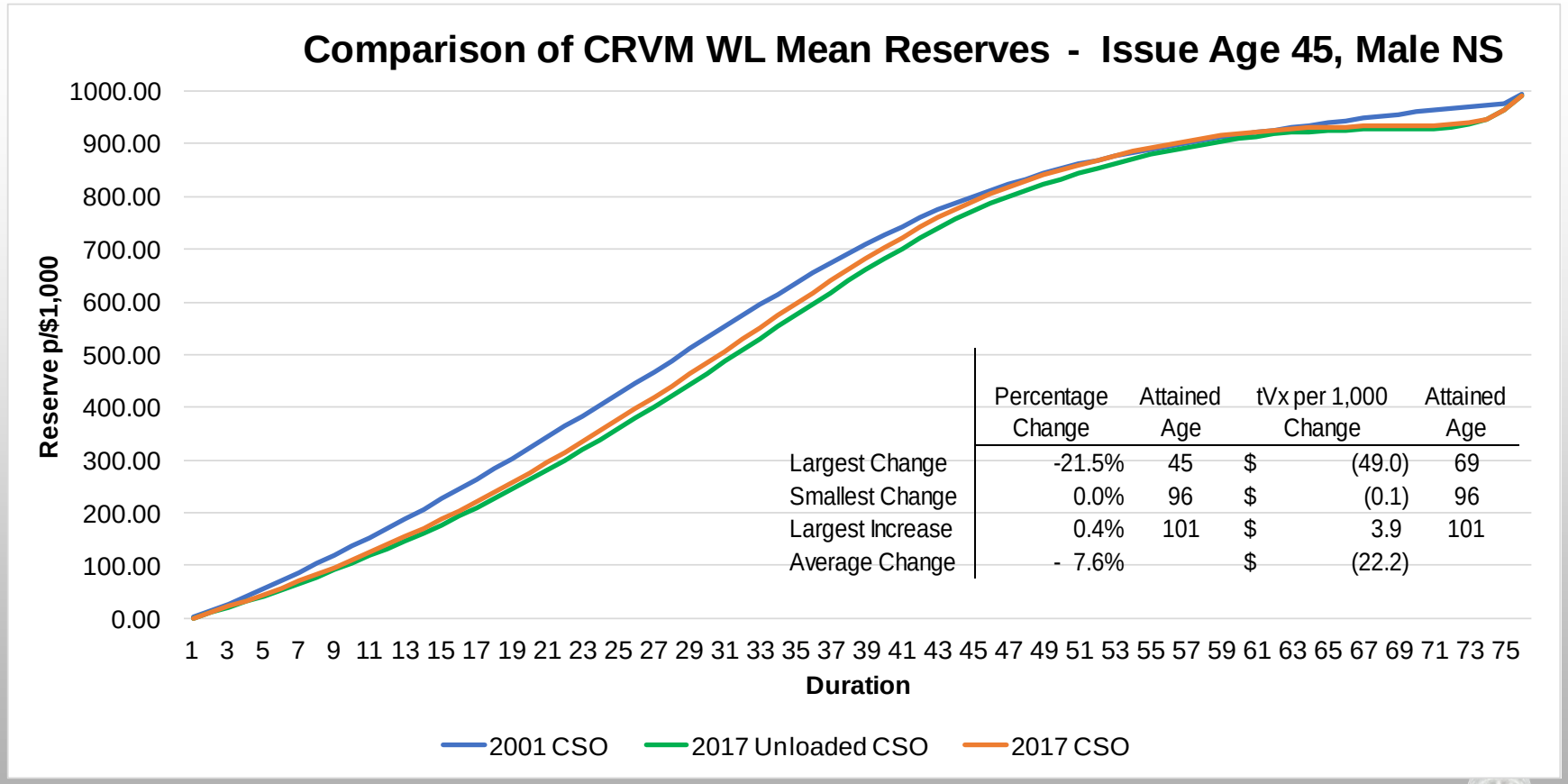
# Whole Life Reserve Comparisons
# CRVM Mean Reserves* - Male NS, Issue Age 45




| | Percentage Change | Attained Age | tVx per 1,000 Change | Attained Age |
|---|---|---|---|---|
| Largest Change | -21.5% | 45 | $ (49.0) | 69 |
| Smallest Change | 0.0% | 96 | $ (0.1) | 96 |
| Largest Increase | 0.4% | 101 | $ 3.9 | 101 |
| Average Change | - 7.6% | | $ (22.2) | |

* Ultimate Table, 4.5% Interest Rate, Fully Continuous

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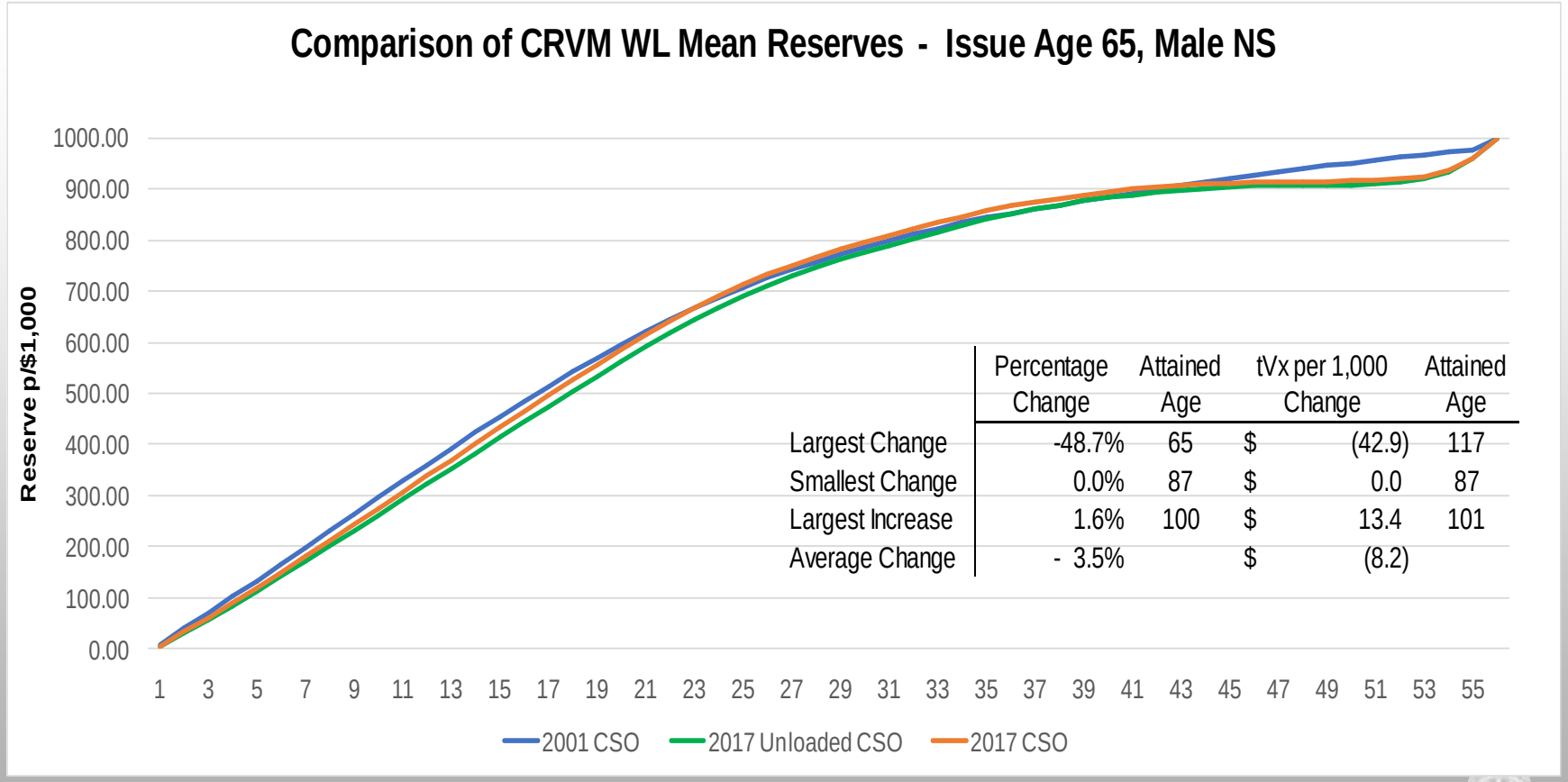
# Whole Life Reserve Comparisons
# CRVM Mean Reserves* - Male NS, Issue Age 65




| | Percentage Change | Attained Age | tVx per 1,000 Change | Attained Age |
|---|---|---|---|---|
| Largest Change | -48.7% | 65 | $ (42.9) | 117 |
| Smallest Change | 0.0% | 87 | $ 0.0 | 87 |
| Largest Increase | 1.6% | 100 | $ 13.4 | 101 |
| Average Change | - 3.5% | | $ (8.2) | |

