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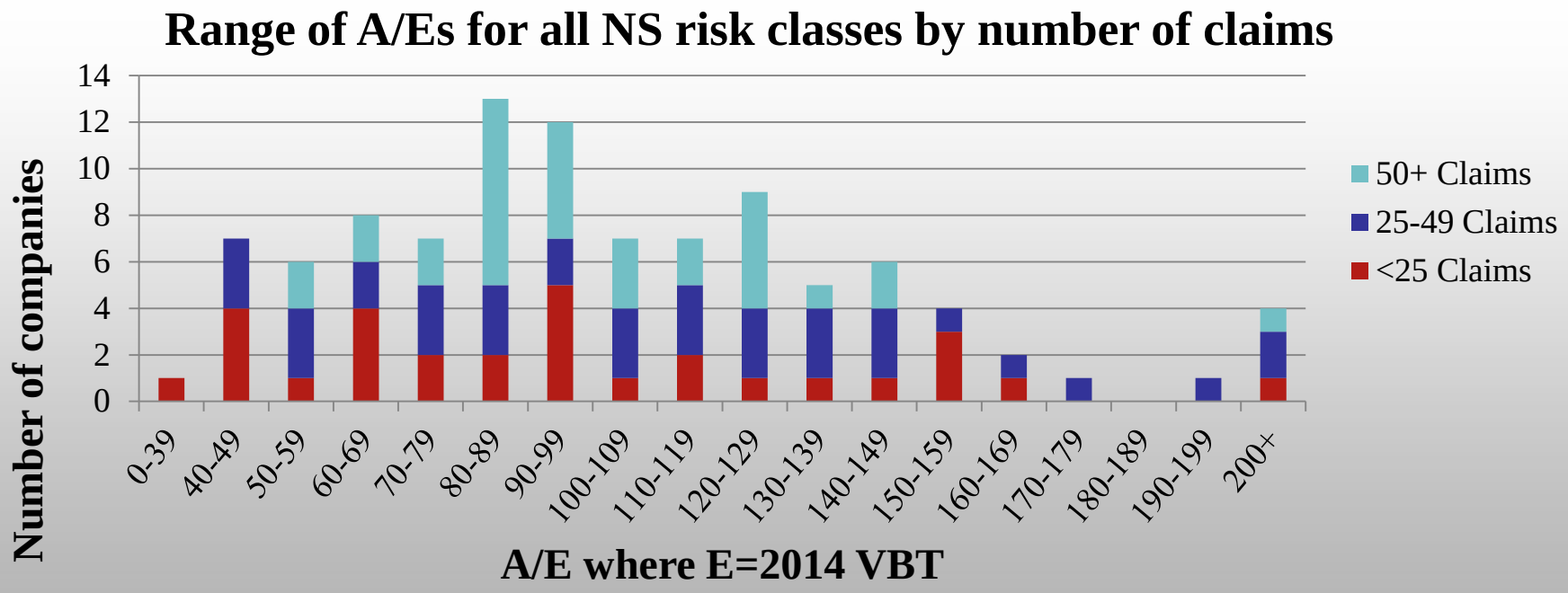
Determination of Relativity for RR Tables - Nonsmoker



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) • Significantly more data than in prior underlying studies • 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 • 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 • 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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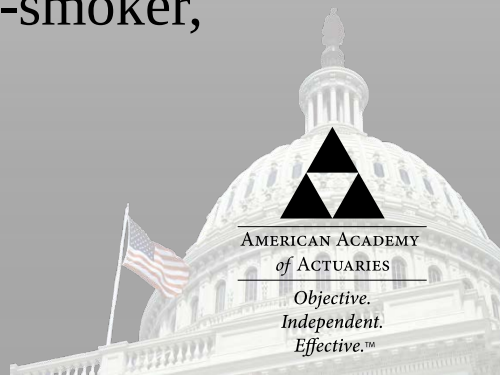

CSO Margin Structure, cont'd

- 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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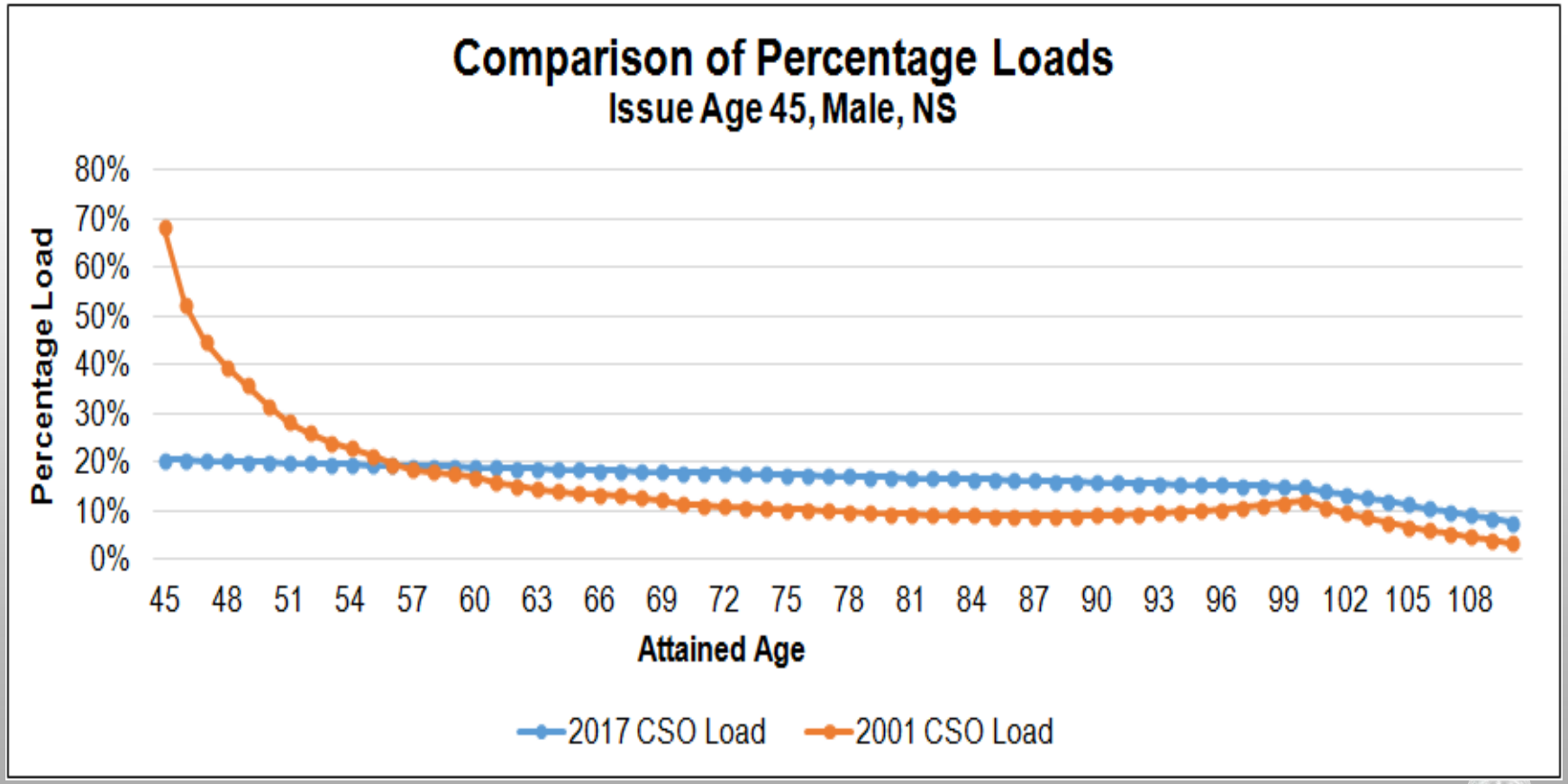
CSO Margin Structure, cont.



