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APPLICATION OF SOUTHWESTERN PUBLIC SERVICE COMPANY FOR AUTHORITY TO CHANGE RATES	§ § §	**BEFORE THE STATE OFFICE OF ADMINISTRATIVE HEARINGS**

SOUTHWESTERN PUBLIC SERVICE COMPANY'S RESPONSE TO ALLIANCE OF XCEL MUNICIPALITIES' FIFTH REQUEST FOR INFORMATION QUESTION NOS. 5-1 THROUGH 5-7
(*Filename*: SPSRespAXM5th.doc; *Total Pages*: 142)

129

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SOUTHWESTERN PUBLIC SERVICE COMPANY'S RESPONSE TO ALLIANCE OF XCEL MUNICIPALITIES' FIFTH REQUEST FOR INFORMATION QUESTION NOS. 5-1 THROUGH 5-7

Southwestern Public Service Company ("SPS") files this response to Alliance of Xcel Municipalities' ("AXM") Fifth Request for Information Question Nos. 5-1 through 5-7.

I. WRITTEN RESPONSES

SPS's written responses to AXM's Fifth Request for Information are attached and incorporated by reference. Each response is stated on or attached to a separate page on which the request has been restated. SPS's responses are made in the spirit of cooperation without waiving SPS's right to contest the admissibility of any of these matters at hearing. In accordance with P.U.C. PROC. R. 22.144(c)(2)(A), each response lists the preparer or person under whose direct supervision the response was prepared and any sponsoring witness. When SPS provides certain information sought by the request while objecting to the provision of other information, it does so without prejudice to its objection in the interests of narrowing discovery disputes under P.U.C. PROC. R. 22.144(d)(5). As allowed under P.U.C. PROC. R. 22.144(c)(2)(F), SPS stipulates that its responses may be treated by all parties as if they were made under oath.

II. INSPECTIONS.

If responsive documents are more than 100 pages but less than eight linear feet in length, the response will indicate that the attachment is voluminous ("(V)") and, pursuant to P.U.C. PROC. R. 22.144(h)(2), the exhibit will be made available for inspection at SPS's voluminous room at 401 Congress Avenue, Suite 2100, Austin, Texas 78701; telephone number (512) 370-2867. Voluminous exhibits will also be provided on CD to any requesting party. Further, SPS will upload all voluminous documents, along with all native files for review to SPS's Sharepoint website:

https://collaboration.xcelenergy.com/sps/SPSFinalRateCases/default.aspx

All parties will be provided a log in id number at time of intervention to access the Sharepoint website.

If a response or the responsive documents are provided pursuant to the protective order in this docket, the response will indicate that it or the attachment is either confidential ("CONF") or highly Sensitive ("HS") as appropriate under the protective order. Confidential and Highly Sensitive materials will be served on all parties that have signed and filed the certification under the protective order entered in this docket. Confidential and Highly Sensitive responsive documents will also be made available for inspection at SPS's voluminous room, unless they form a part of a response that exceeds eight linear feet in length; then they will be available at their usual repository in accordance with the following paragraph. Please call in advance for an appointment to ensure that there is sufficient space to accommodate your inspection.

If responsive documents exceed eight linear feet in length, the response will indicate that the attachment is subject to the FREIGHT CAR DOCTRINE, and, pursuant to P.U.C. PROC. R. 22.144(h)(3), the attachment will be available for inspection at its usual repository, SPS's offices in Amarillo, Texas, unless otherwise indicated. SPS requests that parties wishing to inspect this material provide at least 48 hour notice of their intent by contacting Ron Moss of Winstead P.C., 401 Congress Avenue, Suite 2100, Austin, Texas 78701; telephone number (512) 370-2867; facsimile transmission number (512) 370-2850; email address rhmoss@winstead.com. Inspections will be scheduled to accommodate all requests with as little inconvenience to the requesting party and to SPS's operations as possible.

Respectfully submitted,

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BY: Amy M Shel

ATTORNEYS FOR
SOUTHWESTERN PUBLIC SERVICE COMPANY

RESPONSES

QUESTION NO. AXM 5-1:

[[**Qualified Pension]** **Ref: Schrubbe Direct, page 22**. At page 22, Mr. Schrubbe indicates that SPS did not request a known and measurable adjustment to qualified pension expense. In reference to prior rate cases, Mr. Schrubbe also states that "SPS requested an adjustment to pension and other posts-employment and retirement benefits expense because the forward-looking costs were generally known and measurable." Please provide the following:

a. Please define the term "known and measurable" as used by Mr. Schrubbe in this context.

b. Referring to part (a) above, does Mr. Schrubbe believe that the known and measurable concept should be applied differently for changes that have occurred within the historic test year versus those that may or may not occur subsequent to the historic test year? Please explain.

RESPONSE:

a. Mr. Schrubbe considers an expense to be known if it has occurred, if it is certain to occur, or if it is nearly certain to occur. There may be other circumstances in which an expense could be considered known, but Mr. Schrubbe has not analyzed all possible circumstances. Mr. Schrubbe considers an expense to be measurable if it can be quantified with certainty or near certainty.

b. Mr. Schrubbe has not analyzed this issue and therefore has no opinion on it at this time.