* Ultimate Table, 4.5% Interest Rate, Fully Continuous

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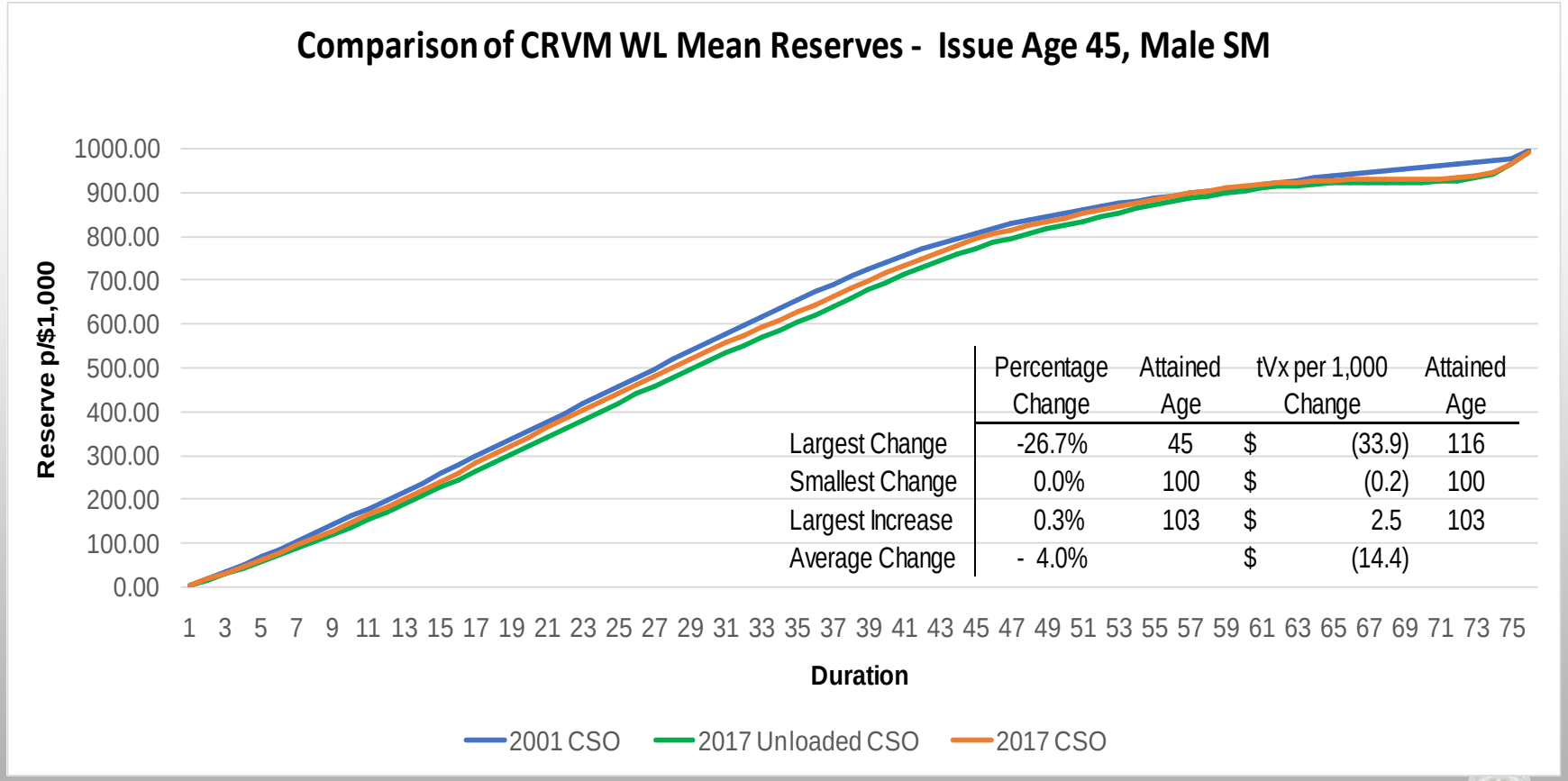
# Whole Life Reserve Comparisons
# CRVM Mean Reserves* - Male SM, Issue Age 45




| | Percentage Change | Attained Age | tVx per 1,000 Change | Attained Age |
|---|---|---|---|---|
| Largest Change | -26.7% | 45 | $ (33.9) | 116 |
| Smallest Change | 0.0% | 100 | $ (0.2) | 100 |
| Largest Increase | 0.3% | 103 | $ 2.5 | 103 |
| Average Change | - 4.0% | | $ (14.4) | |

* Ultimate Table, 4.5% Interest Rate, Fully Continuous

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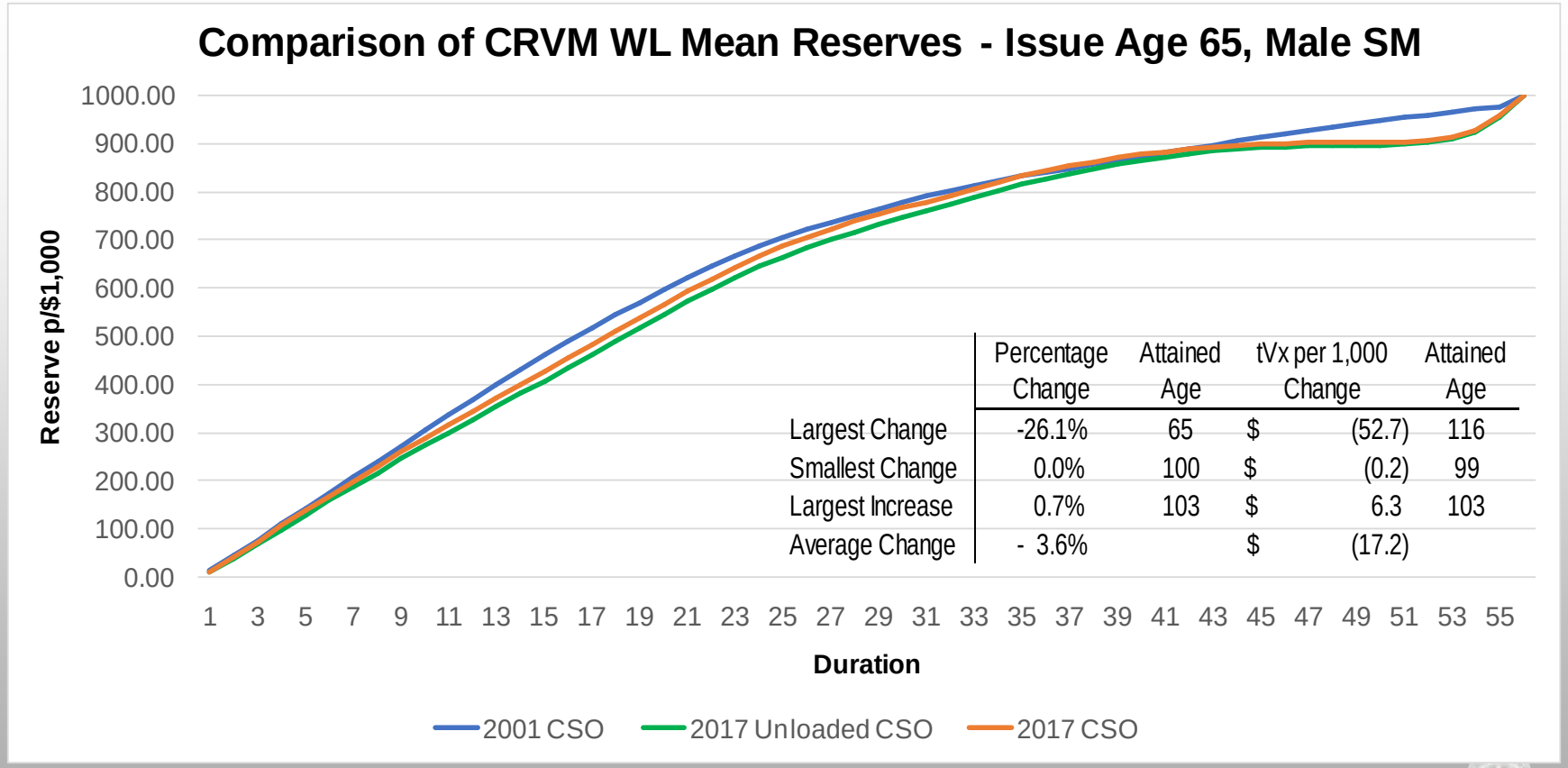
# Whole Life Reserve Comparisons
# CRVM Mean Reserves* - Male SM, Issue Age 65




| | Percentage Change | Attained Age | tVx per 1,000 Change | Attained Age |
|---|---|---|---|---|
| Largest Change | -26.1% | 65 | $ (52.7) | 116 |
| Smallest Change | 0.0% | 100 | $ (0.2) | 99 |
| Largest Increase | 0.7% | 103 | $ 6.3 | 103 |
| Average Change | - 3.6% | | $ (17.2) | |