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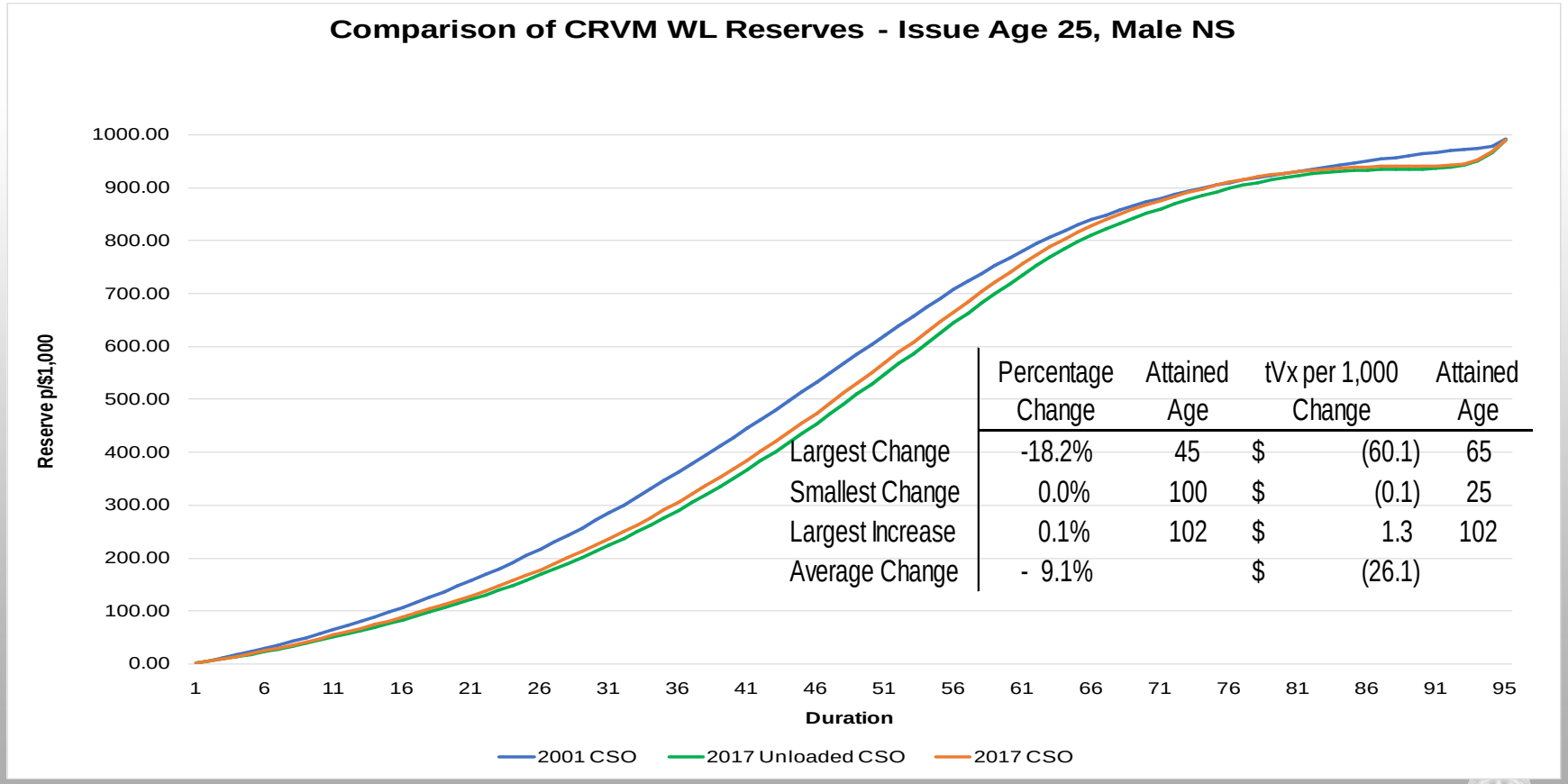
Whole Life Reserve Comparisons
CRVM Mean Reserves* - Male NS, Issue Age 25



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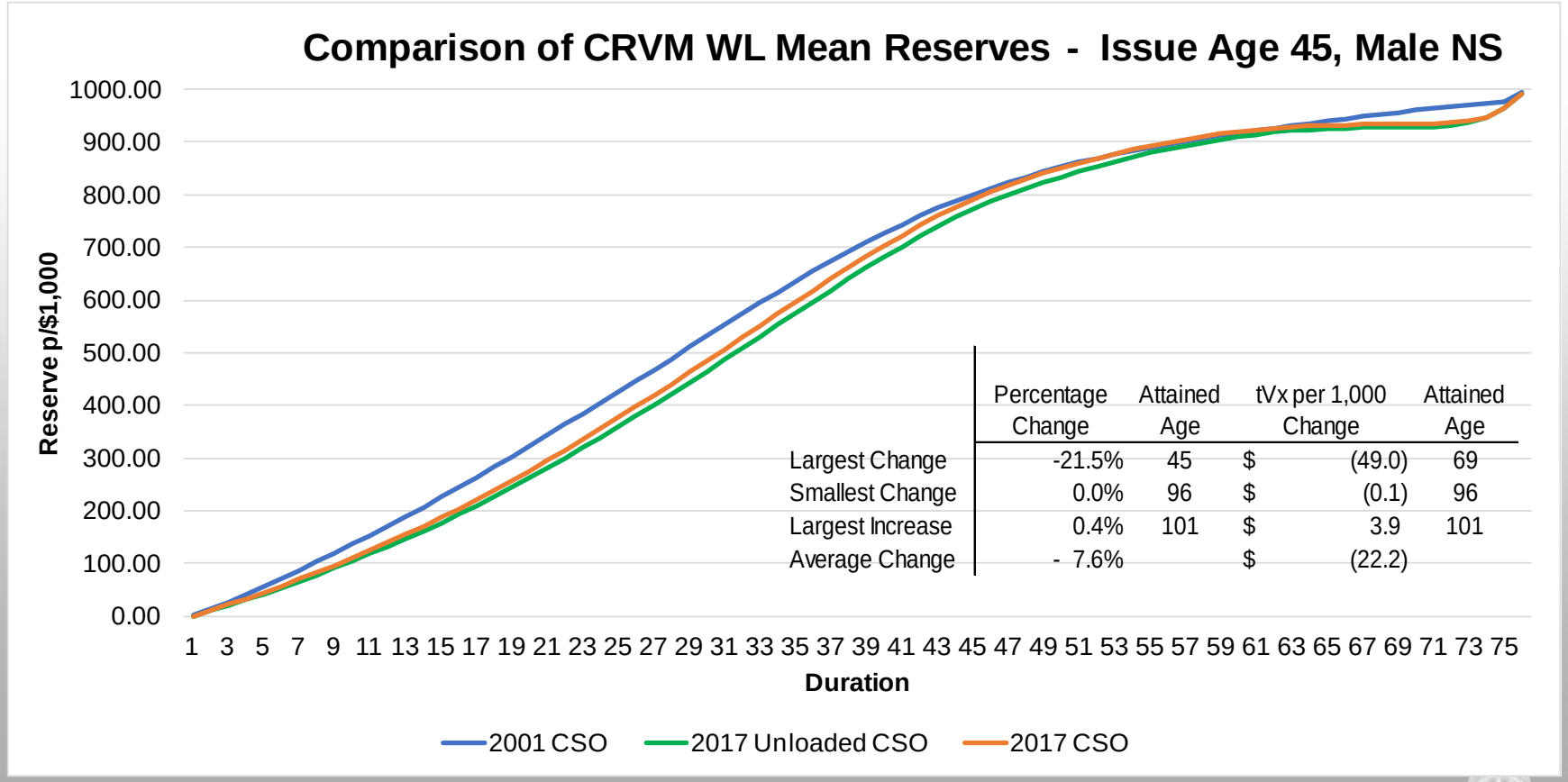
Whole Life Reserve Comparisons
CRVM Mean Reserves* - Male NS, Issue Age 45