Preparer: Kristin Lindemann
Sponsor: Richard R. Schrubbe

QUESTION NO. AXM 5-2:

[Qualified Pension] **<u>Ref: Schrubbe Direct, pages 22-23</u>**. Beginning at page 22, Mr. Schrubbe indicates that SPS did not request a known and measurable adjustment to qualified pension expense and discusses possible changes resulting from new mortality tables issued by the Society of Actuaries (i.e., drafts published in February 2014) "that reflect longer lives, and thus longer periods in which former employees are likely to collect pensions and other post-employment and retirement benefits." With the uncertainty of the impact of adoption of the new mortality tables, "SPS has decided to not propose a known and measurable adjustment to pension and other post-employment and retirement benefits." Please provide the following:

a. Please confirm the accuracy of the above summary. If the Company cannot provide the requested confirmation, please explain.

b. Please provide a copy of the published draft of the new mortality tables, along with any accompanying narrative or explanatory discussion material. If the requested material has already been provided, please provide a pinpoint reference to such documentation.

c. Please explain the process surrounding the solicitation of comments/changes to the published draft, leading to finalizing and implementing new mortality tables.

d. Please provide Mr. Schubbe's best estimate of when new mortality tables will be implemented for use in actuarial studies.

RESPONSE:

a. Confirmed.

b. Please refer to Exhibit SPS-AXM 5-2(b).

c. Please refer to Exhibit SPS-AXM 5-2(c).

d. In February 2015, Xcel Energy's actuaries are expected to provide the new mortality tables that will be used in actuarial reports on a going-forward basis. The mortality rates reflected in the tables will be used in actuarial reports applicable to year-end 2014, although those new mortality rates will not affect the 2014 pension cost. The rates based on the new mortality tables will affect pension cost in 2015 and subsequent years.

Preparer: Kristin Lindemann
Sponsor: Richard R. Schrubbe

QUESTION NO. AXM 5-3:

[Qualified Pension] **<u>Ref: Schrubbe Direct, page 22</u>**. At page 22, Mr. Schrubbe states that the qualified pension expense SPS proposes for the test year is $16,202,277 and refers to Attachment RRS-RR-1. Please provide the following:

a. Please confirm that the $16,202,277 qualified pension amount, as supported by Attachment RRS-RR-1, represents the average of the 2013 and 2014 actuarial studies (i.e., based on a June 2014 test year with 6 months from each study period). If the Company cannot provide the requested confirmation, please explain.

b. Please confirm that if the qualified pension costs were instead based on the more recent 2014 actuarial study the adjusted test year amount would have been $14,262,356 (i.e., simply replace the average calculation on Attachment RRS-RR-1 with the 2014 actuarial study amounts). If the Company cannot provide the requested confirmation, please explain and provide additional supporting calculations.

RESPONSE:

a. Confirmed.

b. Not confirmed. The percentages allocated to O&M and capital would be slightly different if the amount was based solely on calendar year 2014, instead of a blend of 2013 and 2014. If the historical Test Year amounts were replaced with calendar year 2014 amounts, the qualified pension expense would be $14,308,146. Please refer to Exhibit SPS-AXM 5-3 for the supporting calculations.

Preparer: Kristin Lindemann
Sponsor: Richard R. Schrubbe

QUESTION NO. AXM 5-4:

[Pension & Benefit Costs] **Ref: Schrubbe Direct, Attachment RRS-RR-1**. Referring to spreadsheet file "02 – RRS-RR-1.xlsx", the O&M allocation factors are different for qualified pension/non-qualified pension, OPEB retiree medical, FAS112 long-term disability and FAS112 work comp (see spreadsheet rows 20 and 25). Please provide the following:

a. Please explain why the Account 926 O&M allocation factors applied to SPS direct charges are different for qualified pension/non-qualified pension (66.12%), OPEB retiree medical (66.22%), FAS112 long-term disability (65.65%) and FAS112 work comp (65.24%).

b. Please explain why the Account 926 O&M allocation factors applied to XES allocated charges are different for qualified pension/non-qualified pension (11.62%), OPEB retiree medical (11.61%) and FAS112 long-term disability (12.06%).

c. Referring to parts (a) and (b) above, the referenced O&M allocation factors represent hard input values into spreadsheet file "02 – RRS-RR-1.xlsx". Please provide workpapers supporting the derivation of each O&M allocation factor in a spreadsheet file format showing all calculations and intact cell formulae. If the requested information has already been provided, please provide a pinpoint reference to the source spreadsheet files supporting these O&M allocation factors.

RESPONSE:

a. The percentages set forth in the question represent the average for the 12-month period ending June 2014. However, the percentages are calculated on a monthly basis, and they vary by month because the amount of labor allocated to O&M varies by month. Because the amount of benefit costs accrued also varies by month due to the timing of true-ups and adjustments, each of the categories of benefit exhibits a different pattern of expense.

b. Please refer to the response to subpart (a).

c. Please refer to Exhibit SPS-AXM 5-4.

Preparer: Kristin Lindemann
Sponsor: Richard R. Schrubbe

QUESTION NO. AXM 5-5:

[Pension & Benefit Costs] **<u>Ref: Schrubbe Direct, Attachment RRS-RR-1</u>**. Referring to spreadsheet file "02 – RRS-RR-1.xlsx", the actuarial amounts for qualified pension, OPEB retiree medical, non-qualified pension, FAS112 long-term disability and FAS112 work comp (see spreadsheet row 29) are adjusted by values generally identified as "Affiliate Charges/misc". Please provide the following:

a. Please explain and describe the purpose of the Affiliate Charges/misc amounts for qualified pension, OPEB retiree medical, non-qualified pension, FAS112 long-term disability and FAS112 work comp.

b. The cell formulae underlying the amounts referenced in part (a) above are comprised of multiple hard input values. Please provide the source documents from which these values were obtained, clearly identifying which values relate to the 2013 versus 2014 actuarial studies, as applicable. If the requested information has already been provided, please provide a pinpoint reference to the source of each input value.

RESPONSE:

a. Affiliate charges include immaterial amounts allocated from other Xcel Energy operating companies, whereas miscellaneous amounts are due to differences in calculating costs for the 12 months ended June 30, 2014, as opposed to calculating them individually for each month. Please refer to SPS's response to Question No. AXM 5-4(a) for an explanation of the differences that result from calculating a yearly average versus monthly amounts.

b. Please refer to Exhibit SPS-AXM 5-4.