* Ultimate Table, 4.5% Interest Rate, Fully Continuous

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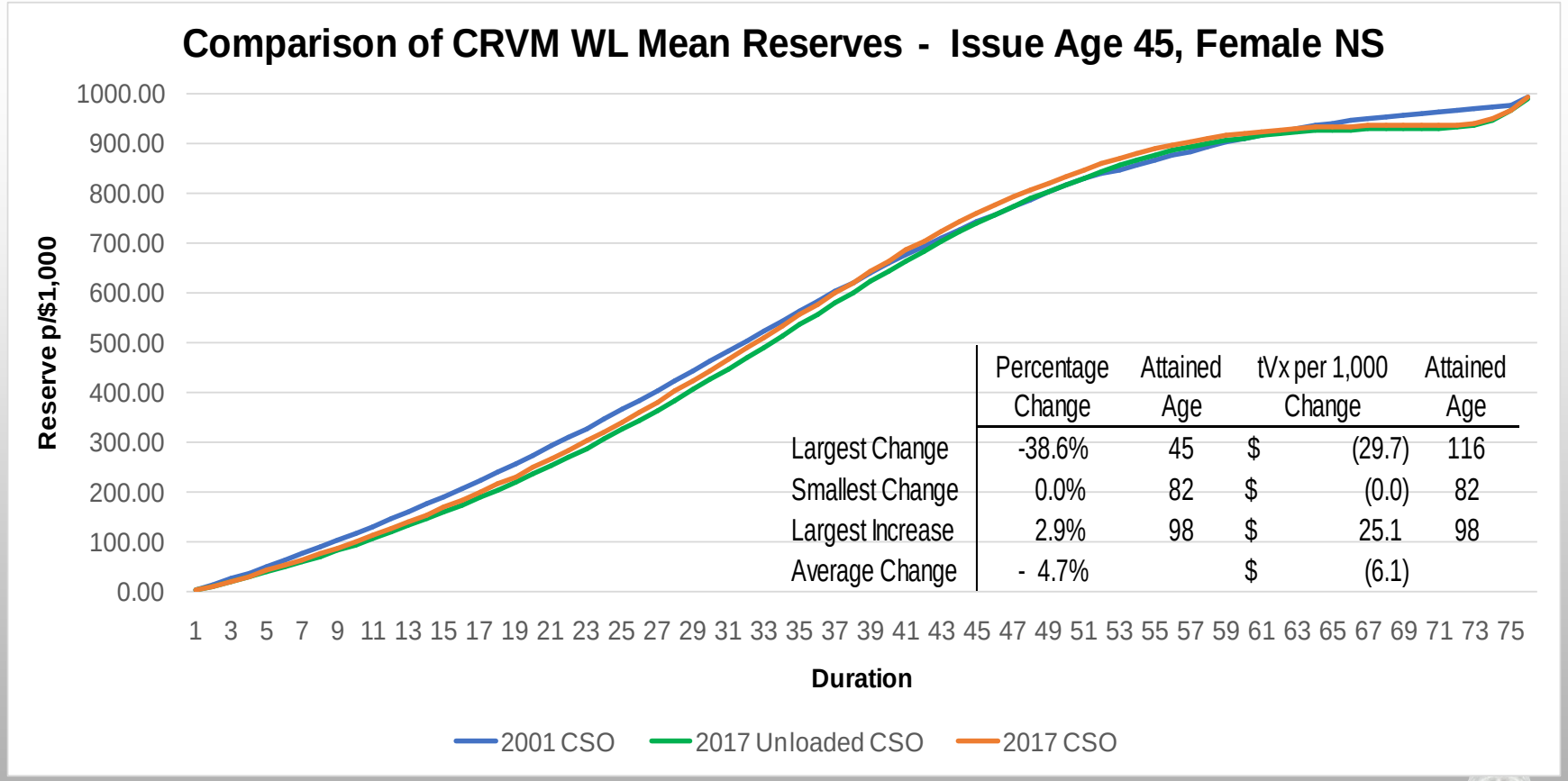
# Whole Life Reserve Comparisons
# CRVM Mean Reserves* - Female NS, Issue Age 45




| | Percentage Change | Attained Age | tVx per 1,000 Change | Attained Age |
|---|---|---|---|---|
| Largest Change | -38.6% | 45 | $ (29.7) | 116 |
| Smallest Change | 0.0% | 82 | $ (0.0) | 82 |
| Largest Increase | 2.9% | 98 | $ 25.1 | 98 |
| Average Change | - 4.7% | | $ (6.1) | |

* Ultimate Table, 4.5% Interest Rate, Fully Continuous

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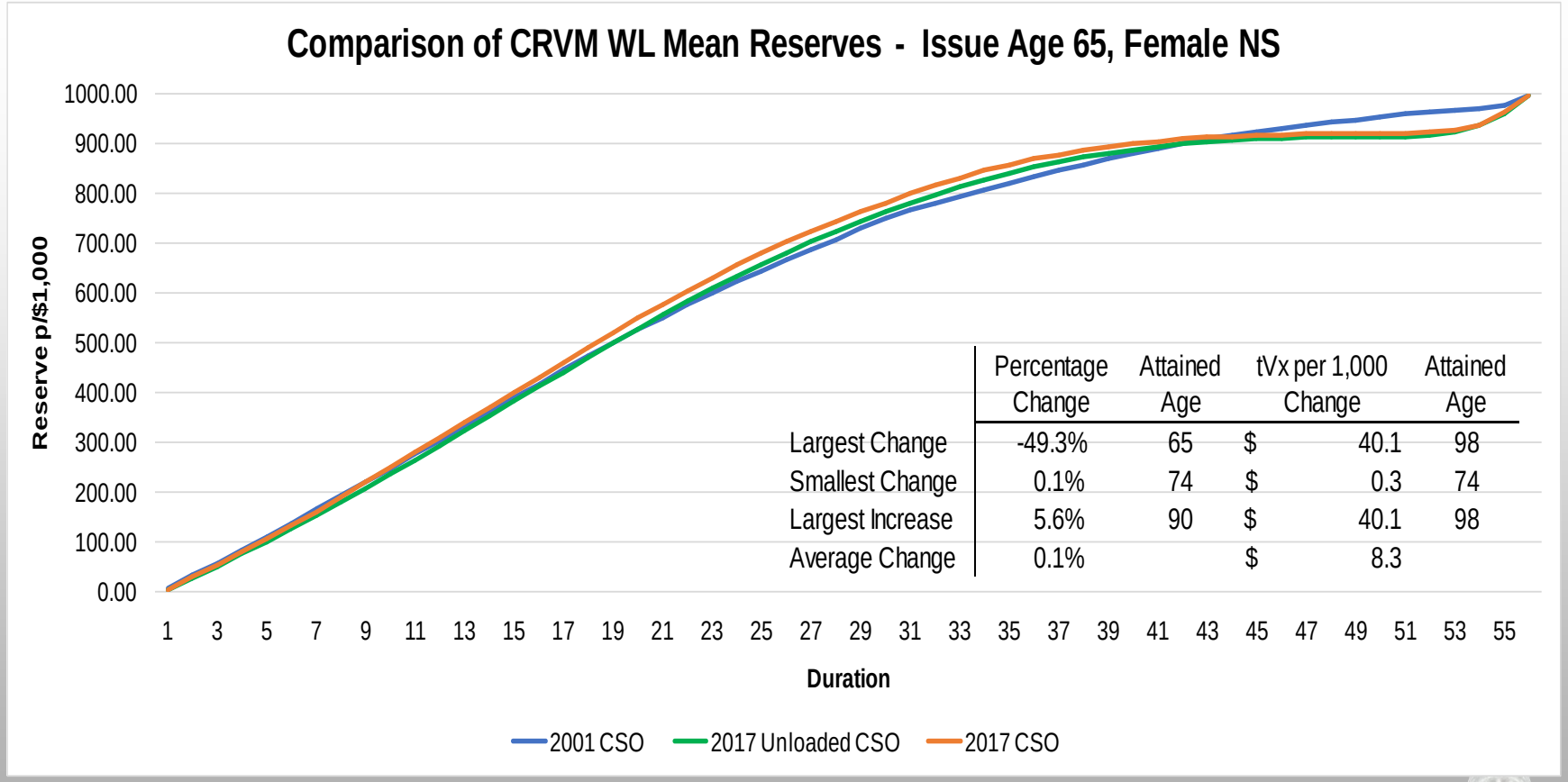
# Whole Life Reserve Comparisons
# CRVM Mean Reserves* - Female NS, Issue Age 65




| | Percentage Change | Attained Age | tVx per 1,000 Change | Attained Age |
|---|---|---|---|---|
| Largest Change | -49.3% | 65 | $ 40.1 | 98 |
| Smallest Change | 0.1% | 74 | $ 0.3 | 74 |
| Largest Increase | 5.6% | 90 | $ 40.1 | 98 |
| Average Change | 0.1% | | $ 8.3 | |