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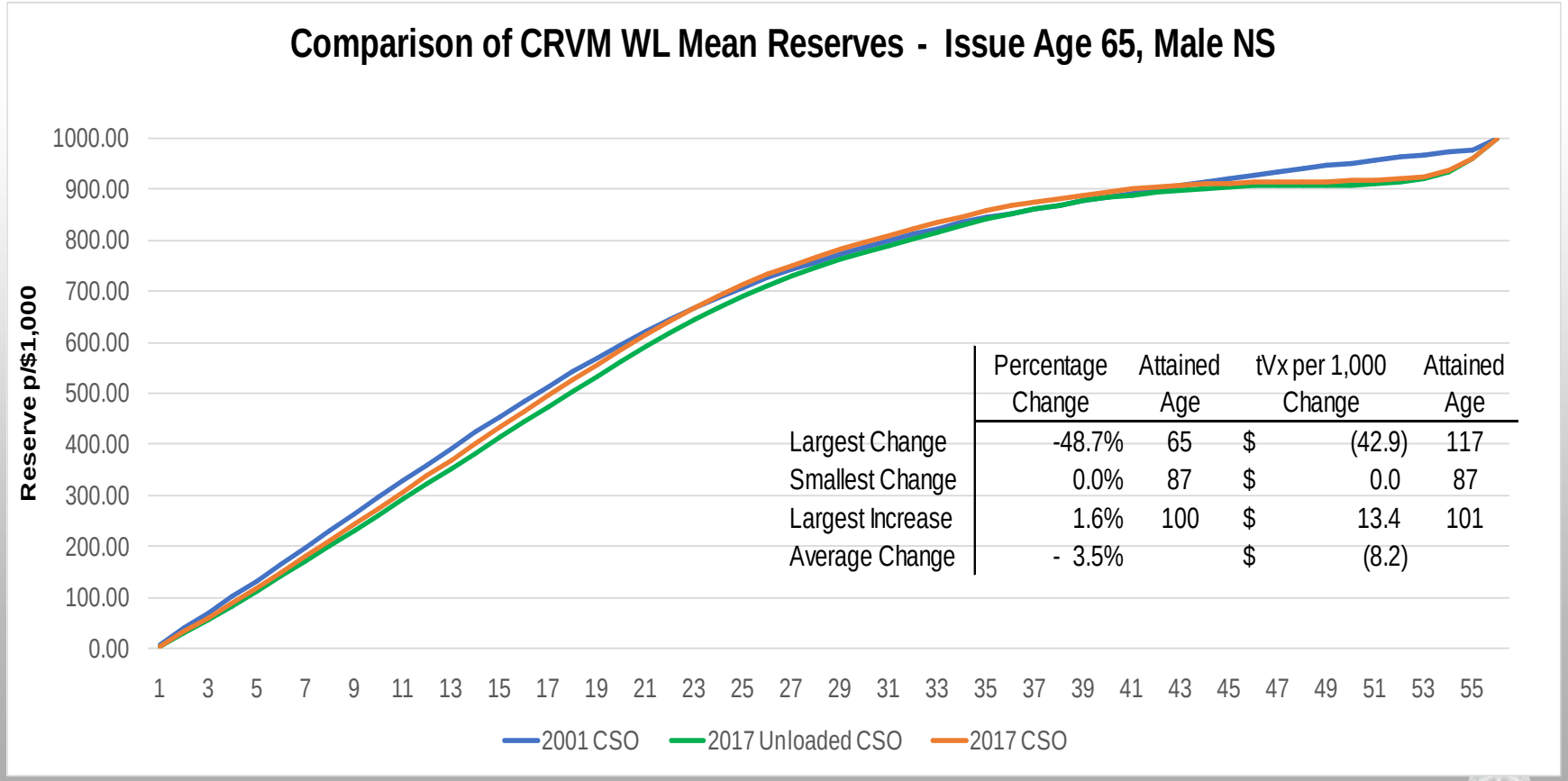
Whole Life Reserve Comparisons
CRVM Mean Reserves* - Male NS, Issue Age 65



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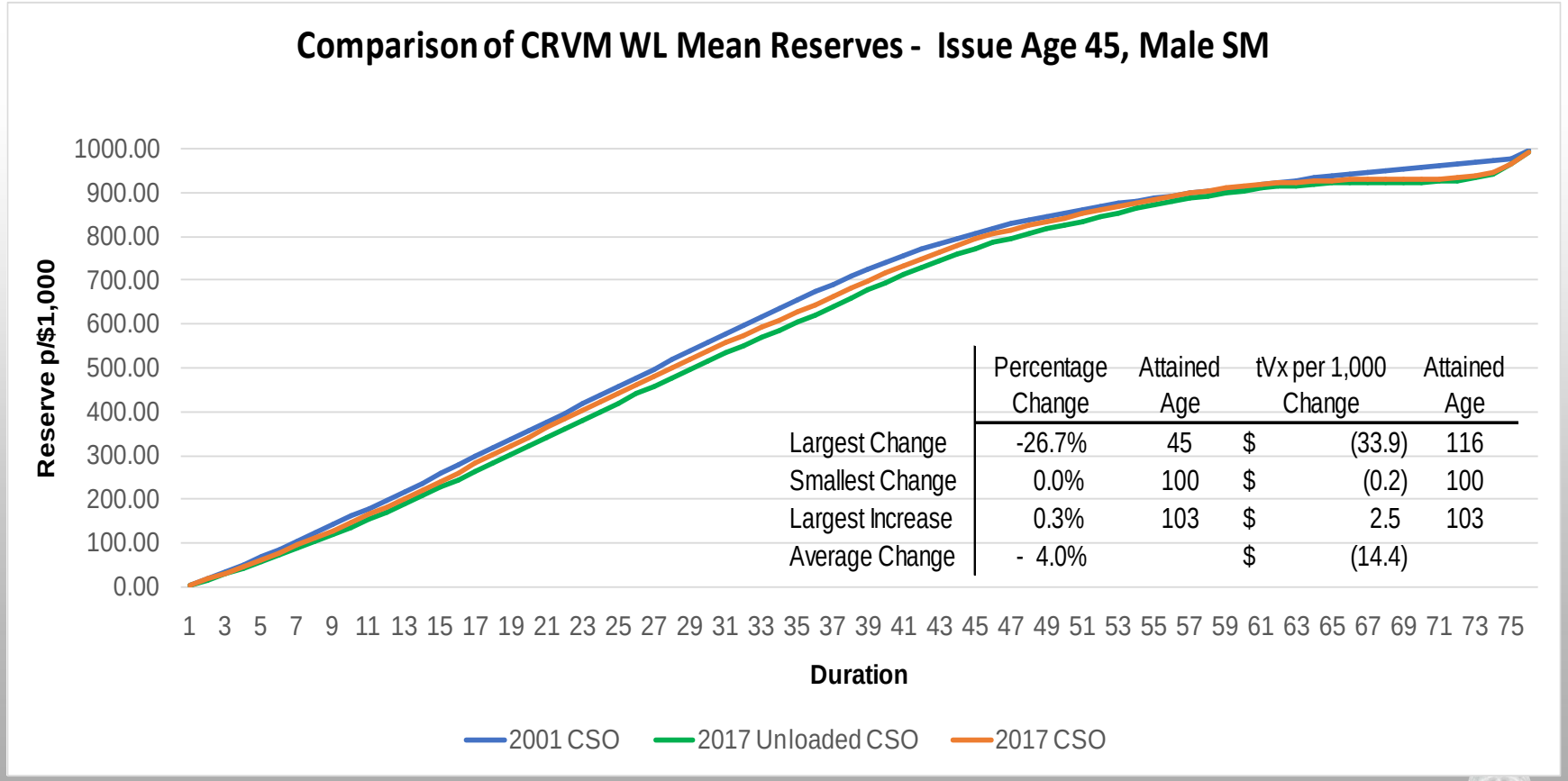
Whole Life Reserve Comparisons
CRVM Mean Reserves* - Male SM, Issue Age 45