Preparer: Kristin Lindemann
Sponsor: Richard R. Schrubbe

QUESTION NO. AXM 5-6:

[Qualified Pension] **Ref: Schrubbe Direct, pages 13 & 22 and Table RRS-RR-1.** According to Table RRS-RR-1, the unadjusted qualified pension expense SPS proposes for the current test year ended June 30, 2014, is $16,202,277. In the last rate case (see Table RRS-RR-1 per Schrubbe Direct at 10), the unadjusted qualified pension for the test year ended June 30, 2013, was $9,566,122. Please provide the following:

a. Please confirm that the primary difference between these qualified pension amounts is that Table RRS-RR-1 from the current case is presented on a total SPS basis (i.e., before jurisdictional allocation) while Table RRS-RR-1 from SPS' last rate case (Docket No. 42004) was presented on a Texas jurisdictional basis. If the Company cannot provide the requested confirmation, please explain.

b. Other than jurisdictional allocation differences, please identify and describe the key factors contributing to the change in qualified pension costs between the test years ended June 2013 and June 2014.

c. Referring to part (b) above, please provide a side by side comparison of each identified key factor.

RESPONSE:

a. Confirmed. The $16,202,277 is the SPS O&M amount before being allocated among jurisdictions, and the $9,566,122 from Docket No. 42004 was the SPS O&M amount on a Texas retail basis. Multiplying the $16,202,277 from this current case by the Texas retail jurisdictional percentage of 58.544898 percent results in a Texas retail amount of $9,485,607. This results in a reduction from the last case of $80,515.

b. The decrease in costs is driven primarily by an increase in the discount rate, an improvement in the market returns on pension trust fund assets, and the expiration of a prior year service cost amortization, all of which decreased costs. Those decreases were partially offset by unfavorable demographic experience and updates to the mortality tables, both of which increased costs. Please note that the updates to the mortality tables are not the same mortality table updates discussed on page 22 of Mr. Schrubbe's testimony. Note also that these explanations of year-over-year cost changes are applicable to Xcel Energy's pension plans as a whole. Xcel Energy's actuary did not provide explanations specific to SPS's pension plans.

c. SPS has not performed the requested analysis. Because of the complexity of the requested calculation, a detailed side-by-side comparison quantifying these key factors would require a special study by SPS's outside actuarial firm. Because such a study would be expensive, and because the dollar amounts are relatively small, SPS has not requested that the study be performed.

Preparers: Arthur P. Freitas, Kristin Lindemann
Sponsor: Richard R. Schrubbe

QUESTION NO. AXM 5-7:

[Qualified Pension] **Ref: Schrubbe Direct, pages 18-21 and Attachment RRS-RR-3**. At page 11 of Attachment RRS-RR-3, the "Net (Gain)/Loss" amortization for 2014 is shown as $5,351,000 for SPS non-bargaining and $7,975,000 for SPS bargaining employees. The referenced testimony discusses how the net (gains)/losses are aggregated and amortized (considering the ten-percent corridor that applies in certain circumstances). Please provide additional support for each identified amortization amount showing the following information by year or vintage:

a. Each year's gains or losses.

b. The 10% corridor, if applicable.

c. The amount outside any applicable corridor that is subject to amortization.

d. The amortization period.

e. The month/year the amortization of each year's gain/loss started and is scheduled to end.

f. Referring to part (e) above, please explain whether the amortization term of each year's gain/loss is reset to reflect the most current average remaining future service of active plan participants.

RESPONSE:

a. Each year's gains and losses are not considered in isolation, but rather the current year's gains and losses are aggregated with the prior years' gains and losses. As a result, each year's specific gain or loss that is being amortized cannot be readily determined. The determination of the gain or loss amortization is a multi-step process composed of the following steps:

- SPS first determines whether it has an asset gain or loss by comparing the actual return on assets for the prior year to the expected return on assets for the prior year.

- To the extent that there is an asset gain or a loss, SPS phases in 20 percent of that gain or loss. SPS also phases in portions of gains and losses from prior years that have not been fully phased in. They are phased in at the rate of 20 percent per year.

- SPS then calculates the gain or loss on the Pension Benefit Obligation ("PBO") by comparing the actual year-end PBO from the prior year to the expected year-end PBO for the prior year.

- SPS next aggregates the cumulative net gains and losses from all prior years to arrive at the cumulative unrecognized gains or losses.

- If the cumulative unrecognized gains and losses are more than 10 percent of the greater of the PBO or the market value of assets, the balance of gains and losses that falls outside the corridor is amortized over the average expected remaining years of service of SPS's employees (typically years to retirement).

b. Both the SPS Bargaining and the Former NCE SPS Non-Bargaining pension plans were outside the 10 percent corridor in 2014. Xcel Energy Services Inc. employees, who are in the Xcel Energy Pension Plan ("XEPP"), also charge a portion of their qualified pension cost to SPS. The XEPP was also outside the corridor in 2014.

c - d. See the table below for the requested information for the three plans that affect SPS.

	(Amounts in Thousands)		
2014	**SPS Bargaining**	**NCE Non-Bargaining**	**XEPP**
Amount outside corridor & subject to amortization	$118,668	$89,314	$706,627
Amortization period in years	14.88	8.41	10.27
Total Plan Amortization	$7,975	$10,620	$68,805
Percent attributable to SPS & XES	100%	50.39%	19.983%
Amortization amount attributable to SPS & XES	$7,975 (SPS)	$5,351 (SPS)	$13,749 (XES)

e. Because the current year's gains and losses are aggregated with the prior years' gains and losses, each year's specific gain or loss that is being amortized cannot be readily determined.

f. The amortization length is reset each year to reflect the most current average remaining future service of active plan participants.