* Ultimate Table, 4.5% Interest Rate, Fully Continuous

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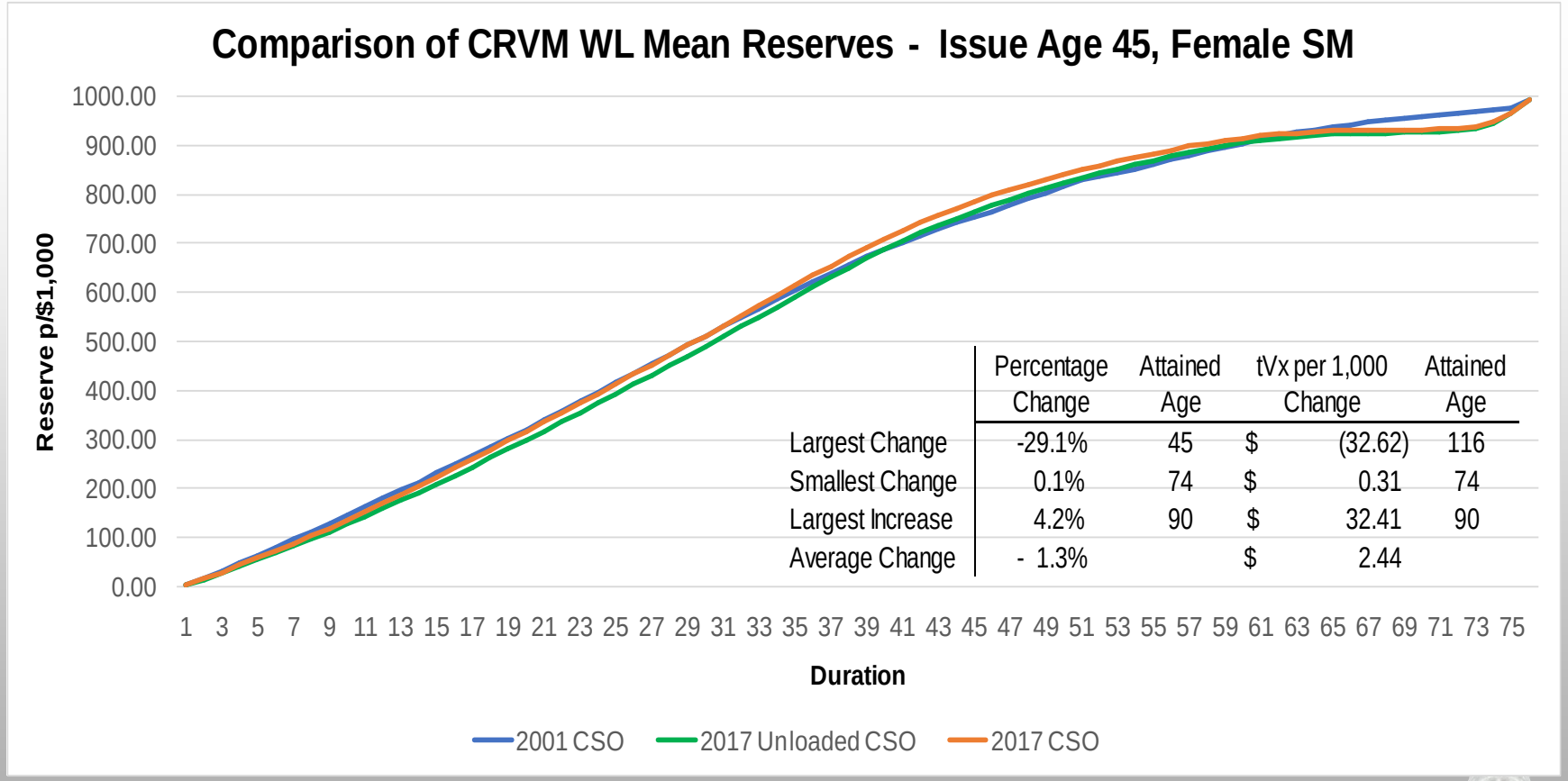
# Whole Life Reserve Comparisons
# CRVM Mean Reserves* - Female SM, Issue Age 45




| | Percentage Change | Attained Age | tVx per 1,000 Change | Attained Age |
|---|---|---|---|---|
| Largest Change | -29.1% | 45 | $ (32.62) | 116 |
| Smallest Change | 0.1% | 74 | $ 0.31 | 74 |
| Largest Increase | 4.2% | 90 | $ 32.41 | 90 |
| Average Change | - 1.3% | | $ 2.44 | |

* Ultimate Table, 4.5% Interest Rate, Fully Continuous

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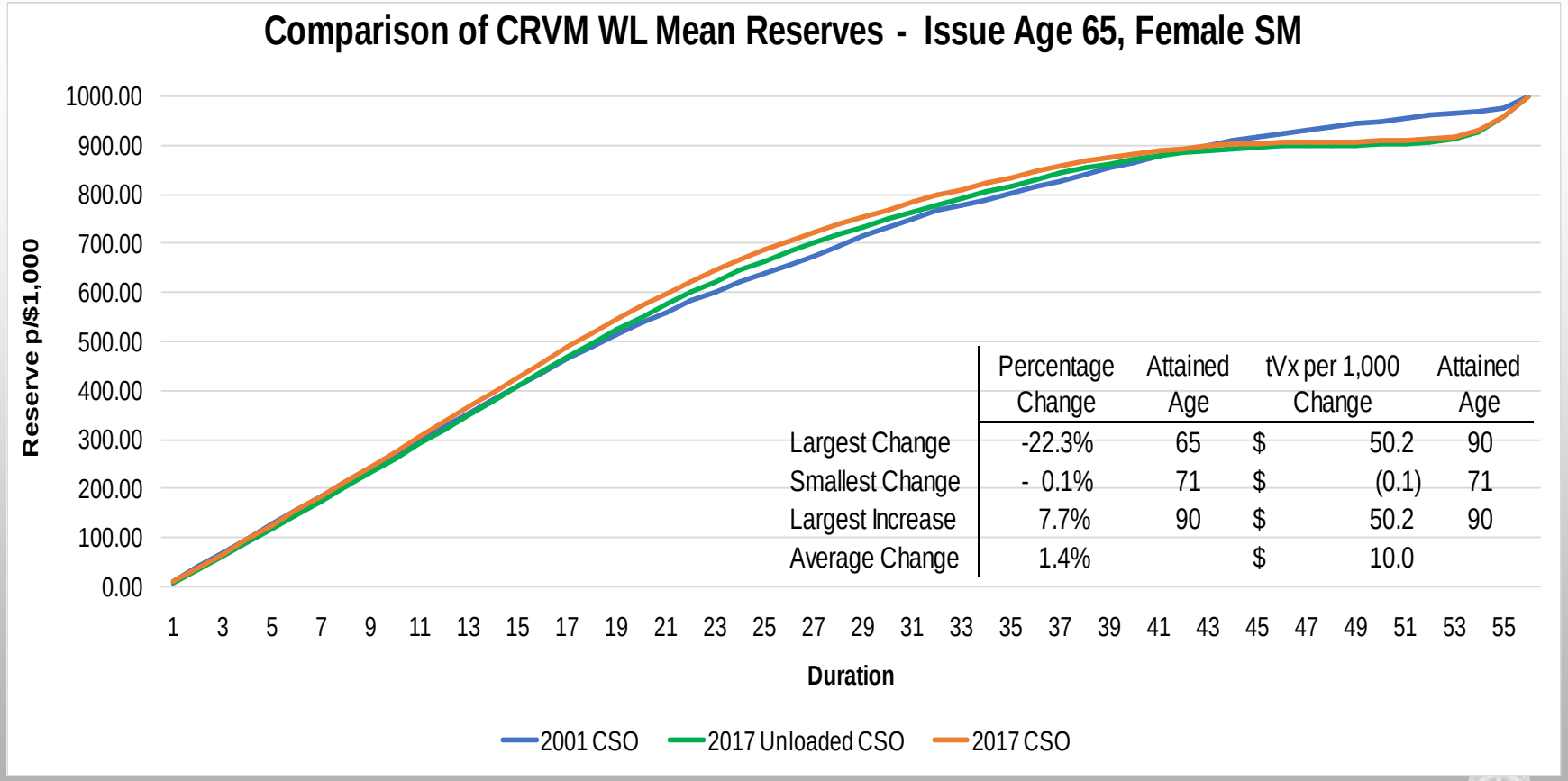
# Whole Life Reserve Comparisons
# CRVM Mean Reserves* - Female SM, Issue Age 65




| | Percentage Change | Attained Age | tVx per 1,000 Change | Attained Age |
|---|---|---|---|---|
| Largest Change | -22.3% | 65 | $ 50.2 | 90 |
| Smallest Change | - 0.1% | 71 | $ (0.1) | 71 |
| Largest Increase | 7.7% | 90 | $ 50.2 | 90 |
| Average Change | 1.4% | | $ 10.0 | |

* Ultimate Table, 4.5% Interest Rate, Fully Continuous

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# 2017 CSO Development – Preferred Structure Tables

- 2014 VBT as base, projected with improvement to 2017 (referred to as Preferred Structure Basic Tables)
- Similar structure as 2001 CSO Preferred Structure Tables
  - 3 NS
  - 2 SM
  - NS and SM classes, when weighted together, equal 2014 VBT aggregate NS and SM mortality, respectively
  - Tables were subsequently improved to 2017
- Omega age of 121 – same as 2001 CSO
  - No grading to omega - rates jump at 121 to 1.000

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# 2017 CSO Development – Preferred Structure Tables, cont'd

- Step 1: Assessed preferred experience based on the 2005-09 ILEC data collected for business issued under a preferred structure basis.
  - Business for nonsmoker risks with 3 or more classes limited to issues since 1990 resulting in little to no data beyond duration 15
  - Business for smoker/nonsmoker risk structures limited to issues since 1980s
- Step 2: Mapped classes into preferred risk class structure (NS classes to Preferred Plus, Preferred and Residual Standard; SM classes to Preferred and Residual Standard)
  - 3 class structures were mapped directly,
  - 4 class structures mapped best class to best class, 2nd best to 2nd best, and 3rd and 4th classes to standard
  - 2 class NS data was ignored as the experience was not consistent with the 3 and 4 NS class structures
- Step 3: Determined a single A/E estimate for the experience by combining
  - All available durations
  - Male and female (because UCS scored do not distinguish between genders)
- Step 4: Determined the Relative Risk of each class, using the combined male and female A/E to point to an RR table. For example, if A/E is 72%, then use 80% of RR 70 and 20% of RR 80


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# 2017 CSO Development – Preferred Structure Tables, cont'd

- Step 5: Performed Aggregation test separately for MNS, MSM, FNS, and FSM to examine if the following equation holds (e.g., for MNS):

$$\textit{Expected claims } MNS_1 + \textit{Expected claims } MNS_2 + \textit{Expected claims } MNS_3 = \textit{Expected claims } MNS$$

where,

  - Expected claims for preferred structure classes were calculated by multiplying the average mortality of 5-year age bands, and 5-year duration bands with the total amount exposed for that age band and the first 10 durations
  - The resulting difference for all four categories combined was about 0.0375% of the total amount exposed.
  - This difference was deemed too small to make any adjustments.