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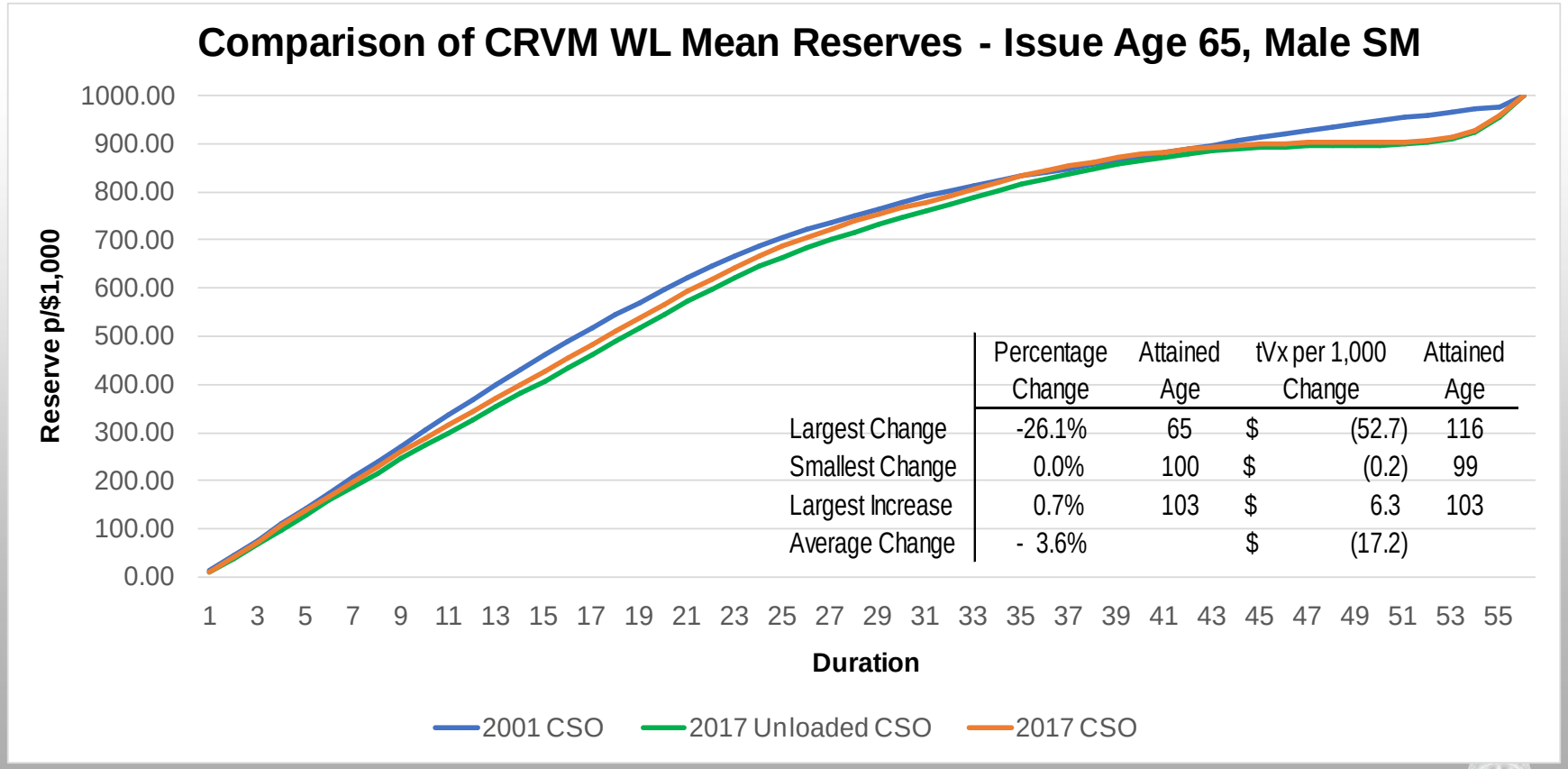
Whole Life Reserve Comparisons
CRVM Mean Reserves* - Male SM, Issue Age 65



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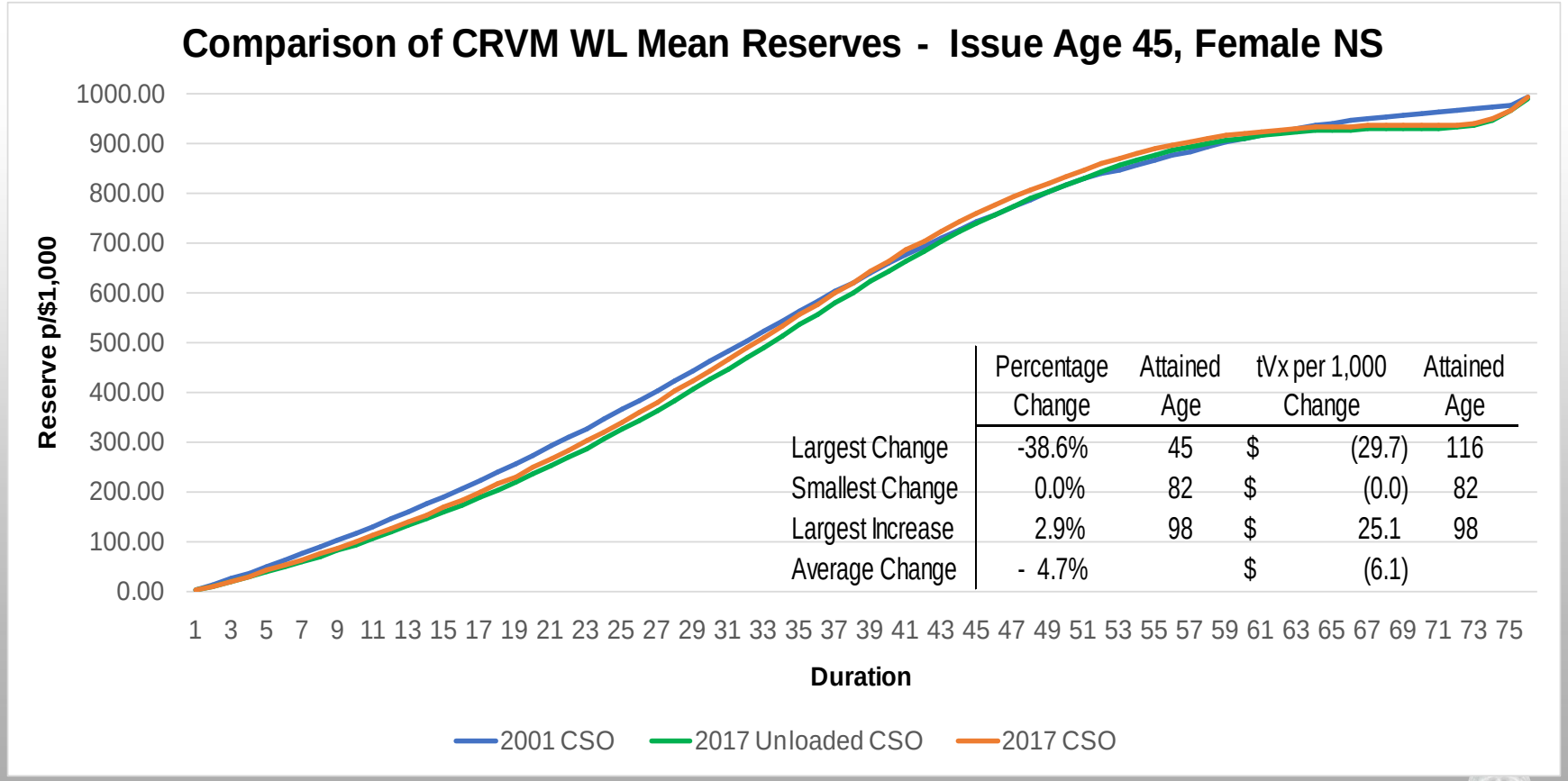
Whole Life Reserve Comparisons
CRVM Mean Reserves* - Female NS, Issue Age 45