Preparer: Todd Degrugillier
Sponsor: Richard R. Schrubbe

CERTIFICATE OF SERVICE

I certify that on the 20th day of January, 2015, a true and correct copy of the foregoing instrument was served on all parties of record by a combination of electronic service and hand delivery, Federal Express, regular first class mail, certified mail, or facsimile transmission as allowed under SOAH Order No. 3, pages 3-4.

EXPOSURE DRAFT

Society of Actuaries

RP-2014 Mortality Tables

February 2014

Society of Actuaries
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Schaumburg, IL 60173
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Caveat and Disclaimer

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About This Exposure Draft

Comments

The SOA solicits comments on this exposure draft. Comments should be sent to Erika Schulty, at eschulty@soa.org by May 31, 2014. Please include "RP-2014 Comments" in the subject line.

TABLE OF CONTENTS

Section 1. Executive Summary

1.1 Purpose of SOA's Pension Mortality Study

As part of its periodic review of retirement plan mortality assumptions, the SOA's Retirement Plans Experience Committee (RPEC or "the Committee") initiated a Pension Mortality Study in 2009. The primary focus of this study was a comprehensive review of recent mortality experience of uninsured private[1] retirement plans in the United States. The ultimate objectives of the study were the following:

1. Propose an updated set of mortality assumptions that would supersede both the RP-2000 base tables and mortality projection Scales AA, BB, and BB-2D and
2. Provide new insights into the composition of gender-specific pension mortality by factors such as type of employment (e.g., collar), salary/benefit amount, health status (i.e., healthy or disabled), and duration since event.

The RP-2014 mortality tables presented in this report and the mortality improvement Scale MP-2014 presented in the accompanying report form a new basis for the measurement of retirement program obligations in the United States. With the exception of the mortality rates at the youngest and oldest ages, the participant data underlying the RP-2014 tables reflect mortality experience of retirement plans subject to the funding rules of the Pension Protection Act of 2006 (PPA).

The mortality assumptions for nondisabled participants currently mandated by the IRS for minimum funding purposes are based on RP-2000 tables projected using mortality improvement Scale AA.[2] Certain Pension Benefit Guaranty Corporation (PBGC) measures, including the determination of the PBGC variable rate premium, rely on the mortality basis applicable to minimum funding valuations. Section 430(h)(3) of the Internal Revenue Code requires periodic review of the mortality assumptions used for PPA funding requirements, and RPEC anticipates that the RP-2014 tables presented in this study will be considered in the next IRS review process.

1.2 Overview of the Data

The final database upon which this study has been constructed reflects approximately 10.5 million life-years of exposure and more than 220,000 deaths, all from uninsured plans subject to PPA funding rules. Data were submitted for 120 private plans[3] in response to RPEC's request for plan experience covering the years 2004 through 2008.[4] For purposes of characterizing plans as blue collar or white collar, RPEC used the same criteria as were described in the RP-2000 study.

1.3 Development of RP-2014 Mortality Tables

RPEC first projected the raw mortality rates from their central year (2006) to 2014 using the Scale MP-2014 mortality improvement rates. Those projected rates were then graduated using

[1] While RPEC collected (and analyzed) the mortality data from a number of large public pension plans, only the data collected on uninsured private plans were used in the development of the RP-2014 mortality tables.
[2] Most U.S. pension actuaries use IRS-published static tables (based on Scale AA projection) for minimum funding purposes, despite the fact that generational projection of Scale AA is permitted. Some larger plans use plan-specific "substitute" mortality assumptions for minimum funding purposes.
[3] The final RP-2014 dataset included data from 38 private plans.
[4] Because of the length of the data collection/validation process and RPEC's desire to maximize study exposures, the final dataset includes some private plan mortality experience that extended into the 2009 calendar year.

Whittaker-Henderson-Lowrie methodology, and subsequently extended to extreme (very old or very young) ages using a variety of standard actuarial techniques. The final result was a set of 11 gender-specific amount-weighted tables with base year of 2014:

- *Employee Tables* (ages 18 through 80)
  - Total (all nondisabled data)
  - Blue Collar
  - White Collar
  - Bottom Quartile (based on salary)
  - Top Quartile (based on salary)
- *Healthy Annuitant*[5] *Tables* (ages 50 through 120)
  - Total (all nondisabled data)
  - Blue Collar
  - White Collar
  - Bottom Quartile (based on benefit amount)
  - Top Quartile (based on benefit amount)
- *Disabled Retiree Table* (ages 18 through 120)

For completeness, the Committee also developed gender-specific Juvenile tables covering ages 0 through 17.

1.4 Estimated Financial Impact

Most current pension-related applications in the United States involve projection of RP-2000 (or possibly UP-94) base mortality rates using either Scale AA or Scale BB. RPEC believes that it will be considerably more meaningful for users to assess the combined effects of adopting RP-2014 Tables projected with Scale MP-2014, rather than trying to isolate the impact of adopting one without the other. The financial impact of the combined change is expected to vary quite substantially based on the starting mortality assumptions; for example, the impact of switching from a static projection using Scale AA will typically be much more significant than the impact of switching from a generational projection using Scale BB-2D.

Table 1.1 presents a comparison of 2014 monthly deferred-to-age-62 annuity due values (at an annual interest rate of 6.0 percent) based on a number of different sets of base mortality rates and generational projection scales, along with the corresponding percentage increases of moving to RP-2014 base rates[6] projected generationally with Scale MP-2014.