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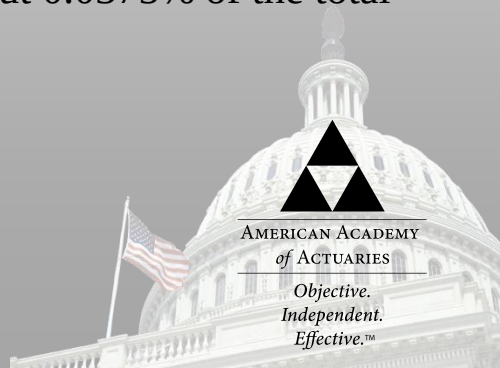

# 2017 CSO Development – Preferred Structure Tables, cont'd

- Step 5, cont'd: The relative risk and prevalence is as follows:

| Risk Class | Relative Risk ( by A/E) | Prevalence (by Face Amount Exposed) | Prevalence (by Amount of Expected Claims) |
|---|---|---|---|
| Super Preferred NS (Class 1) | 77% | 40% | 24% |
| Preferred NS (Class 2) | 98% | 27% | 27% |
| Residual NS (Class 3) | 120% | 32% | 49% |
| Preferred SM | 87% | 64% | 55% |
| Residual SM | 119% | 36% | 45% |


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# 2017 CSO Development – Preferred Structure Tables, cont'd

- Step 6: Developed factors to apply to the 2017 unloaded CSO* using the ratio of the RR table for each preferred class to the underlying RR100 table.
  - All factors were developed using unrounded tables
  - Unrounded, unloaded preferred structure basic tables were loaded with CSO margins
  - The loaded tables were then rounded to 2 decimal places

| Male Age | Improvement Factor | Female Age | Improvement Factor |
|---|---|---|---|
| 0-12 | 1.75% | 0-12 | 1.10% |
| 13 | 1.65% | 13 | 1.04% |
| 14 | 1.55% | 14 | 0.98% |
| 15 | 1.45% | 15 | 0.93% |
| 16 | 1.35% | 16 | 0.87% |
| 17 | 1.25% | 17 | 0.81% |
| 18-82 | 1.15% | 18-80 | 0.75% |
| 83 | 1.06% | 81 | 0.69% |
| 84 | 0.97% | 82 | 0.63% |
| 85 | 0.88% | 83 | 0.58% |
| 86 | 0.80% | 84 | 0.52% |
| 87 | 0.71% | 85 | 0.46% |
| 88 | 0.62% | 86 | 0.40% |
| 89 | 0.53% | 87 | 0.35% |
| 90 | 0.44% | 88 | 0.29% |
| 91 | 0.35% | 89 | 0.23% |
| 92 | 0.27% | 90 | 0.17% |
| 93 | 0.18% | 91 | 0.12% |
| 94 | 0.09% | 92 | 0.06% |
| 95+ | 0.00% | 93+ | 0.00% |

* 2017 unloaded CSO is the 2014 VBT RR Table projected from 2014 to 2017. The improvement factors are the same as those used to project from the mid-point of the 2014 VBT underlying data (2009) to 2014


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# Preferred Structure Loads

- Proposed 2017 CSO preferred structure tables have same percentage load for all tables
  - Question is whether the load should vary by class (smaller for super preferred; larger for residual)
- Arguments in favor of varying load by class:
  - Must 'qualify' to use the super preferred table, so lesser need for load
  - Resulting volatility of mortality in residual class may be higher than the aggregate CSO, suggesting potential for higher load
- Arguments against:
  - More complicated table construction
  - Need to assure tables weight back to the aggregate CSO table?


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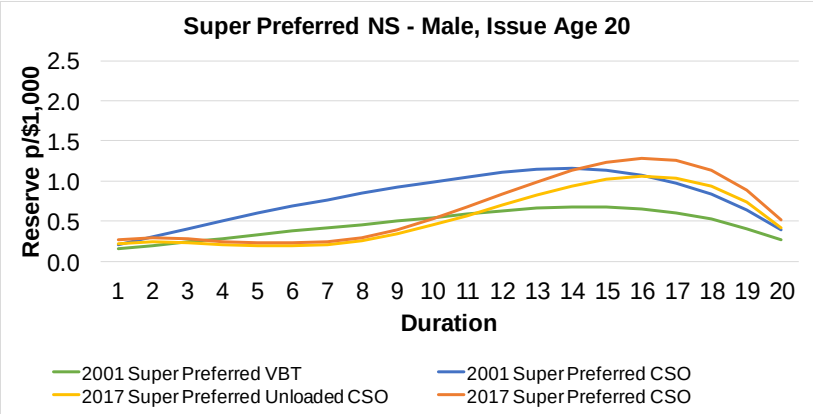
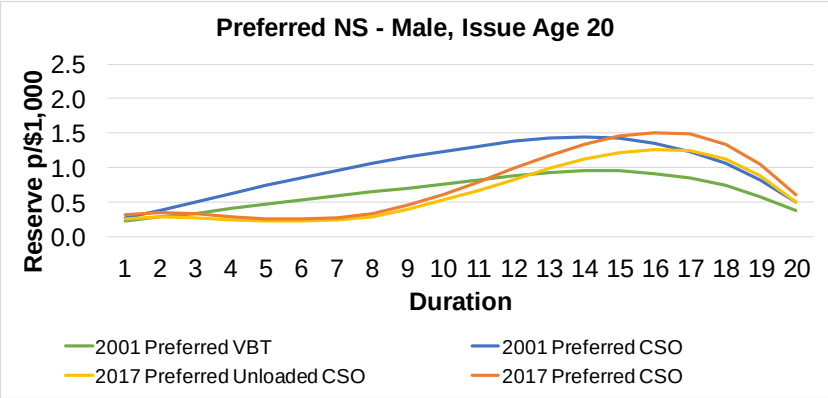
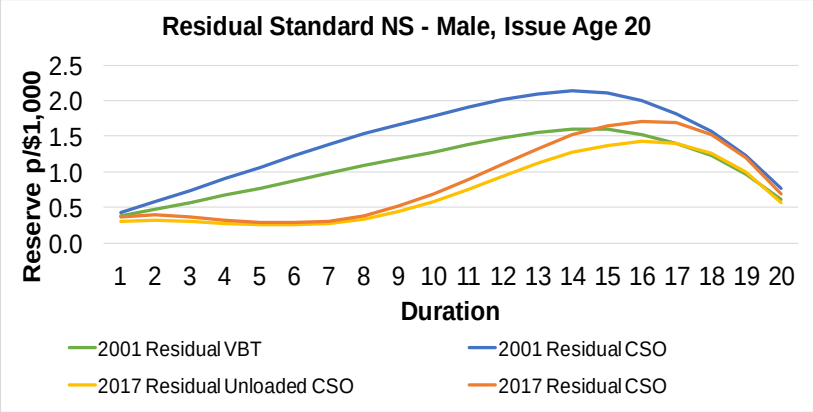
# Preferred Structure Tables – Term Reserve Comparisons Male, NS, Issue Age 20

## Regulation XXX LT20 Mean Reserves*




| | Duration | | | | |
|---|---|---|---|---|---|
| | 1 | 5 | 10 | 15 | 20 |
| **% Change tVx** | | | | | |
| SPNS | 33.3% | -61.6% | -46.4% | 7.9% | 31.3% |
| PNS | 20.0% | -64.6% | -50.4% | 1.8% | 19.4% |
| NS | -13.8% | -72.9% | -61.2% | -21.8% | -9.6% |
| **$ Change p/$1,000** | | | | | |
| SPNS | $ 0.07 | ($ 0.37) | ($ 0.46) | $ 0.09 | $ 0.12 |
| PNS | $ 0.05 | ($ 0.48) | ($ 0.62) | $ 0.03 | $ 0.10 |
| NS | ($ 0.06) | ($ 0.78) | ($ 1.10) | ($ 0.46) | ($ 0.07) |

- Reserve pattern differs from the 2001 CSO. This difference is driven by differences in the underlying VBT at the younger issue ages