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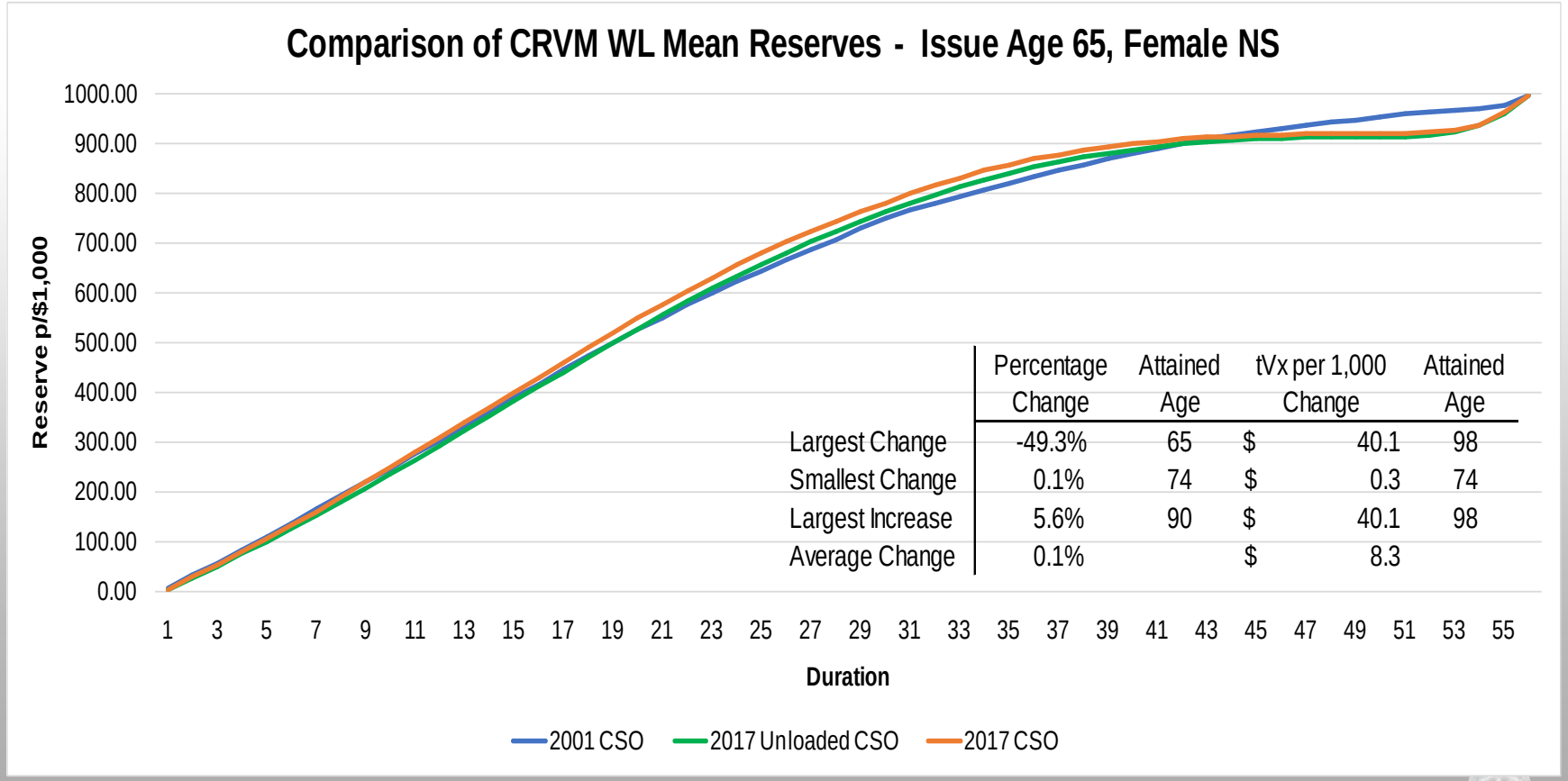
Whole Life Reserve Comparisons
CRVM Mean Reserves* - Female NS, Issue Age 65



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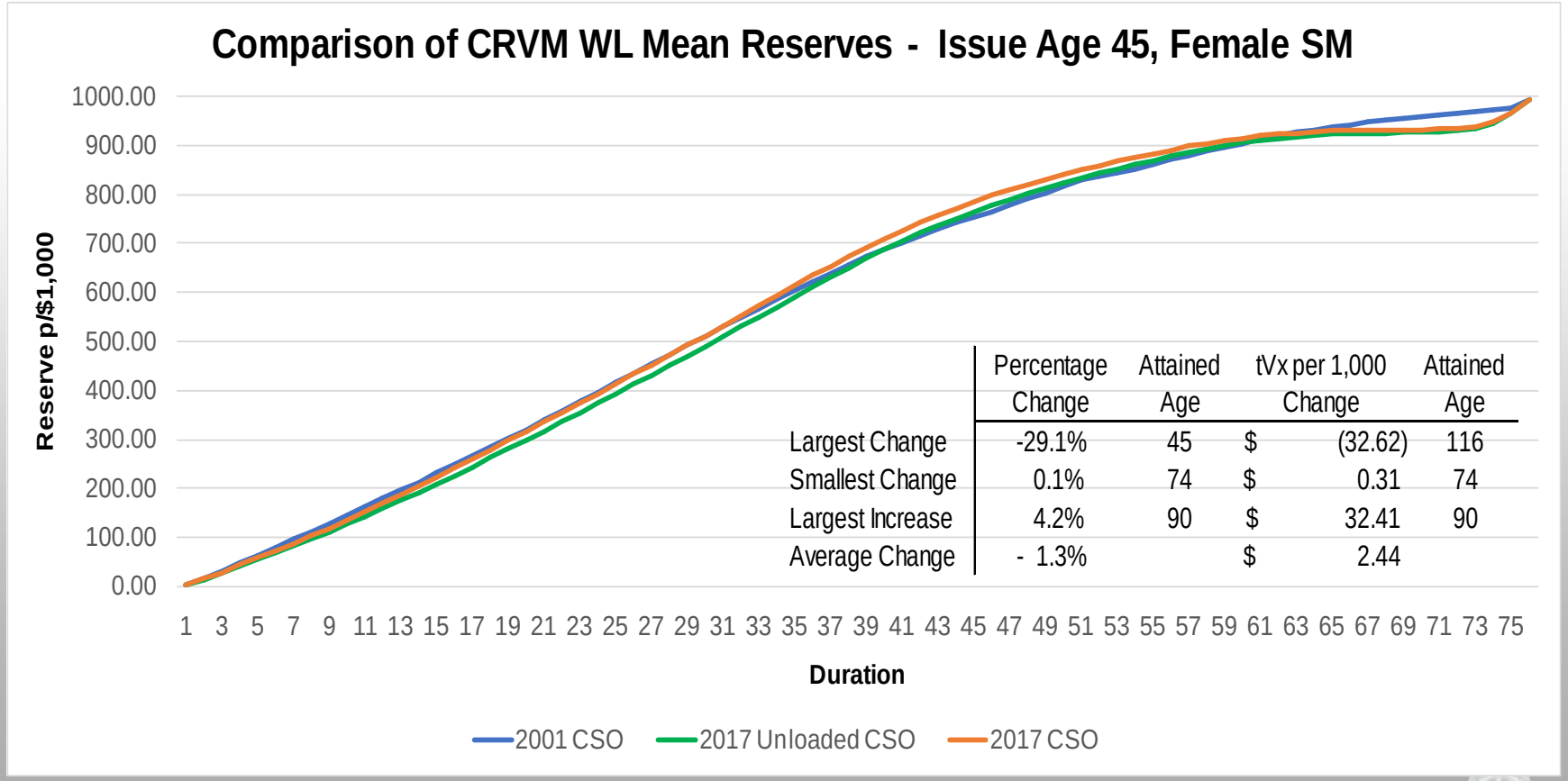
Whole Life Reserve Comparisons
CRVM Mean Reserves* - Female SM, Issue Age 45