[5] The term "Healthy Annuitants" refers to the combined populations of Healthy Retirees and Beneficiaries
[6] Total Employee mortality rates through age 61 and Total Healthy Annuitant mortality rates at ages 62 and older.

	Base Rates	UP-94	RP-2000	RP-2000	RP-2000	RP-2014	UP-94	RP-2000	RP-2000	RP-2000
		Monthly Deferred-to-62 Annuity Due Values; Generational @ 2014					**Percentage Change** of Moving to RP-2014 (with MP-2014) from:			
	Proj. Scale	AA	AA	BB	BB-2D	MP-2014	AA	AA	BB	BB-2D
	Age									
Males	25	1.3944	1.4029	1.4135	1.4115	**1.4379**	*3.1%*	***2.5%***	*1.7%*	*1.9%*
	35	2.4577	2.4688	2.4881	2.4880	**2.5363**	*3.2%*	***2.7%***	*1.9%*	*1.9%*
	45	4.3316	4.3569	4.3963	4.4012	**4.4770**	*3.4%*	***2.8%***	*1.8%*	*1.7%*
	55	7.6981	7.7400	7.8408	7.8739	**7.9755**	*3.6%*	***3.0%***	*1.7%*	*1.3%*
	65	11.0033	10.9891	11.2209	11.3199	**11.4735**	*4.3%*	***4.4%***	*2.3%*	*1.4%*
	75	8.0551	7.8708	8.2088	8.3367	**8.6994**	*8.0%*	***10.5%***	*6.0%*	*4.4%*
	85	4.9888	4.6687	5.0048	5.0992	**5.4797**	*9.8%*	***17.4%***	*9.5%*	*7.5%*
Females	25	1.4336	1.4060	1.4816	1.4904	**1.5195**	*6.0%*	***8.1%***	*2.6%*	*2.0%*
	35	2.5465	2.4931	2.6145	2.6299	**2.6853**	*5.5%*	***7.7%***	*2.7%*	*2.1%*
	45	4.5337	4.4340	4.6264	4.6534	**4.7497**	*4.8%*	***7.1%***	*2.7%*	*2.1%*
	55	8.1245	7.9541	8.2532	8.3155	**8.4544**	*4.1%*	***6.3%***	*2.4%*	*1.7%*
	65	11.7294	11.4644	11.8344	11.9486	**12.0932**	*3.1%*	***5.5%***	*2.2%*	*1.2%*
	75	8.9849	8.6971	9.0650	9.1654	**9.3995**	*4.6%*	***8.1%***	*3.7%*	*2.6%*
	85	5.7375	5.5923	5.9525	6.0148	**6.1785**	*7.7%*	***10.5%***	*3.8%*	*2.7%*

Table 1.1

1.5 RPEC Recommended Application and Adoption of RP-2014 Tables

RPEC recommends that all pension actuaries in the United States carefully review the findings presented in this report and the companion Scale MP-2014 report. Subject to standard materiality criteria (including Actuarial Standard of Practice No. 35) and the user's specific knowledge of the covered group, the Committee recommends that the measurement of U.S. private retirement plan obligations be based on the appropriate RP-2014 Table projected generationally for calendar years after 2014 using Scale MP-2014 mortality improvement rates.

RPEC recommends that the individual characteristics and experience of the covered group be considered in the selection of an appropriate set of base mortality rates. While statistical analyses summarized in this report continue to confirm that both collar and amount quartile are statistically significant indicators of differences in base mortality rates for nondisabled lives, RPEC believes that the use of collar-based tables will generally be more practical than the use of amount-based tables.

This RP-2014 report does not include mortality tables analogous to the "Combined Healthy" tables in the RP-2000 report. Users who wish to develop Combined Healthy tables are encouraged to blend appropriately selected RP-2014 Employee and Healthy Retiree tables using plan-specific retirement rate assumptions.

Members of RPEC

William E. Roberts, Chair
Paul Bruce Dunlap
Andrew D. Eisner
Timothy J. Geddes
Robert C. W. Howard
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Cynthia MacDonald, SOA Senior Experience Studies Actuary
Andrew J. Peterson, SOA Staff Fellow—Retirement
Muz Waheed, SOA Experience Studies Technical Actuary

Special Recognition of Others Not Formally on RPEC

First and foremost, the Committee would like to express its sincere and profound appreciation for the support provided throughout the project from the following team of Swiss Re employees:

Curtis Burgener
JJ Carroll
Steven Ekblad
Dr. Brian Ivanovic
Allen Pinkham

It is difficult to overstate the importance of the work performed by the Swiss Re team in the successful completion of this report. In addition to expending a great deal of effort ensuring the accuracy of the final dataset, the Swiss Re team produced a vast number of univariate and multivariate analyses that were critical to the construction of the RP-2014 tables.

RPEC would also like to thank Stephen Goss, Alice Wade, Michael Morris, Karen Glenn, and Johanna P. Maleh, all from the Office of the Chief Actuary at the Social Security Administration (SSA), for the valuable comments and information they have provided throughout the study. RPEC would especially like to acknowledge the assistance it received from Michael Morris, who was the Committee's main point of contact with respect to SSA mortality data and methodology.

Finally, the Committee would like to thank Greg Schlappich at Pacific Pension Actuarial who was extremely helpful in developing Excel-based software for the Whittaker-Henderson-Lowrie graduation described in Section 5.

Reliance and Limitations

The RP-2014 mortality tables have been developed from private pension mortality experience in the United States and are intended for actuarial measurements concerning plans contained within this category. No assessment has been made concerning the applicability of these tables to other purposes.