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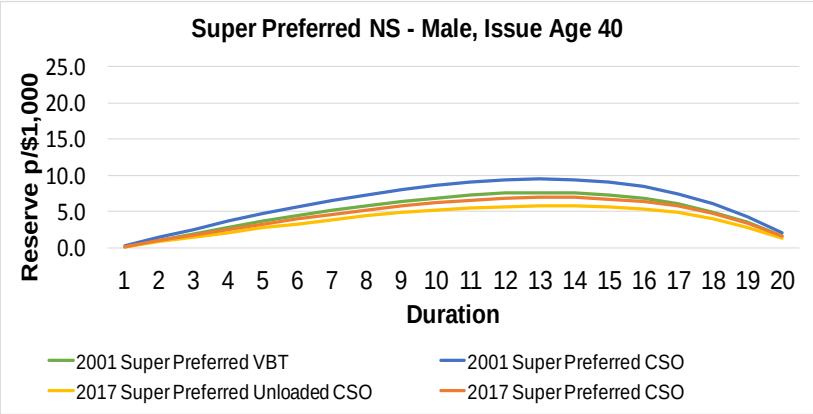
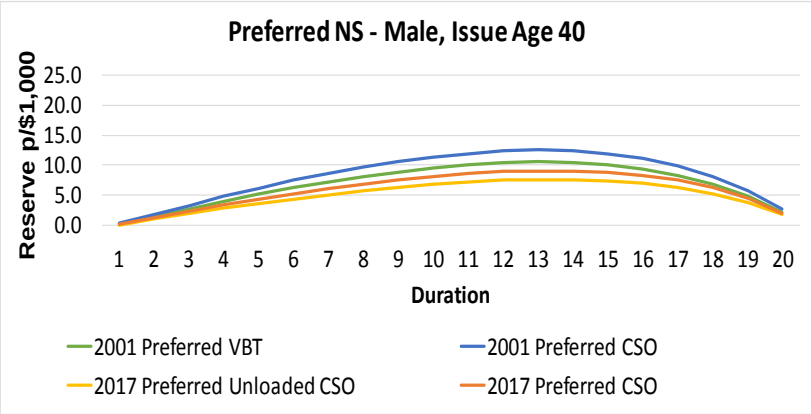
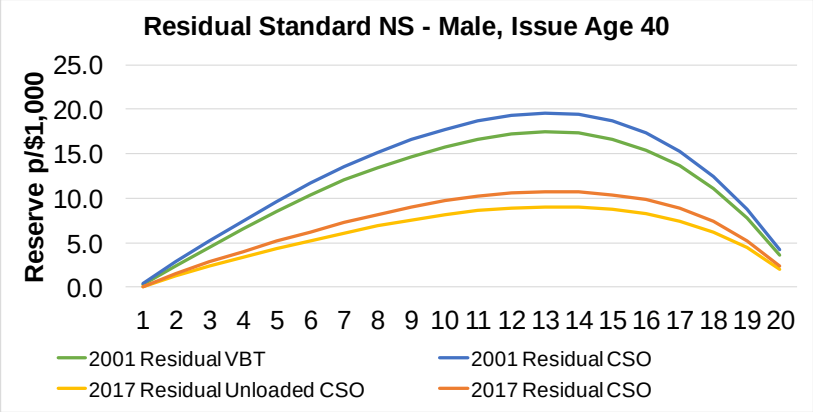
# Preferred Structure Tables – Term Reserve Comparisons
# Male, NS, Issue Age 40

## Regulation XXX LT20 Mean Reserves*




| | Duration | | | | |
|---|---|---|---|---|---|
| | 1 | 5 | 10 | 15 | 20 |
| **% Change tVx** | | | | | |
| SPNS | -72.0% | -30.3% | -27.7% | -25.7% | -24.8% |
| PNS | -67.8% | -30.0% | -28.1% | -26.5% | -24.4% |
| NS | -70.4% | -46.5% | -45.3% | -44.2% | -41.8% |
| **$ Change p/$1,000** | | | | | |
| SPNS | ($ 0.18) | ($ 1.42) | ($ 2.38) | ($ 2.34) | ($ 0.52) |
| PNS | ($ 0.20) | ($ 1.86) | ($ 3.19) | ($ 3.17) | ($ 0.66) |
| NS | ($ 0.28) | ($ 4.50) | ($ 8.04) | ($ 8.25) | ($ 1.76) |

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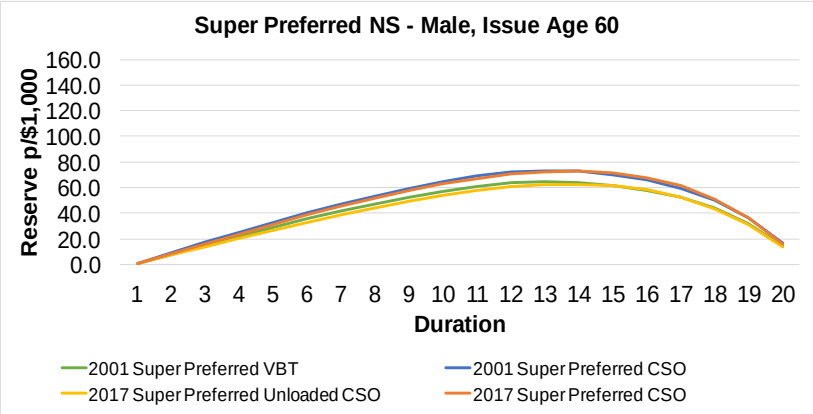
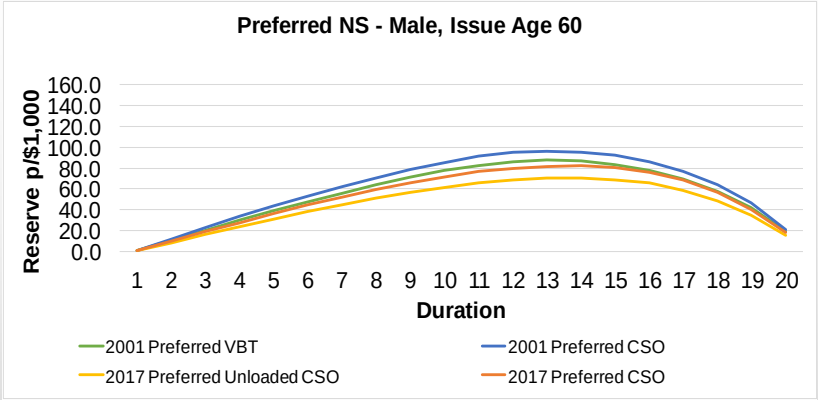
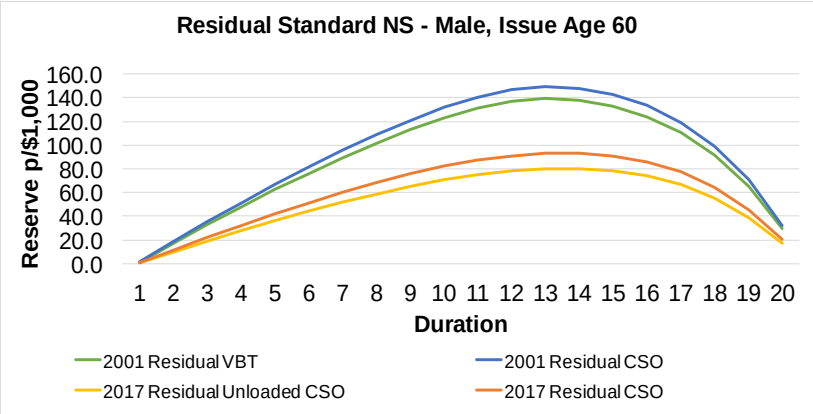
# Preferred Structure Tables – Term Reserve Comparisons Male, NS, Issue Age 60

## Regulation XXX LT20 Mean Reserves*




| | Duration | | | | |
|---|---|---|---|---|---|
| | 1 | 5 | 10 | 15 | 20 |
| **% Change tVx** | | | | | |
| SPNS | -35.6% | -5.4% | -3.0% | 1.6% | -3.4% |
| PNS | -30.5% | -17.0% | -16.1% | -12.8% | -14.9% |
| NS | -36.4% | -37.4% | -37.6% | -36.2% | -36.4% |
| **$ Change p/$1,000** | | | | | |
| SPNS | ($ 0.31) | ($ 1.77) | ($ 1.96) | $ 1.16 | ($ 0.56) |
| PNS | ($ 0.33) | ($ 7.37) | ($13.72) | ($11.83) | ($ 3.18) |
| NS | ($ 0.55) | ($25.01) | ($49.55) | ($51.67) | ($11.78) |

- Reserves for the Male, SPNS class exceed those using 2001 CSO SPNS for durations 15-19.

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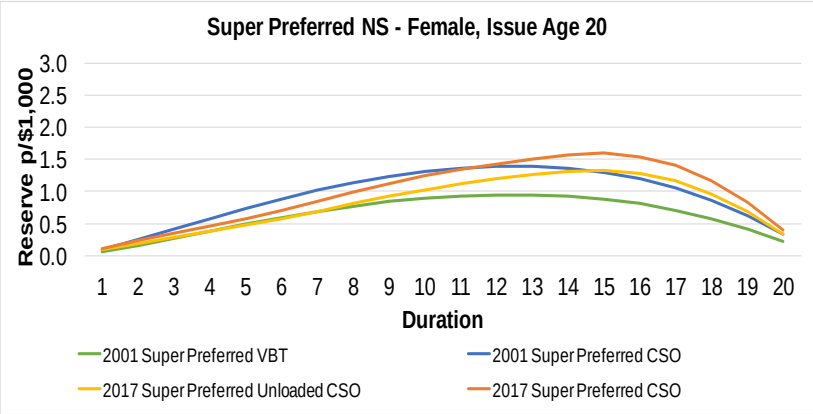
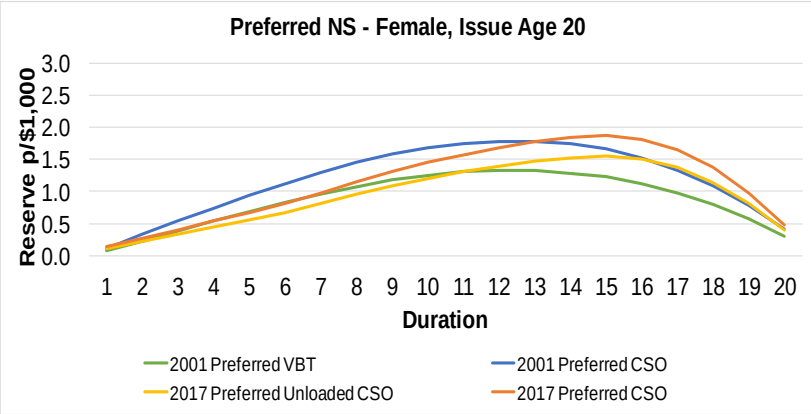
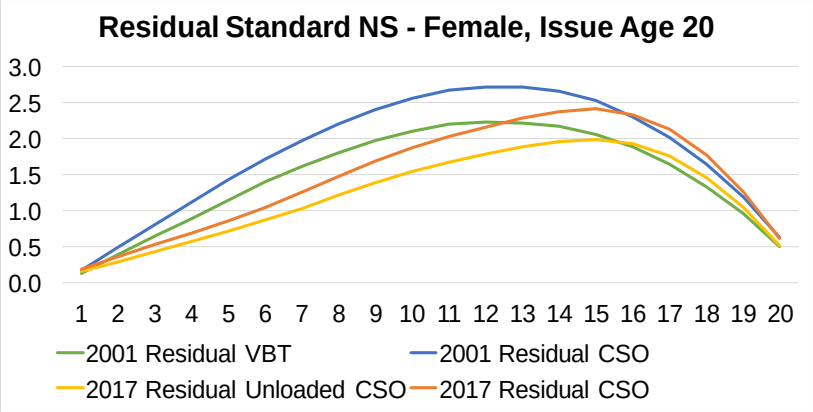
# Preferred Structure Tables – Term Reserve Comparisons
# Female, NS, Issue Age 20