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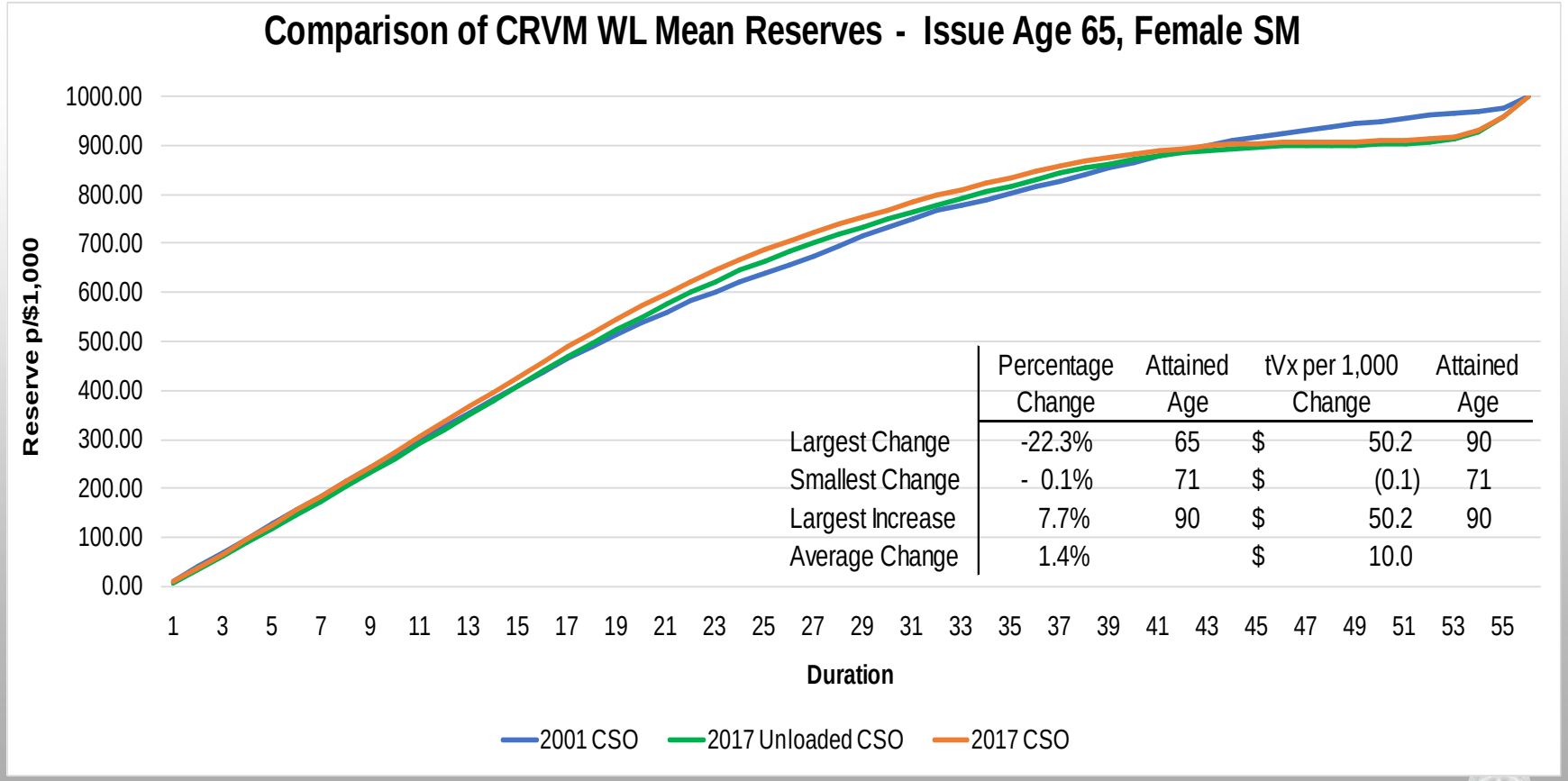
Whole Life Reserve Comparisons
CRVM Mean Reserves* - Female SM, Issue Age 65



	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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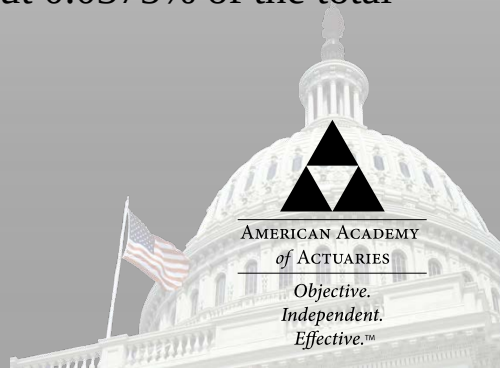

2017 CSO Development – Preferred Structure Tables, cont'd

- 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

* 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

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%

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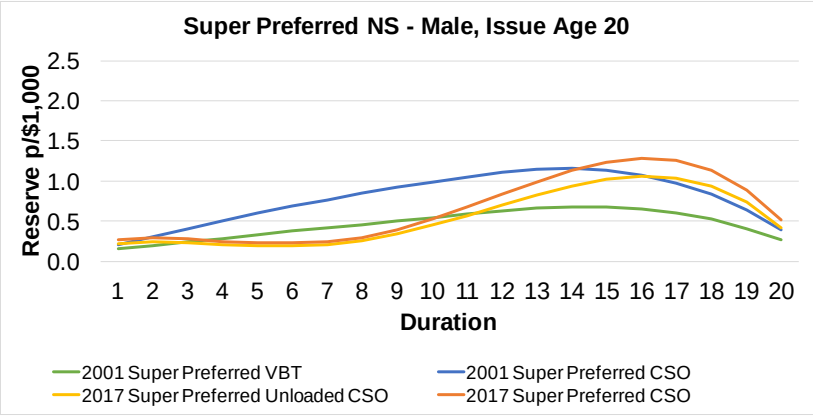
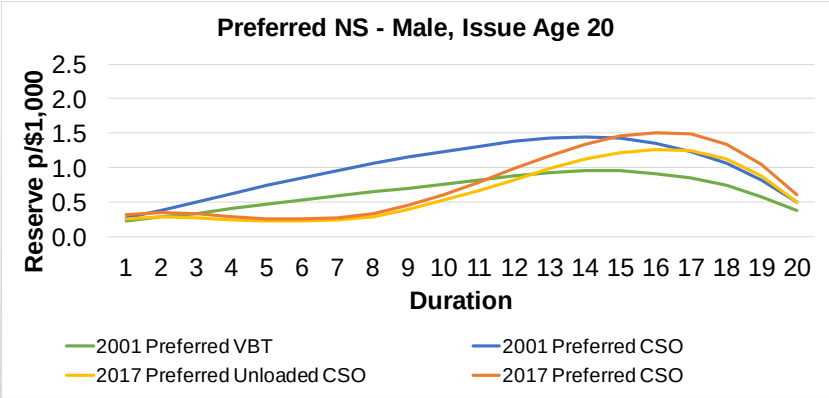
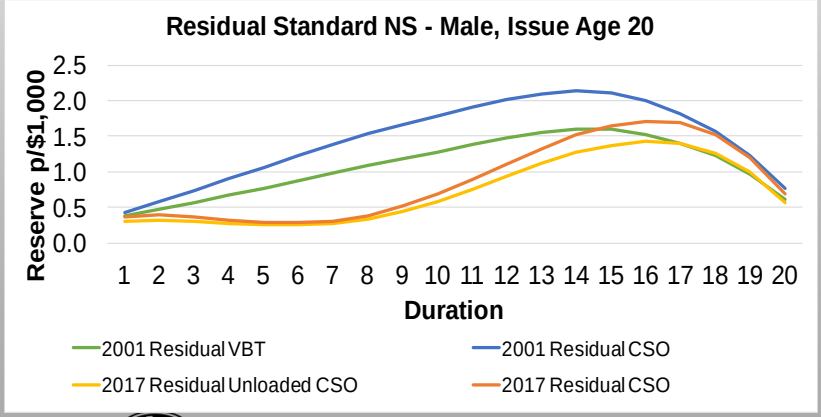
Preferred Structure Tables – Term Reserve Comparisons Male, NS, Issue Age 20

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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* Select & Ultimate Table, 4.5% Interest Rate, Fully Continuous