Section 2. Background and Process

2.1 Reason for New Study

The mortality assumptions currently used to value most retirement programs in North America were developed from data that are more than 20 years old. The two most commonly used pension-related mortality tables are UP-94 and RP-2000, which were based on mortality experience with central years of 1987 and 1992, respectively [11, 12].[7] Prior to the SOA's release of the Scale BB Report in September 2012, the only mortality projection scale generally available to North American pension actuaries was Scale AA, which was based on mortality improvement experience between 1977 and 1993.

The Retirement Plans Experience Committee (RPEC) initiated a Pension Mortality Study in 2009 with the ultimate objective of developing updated base mortality rates and mortality improvement scales for use with pension and other postretirement programs in the United States and Canada. After RPEC became aware that the Canadian Institute of Actuaries was planning to undertake a similar study of pension-related mortality experience in Canada, the Committee decided to limit the scope of the SOA project to U.S. retirement programs.

An important motivation for this study is the requirement in IRC Section 430(h)(3) for the Secretary of the Treasury to review at least every 10 years "applicable mortality rates" for various qualified plan funding requirements. Since the RP-2014 mortality tables are based on the mortality experience of uninsured private pension plans[8] in the United States, RPEC believes they should be considered as potential replacements for the current mortality basis (generally RP-2000 rates projected with Scale AA) that is mandated for a number of Department of the Treasury and PBGC applications.

The requirements of the IRS and PBGC notwithstanding, U.S. pension actuaries need to have available a variety of up-to-date mortality tables to accurately measure pension and other postretirement benefit obligations. The Committee is hopeful that future studies of pension-related mortality assumptions will be performed on a more frequent basis.

RPEC encourages all members of the U.S. pension actuarial community to carefully review the base tables described in this Report—in conjunction with the new mortality projection methodology described in the companion Scale MP-2014 Report—as part of their ongoing review of pension-related mortality assumptions.

2.2 RPEC's Process

RPEC generally met two times a month, with almost all of those meetings taking place via conference call. These meetings were not open to the public. Status updates of the Committee's progress were shared periodically (approximately quarterly) with representatives of the IRS and the PBGC. The Committee also had numerous helpful interactions with the Office of the Chief Actuary at the SSA. Timothy Geddes, an RPEC member, and Andrew Peterson, SOA Staff Fellow–

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[7] Numbers in square brackets refer to references, which can be found in Section 13.

[8] In addition to the raw pension plan data collected, RPEC made use of Social Security mortality rates for juvenile mortality rates as well as 2008VBT (individual life insurance) mortality rates in the development of final RP-2014 rates; see Sections 6 through 9 for details.

Retirement, were responsible for keeping appropriate groups within the American Academy of Actuaries apprised of RPEC's progress.

One of RPEC's first decisions was to create a number of subteams, each of which would focus on a particular fundamental component of the mortality table construction process. This allowed the group to work on key aspects of the RP-2014 project simultaneously rather than sequentially. The following is a list of those subgroups and the names of the respective team members; subteam leaders are denoted with asterisks, and Swiss Re employees are denoted with plus signs:

- *Data Processing and Validation (the "Data" subteam):* Ed Hustead*, Curtis Burgener$^+$, Andy Eisner, Allen Pinkham$^+$, and Bart Prien
- *Graduation Methodology (the "Graduation" subteam):* David Kausch*, Bob Howard, and Larry Pinzur
- *Univariate and Multivariate Analyses (the "Statistical Analysis" subteam):* Larry Pinzur*, Steve Ekblad$^+$, Brian Ivanovic$^+$, Allen Pinkham$^+$, and Bill Roberts
- *Disabled Life Mortality (the "Disability" subteam):* Paul Dunlap*, Pete Zouras*, David Kausch, Pat Pruitt, and Bob Pryor
- *Extension to Extreme Ages (the "Table Extension" subteam):* Ed Hustead*, Paul Dunlap, Andy Eisner, Bob Howard, David Kausch, and Pete Zouras

In addition to these RP-2014 subteams, a separate subcommittee (composed of Larry Pinzur*, Bob Howard, Brian Ivanovic$^+$, Paul Dunlap, Allen Pinkham$^+$, Bob Pryor, and Bill Roberts) was formed to study U.S. mortality improvement trends and develop an updated projection model. The findings of that subcommittee's research are presented in the companion Scale MP-2014 Report [14].

2.3 Designation of Various Participant Subgroups

The following list summarizes the official name used by RPEC throughout this report to describe various subgroups of plan participants and the description of the participants covered by that designation:

- *Employee:* A nondisabled participant who is actively employed[9] (including those in plans that no longer have ongoing benefit accruals).
- *Healthy Annuitant:* A formerly active participant in benefit receipt who was not deemed disabled at the date of retirement (a "*Healthy Retiree*") or the beneficiary of a formerly active participant who is older than age 17 and in benefit receipt (a "*Beneficiary*").
- *Disabled Retiree:* A retired participant in benefit receipt who was deemed disabled as of the date of retirement.
- *Juvenile*: A participant's beneficiary who is under the age of 18.

The term *Annuitant* is sometimes used when it is not necessary to distinguish between a Healthy Retiree, a Beneficiary or a Disabled Retire.

[9] Terminated vested participants not yet in payment status were excluded from the study due to insufficient data.

Section 3. Data Collection and Validation

3.1 Data Processing Overview

The following list outlines the phases involved in the development of the final dataset from which the raw mortality rates for this study were produced:

1. Data collection
2. Preliminary review for reasonableness and completeness
3. Consolidation of data records
4. In-depth data review and validation

Each of these phases is discussed in more detail in the remainder of this section.

3.2 Data Collection

The data collection process started in October 2009, with RPEC sending data request letters to the largest actuarial consulting firms and a number of large public pension plans.[10] The formal request package consisted of the following three documents, which are reproduced in Appendix F:

1. A cover letter outlining the goals of the study, an approximate timetable, and preferred file formats;
2. A "Participant Information" summary, detailing the requested personnel data elements for calendar years 2004 through 2008; and
3. A "Plan Information" summary, requesting plan-specific information such as type of pension formula and eligibility criteria for disability benefits.