## Regulation XXX LT20 Mean Reserves*




| | Duration | | | | |
|---|---|---|---|---|---|
| | 1 | 5 | 10 | 15 | 20 |
| **% Change tVx** | | | | | |
| SPNS | 20.0% | -21.6% | -5.3% | 23.0% | 22.1% |
| PNS | 16.7% | -28.5% | -13.7% | 12.5% | 12.8% |
| NS | 8.8% | -39.7% | -27.1% | -4.6% | -3.1% |
| **$ Change p/$1,000** | | | | | |
| SPNS | $ 0.02 | ($ 0.16) | ($ 0.07) | $ 0.30 | $ 0.07 |
| PNS | $ 0.02 | ($ 0.27) | ($ 0.23) | $ 0.21 | $ 0.05 |
| NS | $ 0.01 | ($ 0.56) | ($ 0.69) | ($ 0.11) | ($ 0.02) |

- The same anomaly seen with the male nonsmoker classes at issue age 20 does not exist for female risks.

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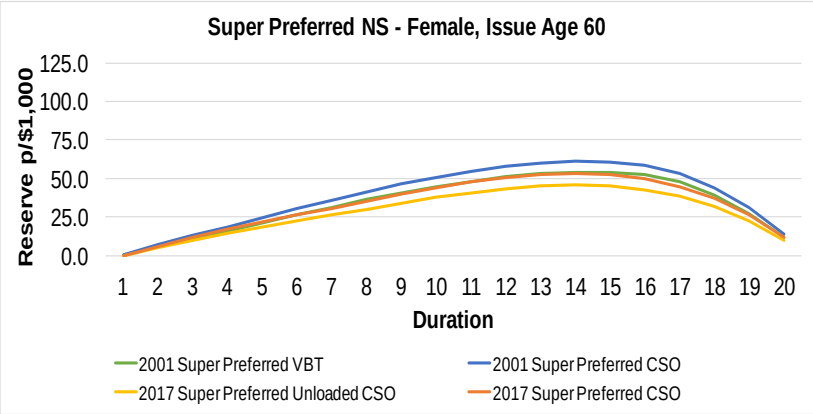
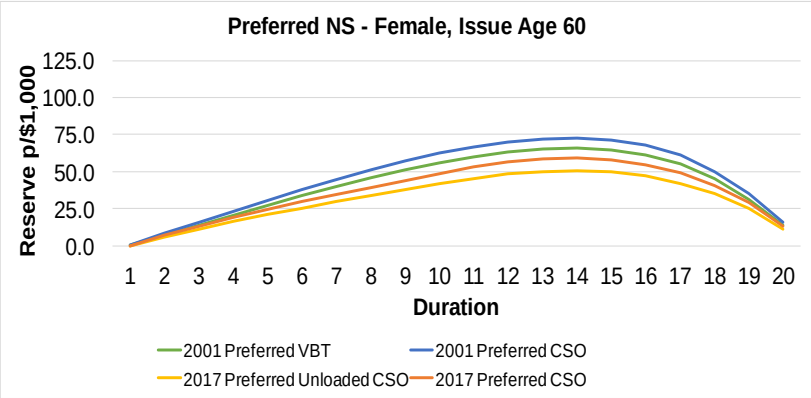
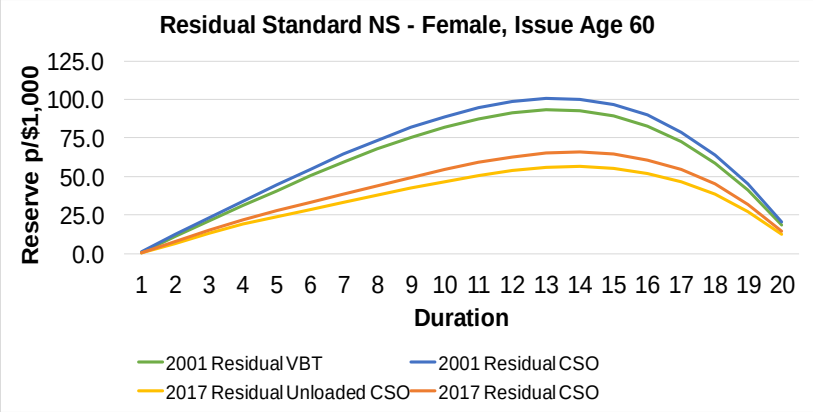
# Preferred Structure Tables – Term Reserve Comparisons Female, NS, Issue Age 60

## Regulation XXX LT20 Mean Reserves*




| | Duration | | | | |
|---|---|---|---|---|---|
| | 1 | 5 | 10 | 15 | 20 |
| **% Change tVx** | | | | | |
| SPNS | -74.0% | -11.7% | -13.8% | -13.4% | -14.1% |
| PNS | -72.6% | -19.8% | -21.7% | -18.8% | -17.4% |
| NS | -75.3% | -37.3% | -38.6% | -33.5% | -29.8% |
| **$ Change p/$1,000** | | | | | |
| SPNS | ($ 0.54) | ($ 2.90) | ($ 7.00) | ($ 8.14) | ($ 1.94) |
| PNS | ($ 0.64) | ($ 6.12) | ($13.57) | ($13.47) | ($ 2.75) |
| NS | ($ 0.91) | ($16.68) | ($34.38) | ($32.40) | ($ 6.15) |

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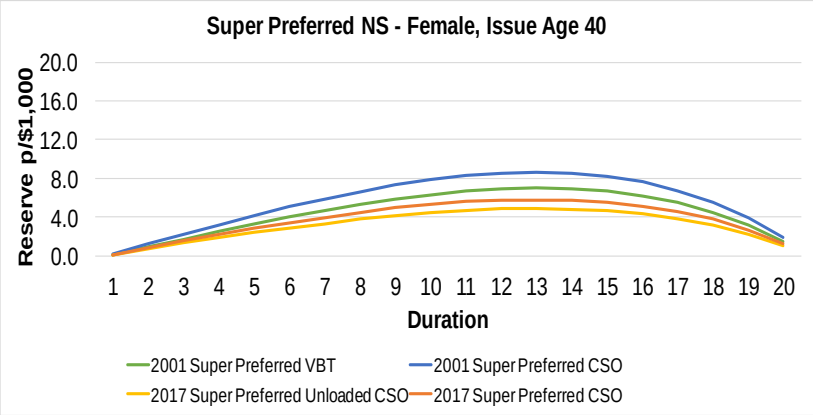
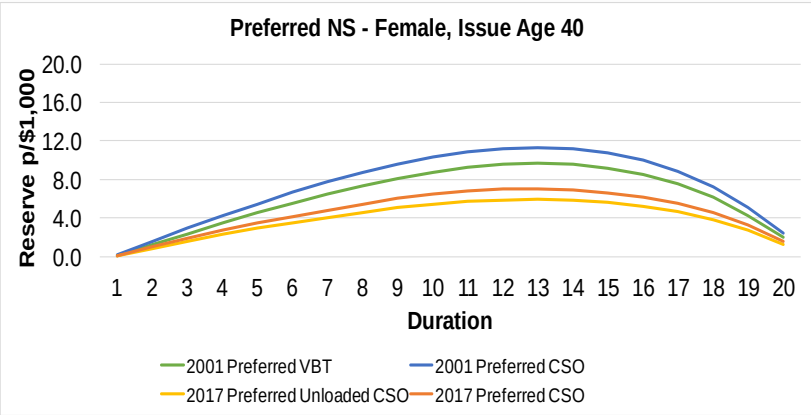
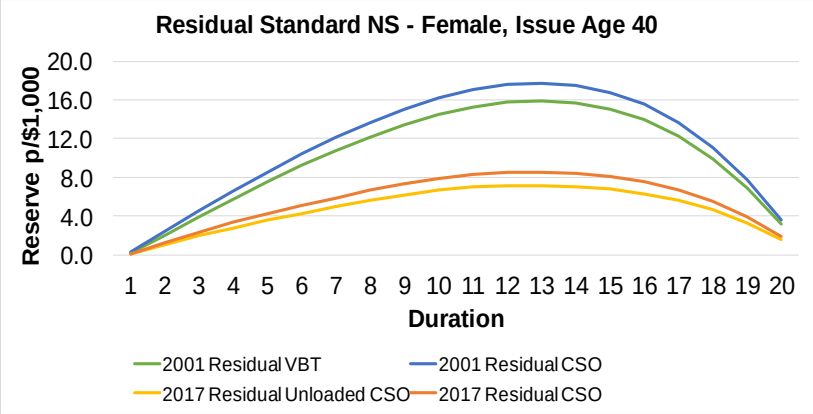
# Preferred Structure Tables – Term Reserve Comparisons
# Female, NS, Issue Age 40