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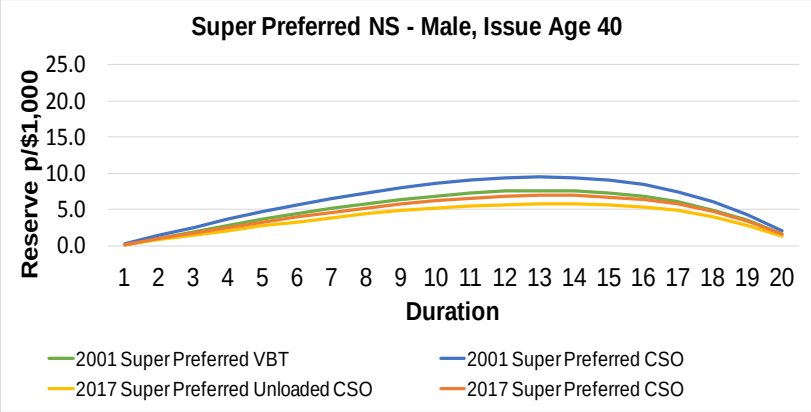
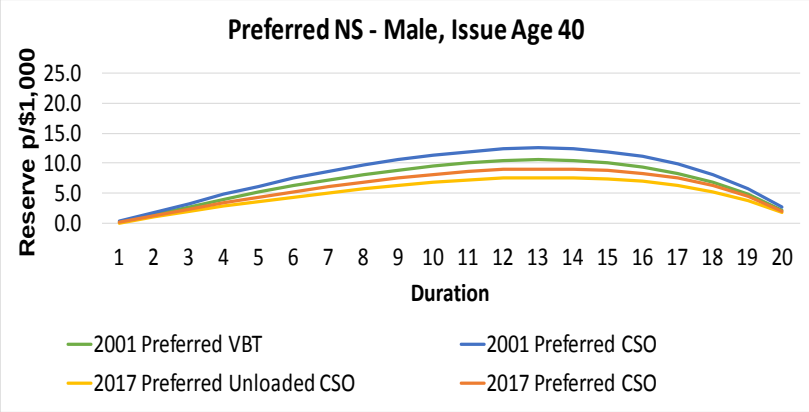
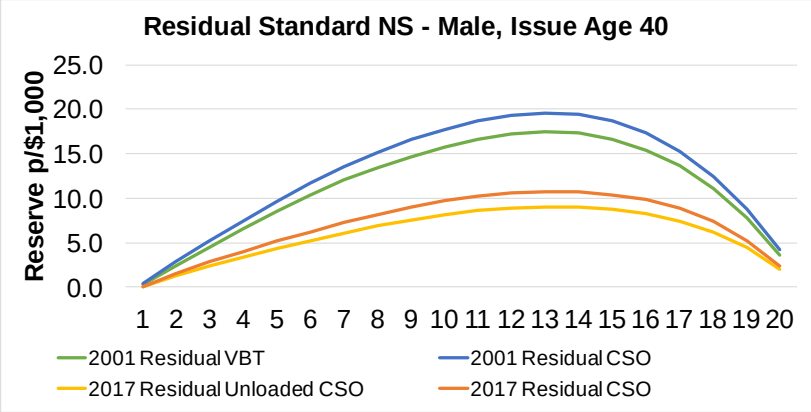
Preferred Structure Tables – Term Reserve Comparisons
Male, NS, Issue Age 40

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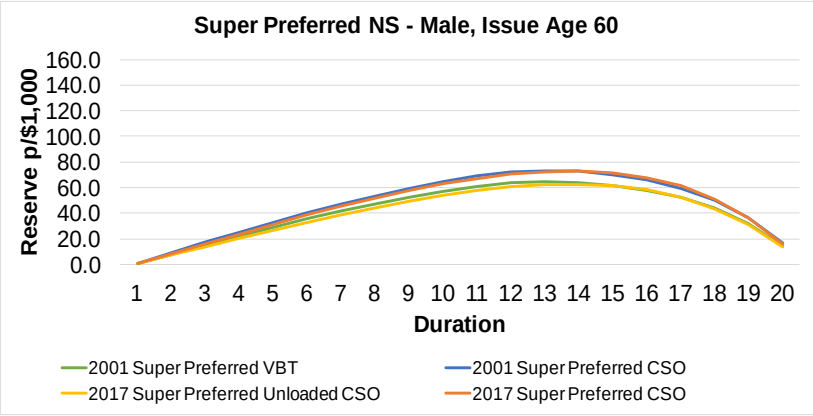
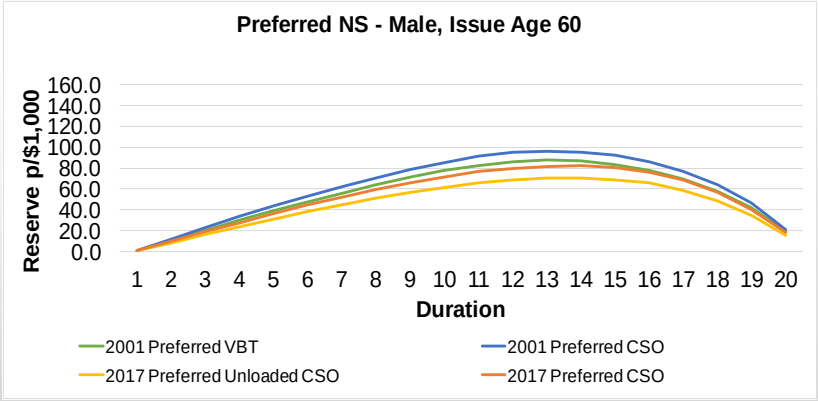
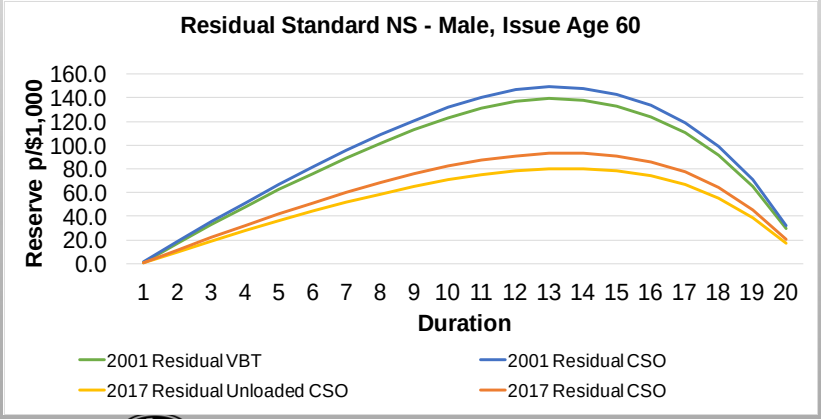
Preferred Structure Tables – Term Reserve Comparisons Male, NS, Issue Age 60

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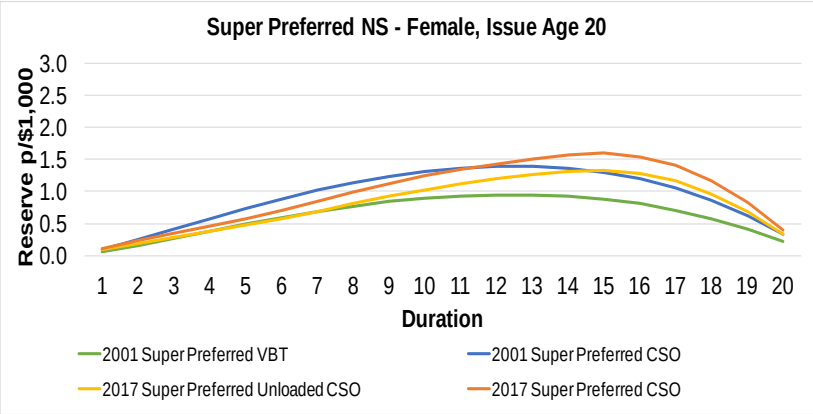
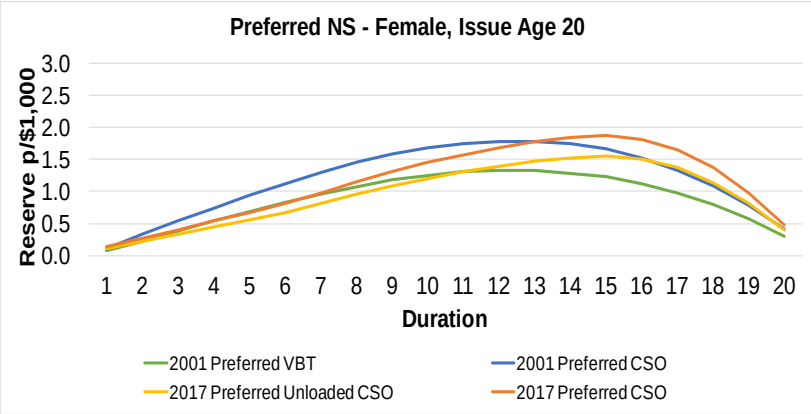
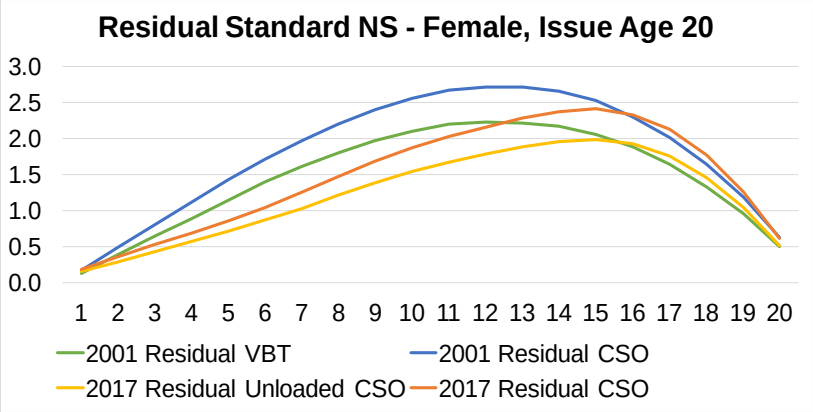
Preferred Structure Tables – Term Reserve Comparisons
Female, NS, Issue Age 20