Organizations that were sent the data request packages were requested to confirm their intent to provide data to the study by October 30, 2009. The due date originally requested for the submission of data was December 31, 2009, but that was subsequently extended to June 30, 2010, after it became clear that certain firms would not be able to submit accurate data until that later date.

At the request of RPEC, SOA staff later requested that firms provide information regarding the "collar type" of each plan for which data was submitted. The collar criteria used in the current study were the same as those used in the RP-2000 study; that is, the type was classified as Blue Collar if at least 70 percent of the plan participants were (either) hourly or union, and the type was classified as White Collar if at least 70 percent of the plan participants were (both) salaried and non-union. Plans whose participants failed to satisfy either of those two conditions were to be classified as Mixed Collar.

To maintain confidentiality of the submitted data, the data collection and data processing phases of the project were coordinated by SOA staff, working directly with outside data compilers. MIB Solutions, Inc. (MIB) was used to perform the initial validation checks on the data. Swiss Re was subsequently selected to perform additional validation checks, initiate various statistical

[10] The final dataset used by RPEC to develop the RP-2014 tables did not include any public plan mortality data; see subsection 4.3 for additional details.

analyses, and, when appropriate, impute missing information. In a number of cases, direct contact was made with the data contributors (coordinated through and including SOA staff) to address specific issues with their data submission.

In large part because of efforts by RPEC to increase the total amount of experience to be included in the study, the submission of raw data for the project continued through April 2011. As a consequence of this prolonged data collection process, some contributors of private plan information submitted data that included mortality experience that extended into the 2009 calendar year.[11] Ultimately, the SOA received raw data from 120 private plans and three large public plans.

3.3 Preliminary Review for Reasonableness and Completeness

MIB performed a number of high-level tests designed to assess the overall reasonableness and completeness of the raw data collected. These tests identified a surprisingly large number of plans (primarily private plans) that had missing, incomplete, or inconsistent information. In addition to those more obvious data problems, a significant number of plans that passed the initial data checks produced preliminary actual-to-expected ("A/E") ratios[12] (with expected deaths based on RP-2000 rates projected to the exposure year using Scale BB) that were unusually high or low.

Swiss Re was engaged to perform a detailed reasonableness analysis on the data (plan identity was masked) and to determine a course of action to retain as much data in the study as possible. SOA staff worked with Swiss Re to contact the data contributors through December 2012 in an attempt to correct the inconsistent/incomplete data. In the end, questionable data that could not be verified by the contributing firm were excluded from further analysis.

3.4 Consolidation of Data Records

RPEC requested that a unique identifier be included for each record submitted as part of the original data collection process. The intent was to use this identifier to link together multiple years' worth of data for each participant (within a single plan) resulting in one "consolidated" record per person. These consolidated records could then be followed through their entire exposure window, increasing the probability that each participant was credited with his or her appropriate amount (and type) of exposure, particularly when the participant had transitions between the different retirement plan phases (e.g., active Employee to Healthy Retiree). The use of consolidated records also facilitated the checking of key data fields for internal consistency and the handling of late-reported deaths.

The Swiss Re team devoted a great deal of effort to the construction of the consolidated records, and the process did, in fact, uncover a significant number of previously undetected data inconsistencies. For example, Swiss Re identified a number of records with inconsistent gender codes, which were later found to be concentrated in plans whose data was submitted by organizations that often reused the same identifier for the beneficiary of a deceased participant.

A number of plans were unable to supply unique identifier codes and the data for those plans were excluded from the remainder of the study. Subsection 3.5 summarizes the more in-depth

[11] The basic data submitted by two of the large public plans contained mortality experience extending into calendar year 2009, as well as for calendar years prior to 2004.
[12] The ratio of the actual number of deaths to the expected number of deaths, calculated on a plan-by-plan basis.

data reviews performed by Swiss Re (with oversight by the Data subteam) after they developed an intermediate database composed exclusively of the records they were able to consolidate.

3.5 In-Depth Data Review and Validation

After signing confidentiality agreements that permitted access to individual de-identified plan level data, members of the Data subteam reviewed the univariate analyses of the consolidated record dataset prepared by Swiss Re. The univariate analyses, performed separately on each of the Employee, Healthy Retiree, Beneficiary, and Disabled Retiree subpopulations, provided the subteam with summaries of the overall quality and quantity of the data, including exposures, deaths, and A/E ratios (on both headcount and amount-weighted bases) stratified by factors such as gender, age[13] grouping, collar, amount, and calendar year. The univariate analyses also identified aspects of the intermediate database that required additional attention.

The remainder of this subsection highlights the reasonability analyses undertaken and the procedures implemented by Swiss Re (with oversight by RPEC) to determine a final set of data to be used as the starting point for the development of RP-2014 mortality tables.

Age Ranges

RPEC excluded individual life-years of exposure from the study that lied outside of defined age ranges. The age ranges were established according to patterns typically observed in pension plans, informed by the results of the univariate analysis as to the depth of data available. The following table presents the age ranges for the four participant categories:

Participant Category	Lowest Reasonable Age	Highest Reasonable Age
Employee	20	70
Healthy Retiree	50	100
Beneficiary	50	100
Disabled Retiree	45	100

Missing Dates of Death

Some retiree records switch to survivor status without indicating a date of death for the retiree. The following approach was adopted to address the missing data:

- If a date of death is included in the data, it was assumed to be the date of the retiree's death rather than the beneficiary's.
- If a date of benefit commencement for the beneficiary is included in the data, the retiree was assumed to have died the preceding day.
- If neither date is provided, RPEC estimated the date of death to have been on the retiree's birthday in the year of status change.