## Regulation XXX LT20 Mean Reserves*




| | Duration | | | | |
|---|---|---|---|---|---|
| | 1 | 5 | 10 | 15 | 20 |
| **% Change tVx** | | | | | |
| SPNS | -66.7% | -31.5% | -31.8% | -32.8% | -32.1% |
| PNS | -64.4% | -36.4% | -37.0% | -38.2% | -35.9% |
| NS | -67.2% | -50.2% | -51.0% | -52.0% | -49.0% |
| **$ Change p/$1,000** | | | | | |
| SPNS | ($ 0.13) | ($ 1.32) | ($ 2.49) | ($ 2.69) | ($ 0.60) |
| PNS | ($ 0.14) | ($ 2.00) | ($ 3.82) | ($ 4.11) | ($ 0.86) |
| NS | ($ 0.19) | ($ 4.29) | ($ 8.24) | ($ 8.73) | ($ 1.79) |

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# PBR Margins

- Requests of LATF – Opine On:
  - Structure/level of margins
  - Variation by statistical credibility method
  - Revision to VM-20
  - Timing for exposure


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# PBR Margin Development

- Underlying data used for analysis same as that underlying the 2014 VBT:
  - 51 companies;
  - One company with an A/E ratio of over 1000% by amount was dropped as an outlier, as it was significantly impacting the calculations.
- A credibility factor (Z) for each of the remaining 50 companies was determined and compared using four methods:
  1. Bühlmann by amount
  2. Bühlmann by count
  3. Limited Fluctuation by amount
  4. Limited Fluctuation by count
- For the final analysis, credibility factors by amount were used.
  - Believed to be a better approach to differentiate among individual company experiences
  - Using 'by count' approach, only a few thousand claims will result in full credibility (of the 50 companies studied, 47 have full credibility using the Limited Fluctuation method by count).


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# Bühlmann Approach

- Uses variances of observations both within each company and between companies
- Credibility Factor $Z = n/(n + k)$
  - n = # of exposure units
  - k = expected value of the process variance/variance of the hypothetical means
    - i.e., average of the variances between companies/variance of the company means
- Does not assume that the expected basis is correct


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# PBR Margin Development

- Step 1: Calculated the estimated A/E ratio for each company using the following formula:

$$\textit{Estimated A/E Ratio} = Z \times (\textit{Company A/E Ratio}) + (1 - Z) \times (\textit{Overall A/E Ratio})$$

where, Z = Bühlmann credibility factor by amount

- Step 2: Determined the standard error of this estimated A/E Ratio as follows:

$$\textit{Standard error of estimate} = ((1 - Z) \times \textit{variance of individual companies' means})^{0.5}$$

- Step 3: Determined the one-sided margin at the 95% confidence level by multiplying the standard error with the appropriate factor from the standard normal table, as follows:

$$\textit{Margin} = 1.65 \times \textit{standard error estimate}$$
$$= 1.65 \times (0.0196 \times (1 - Z))^{0.5}$$


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# PBR Margins

- Resulting margins for the 50 companies ranged from 1% to 19%
- Constraints in determining margins:
  - For the industry table, should be consistent with the margins for the lowest credibility levels
  - On the industry table, should not exceed the margin applied to the VBT in constructing the CSO table
  - Percentages at ages less than 45 are equal to those at 45
  - Percentages above age 107 are equal to the percentage at 107
  - For the lowest credibility level, a 10% Bühlmann Z factor was assumed but limited to the CSO margins

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# PBR Margins, cont'd

- Margin recommendation 1: Different margins for credibility determined using Bühlmann versus Limited Fluctuation
  - Buhlmann Z factors by amount compared to the Limited Fluctuation Z factors by amount revealed that for the same data the two can be very different.
  - 19 "high credibility" companies had a Limited Fluctuation Z of 1.00, whereas the Bühlmann Z factors for these same companies ranged from 0.998 to 0.972 and the margins from the Bühlmann formula range from 1.0% to 4.0%.
  - For 16 companies with Limited Fluctuation Z factors that ranged from 0.893 to 0.512, the corresponding Bühlmann Z factors for these same companies ranged from 0.958 to 0.889 and the margin from the Bühlmann formula ranged from 4.1% to 7.7%.
- Margin recommendation 2: Bühlmann margin table should be more granular for Z factors above 0.90 due to the multitude of companies above that level
  - 35 out of 50 of the contributing companies had a Bühlmann Z above 0.90 compared to 19 for Limited Fluctuation – which were all at 1.0


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# PBR Margins, cont'd

- Margin recommendation 3: Bühlmann credibility typically requires the statistical agent to calculate. LATF could put a formula into VM-20 to allow companies to determine this directly. This would need to be revised as the underlying industry studies were revised.

$$Buhlmann\,Z = \frac{A}{A + \frac{(109\% * B)}{(0.019604 * A)} - \frac{(121\% * C)}{(0.019604 * A)}}$$

*where,*

- *A = Sum of expected deaths by amount = ∑ (amount insured) x (exposure) x (mortality)*
- *B = ∑(amount insured)$^2$ x (exposure) x (mortality)*
- *C = ∑(amount insured)$^2$ x (exposure)$^2$ x (mortality)$^2$*


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# PBR Margins – Bühlmann Credibility

| | % Margin by Credibility level (based on Bühlmann by Amount) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **AAGE** | **0-19** | **20-39** | **40-59** | **60-79** | **80-89** | **90-91** | **92-93** | **94-95** | **96-97** | **98** | **99+** |
| 0-45 | 20.4% | 19.3% | 16.3% | 12.7% | 8.9% | 7.3% | 6.5% | 5.7% | 4.6% | 3.3% | 2.3% |
| 50 | 19.8% | 18.8% | 15.9% | 12.3% | 8.7% | 7.1% | 6.4% | 5.5% | 4.5% | 3.2% | 2.2% |
| 60 | 18.2% | 17.2% | 14.5% | 11.2% | 7.9% | 6.5% | 5.8% | 5.0% | 4.1% | 2.9% | 2.1% |
| 70 | 16.1% | 15.2% | 12.8% | 9.9% | 7.0% | 5.7% | 5.1% | 4.4% | 3.6% | 2.6% | 1.8% |
| 80 | 13.6% | 12.8% | 10.8% | 8.4% | 5.9% | 4.9% | 4.3% | 3.8% | 3.1% | 2.2% | 1.5% |
| 90 | 10.7% | 10.1% | 8.5% | 6.6% | 4.7% | 3.8% | 3.4% | 3.0% | 2.4% | 1.7% | 1.2% |
| 100 | 7.4% | 7.0% | 5.9% | 4.6% | 3.2% | 2.6% | 2.4% | 2.1% | 1.7% | 1.2% | 0.8% |
| 106+ | 5.3% | 5.0% | 4.2% | 3.3% | 2.3% | 1.9% | 1.7% | 1.5% | 1.2% | 0.8% | 0.6% |


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# PBR Margins – Limited Fluctuation Method

- To determine the comparable margins using Limited Fluctuation Method for determining credibility, the following formula was used:

$$Margin = a/(b \times Z^2 + 1)$$

where,

- Z = credibility factor under Limited Fluctuation Method
- a and b are parameters solved for by minimizing the sum of squared differences of the Bühlmann and the Limited Fluctuation margins
- a = 0.198187; b = 4.577897
- Limited Fluctuation method assigns a credibility of 1 to many companies with different corresponding Bühlmann Zs. To get a tighter fit, the companies with a Limited Fluctuation margin of 1 were excluded to determine the values of the parameters.


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# PBR Margins – Limited Fluctuation Credibility

| | % Margin by Credibility level (based on Limited Fluctuation Method) | | | | | |
|---|---|---|---|---|---|---|
| **AAGE** | **0-19** | **20-39** | **40-59** | **60-79** | **80-89** | **90-100** |
| 0-45 | 20.4% | 13.2% | 9.1% | 6.3% | 4.8% | 4.0% |
| 50 | 19.8% | 12.9% | 8.9% | 6.1% | 4.7% | 3.9% |
| 60 | 18.2% | 11.7% | 8.1% | 5.6% | 4.3% | 3.5% |
| 70 | 16.1% | 10.4% | 7.2% | 5.0% | 3.8% | 3.1% |
| 80 | 13.6% | 8.8% | 6.1% | 4.2% | 3.2% | 2.6% |
| 90 | 10.7% | 6.9% | 4.8% | 3.3% | 2.5% | 2.1% |
| 100 | 7.4% | 4.8% | 3.0% | 2.1% | 1.6% | 1.3% |
| 106+ | 5.3% | 3.4% | 2.4% | 1.6% | 1.2% | 1.0% |

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