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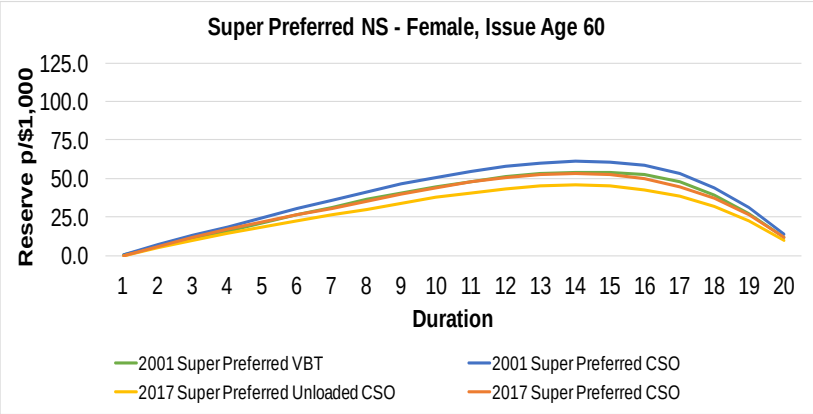
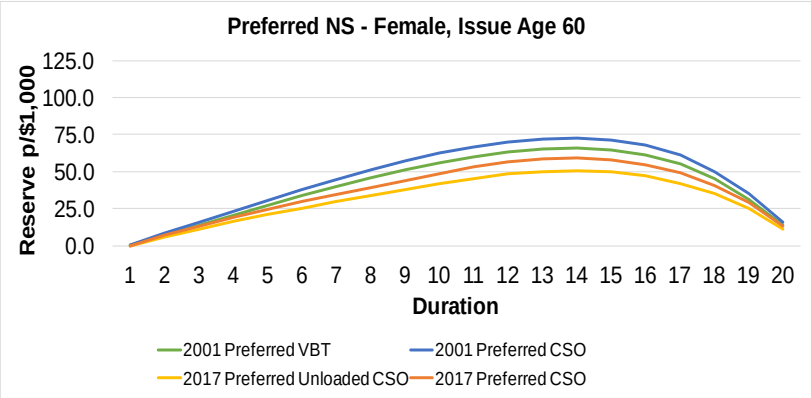
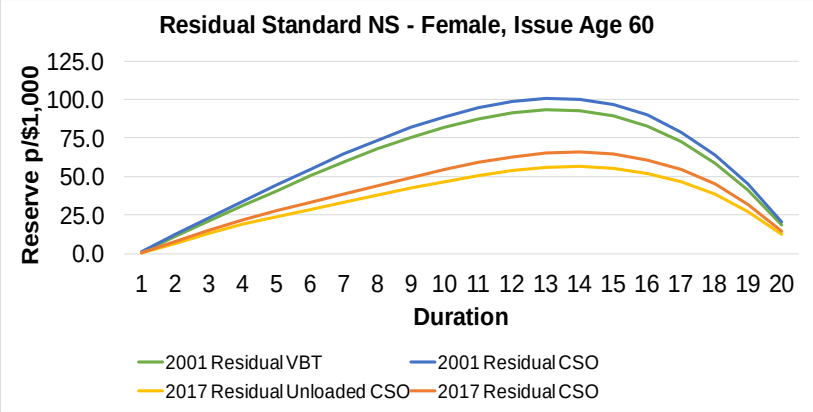
Preferred Structure Tables – Term Reserve Comparisons Female, NS, Issue Age 60

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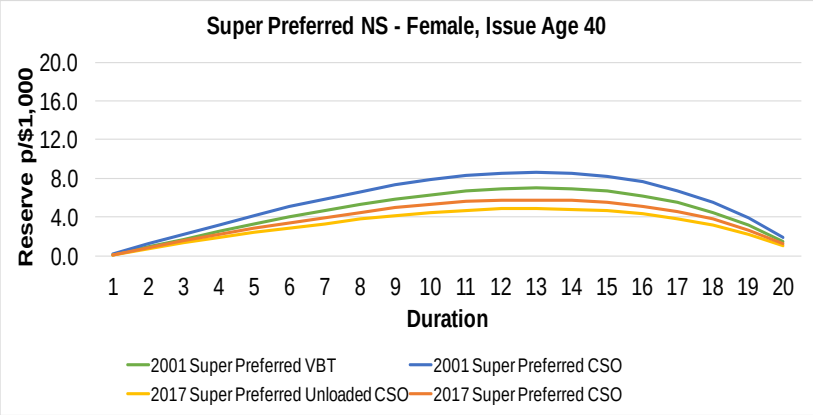
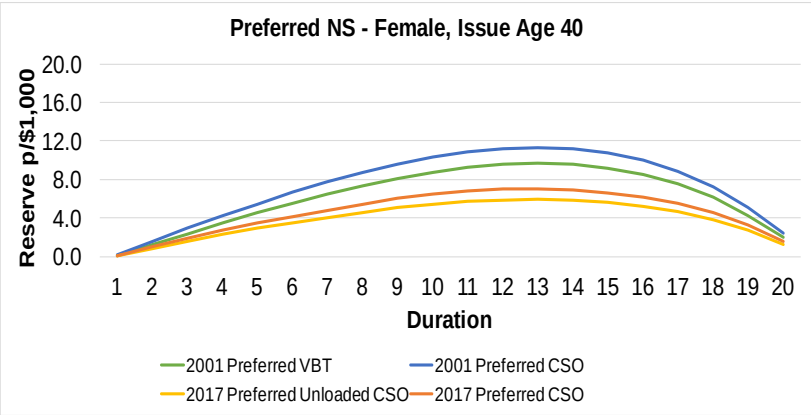
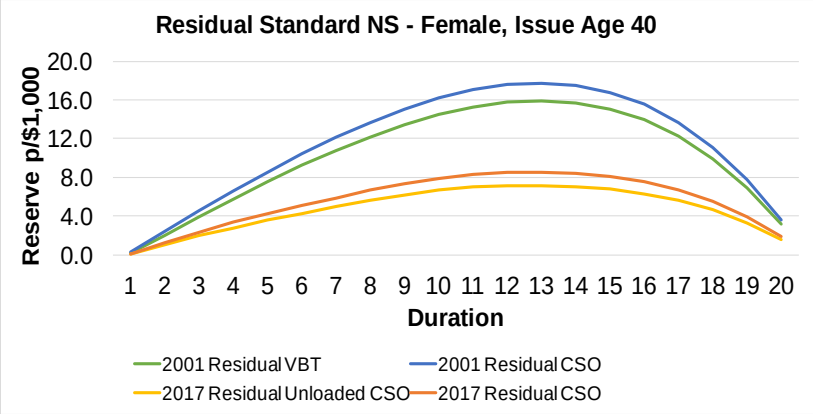
Preferred Structure Tables – Term Reserve Comparisons Female, NS, Issue Age 40

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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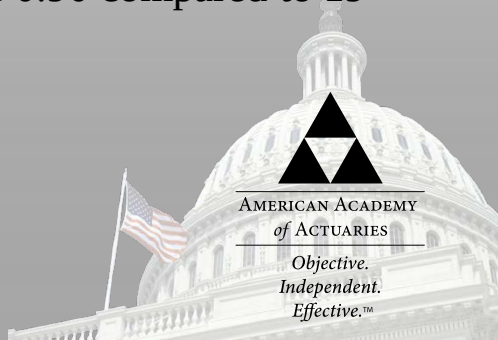

PBR Margins, cont'd

- 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.

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

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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