Status at Death for First Exposure Year Death Records

Most of the records for deaths in the first year of the submitted data did not include status at the to determine status as of the beginning of the year of death. For example, if there was neither a

[13] All ages in this study were calculated on an age nearest birthday basis.

retirement date nor a disability date on the record, the participant was assumed to be an active employee at the time of death.

Multiple Retirement Dates

Generally, multiple retirement dates were ignored with retirement assumed to have occurred on the initial retirement date. If the individual was indicated to be disabled, the first retirement date was assumed to be the date of disability and the participant was assumed to be disabled from that point. If there was more than one retirement date and the record indicated that the participant was likely a surviving beneficiary, then the second retirement date was assumed to be the date of death.

Plans with Predominantly Male or Female Participants

Plans consisting of less than 30 percent male lives or more than 80 percent male lives were flagged for verification. The SOA staff contacted submitters who then confirmed that the male/female proportions in the plan data were reasonable.

Missing Termination Dates

Some records contained neither termination date nor reason for termination. In these cases, the termination year was assumed to be the year after the last record.

Gender and Hire Age

In a few cases, gender was not consistent within a single consolidated record, in which case it was assumed the correct gender is the one that appeared most often.

If hire date was missing, hire age was assumed to be 30 or, if younger than 30 at the beginning of the record, the date of hire was assumed to be in the year preceding the earliest year in the record.

Salary and Benefit Amounts

The submitted data included a number of very low or very high retirement benefit amounts. In those cases, the Data subteam went back to the data submitters to verify the accuracy of those amounts. If submitters indicated that their data was not submitted on the expected monthly basis, the amounts were adjusted appropriately.

Salary and retirement benefit amounts for those Employees and Annuitants, respectively, were imputed if no such amount was originally submitted. The imputed amount for Employees with missing salary was $50,000 per year. The imputed annual retirement benefit for Healthy and Disabled Retirees was $21,300, and the imputed annual retirement benefit for Beneficiaries was $14,200.

Outlier Actual-to-Expected Ratios

The expected number of deaths was determined on a year-by-year basis for each submitted plan based on the RP-2000 mortality rates projected to the exposure year by Scale BB. The Data subteam then developed approximate 95 percent confidence intervals for the resulting A/E ratios on a plan-by-plan basis to gauge the overall reasonableness of individual plan results. If the low end of the 95 percent confidence interval was greater than 110 percent or the high end less than 90 percent, the plan was flagged for additional analysis. For example, assume Employees in Plan X produced an A/E ratio of 0.63, with a corresponding 95 percent confidence interval of 0.50 to 0.76. Since 0.76 (the high end of the confidence interval) is less than 0.90, Plan X would be flagged.

Flagged plans with a small number of expected deaths[14] were dropped from the study. For the remaining flagged plans, the Data subteam asked the respective contributors about the reasonableness of the submitted data. If the contributing organization confirmed that the observed A/E ratio was reasonable, the plan remained in the study data; otherwise, the plan was dropped.

3.6 Summary of the Final Dataset

The validation processes summarized in the previous subsection resulted in the exclusion of an unusually large percentage of the data initially submitted for the study. Of the nearly 60 million life-years of data originally submitted, the dataset at this point included approximately 33 million life-years of public and private plan data. Additional details of the Data Processing and Validation subteam's processes are presented in Appendix B.

After review of the multivariate analysis subsequently performed by Swiss Re, RPEC decided to exclude the public plan data from the study; see subsection 4.3. Therefore, the basic data summarized in Table 3.1 and the tables split by participant subgroup (Tables C-1 through C-8 in Appendix C) reflect the mortality experience of U.S. private pension plan data exclusively. The five plans with largest amount of dollar-weighted Employee exposure represented approximately 37 percent of the total dollar-weighted exposure in the Employee dataset. The five plans with largest amount of dollar-weighted Healthy Retiree exposure represented approximately 66 percent of the total dollar-weighted exposure of that dataset.

Summary of Final Dataset

	Number		Number with Amount		Annual Amount ($000s)		Percent with Amounts	
	Life-Years of Exposure	Deaths	Life-Years of Exposure	Deaths	$-Years of Exposure	$-Weighted Deaths	Exposure	Deaths
Employees								
Males	2,467,108	5,358	1,656,319	2,432	110,486,189	142,103	67.1%	45.4%
Females	1,989,637	2,277	1,763,513	1,807	89,903,158	76,639	88.6%	79.4%
Total	4,456,745	7,635	3,419,833	4,239	200,389,346	218,741	76.7%	55.5%
Healthy Retirees								
Males	3,165,190	110,647	3,073,985	109,400	50,632,202	1,317,018	97.1%	98.9%
Females	1,470,855	45,586	1,381,319	44,838	14,154,745	345,305	93.9%	98.4%
Total	4,636,045	156,233	4,455,303	154,238	64,786,947	1,662,323	96 1%	98.7%
Beneficiaries								
Males	60,549	3,245	59,653	3,174	298,633	14,875	98.5%	97.8%
Females	978,819	45,341	977,104	45,195	6,502,346	266,151	99.8%	99 7%
Total	1,039,368	48,586	1,036,758	48,369	6,800,979	281,026	99.7%	99.6%
Disabled Retirees								
Males	240,917	11,901	232,495	11,678	2,311,336	101,974	96.5%	98.1%
Females	127,769	4,062	110,378	3,725	907,787	26,033	86.4%	91.7%
Total	368,686	15,963	342,873	15,403	3,219,123	128,008	93.0%	96 5%
Total Annuitants	6,044,099	220,782	5,834,934	218,010	74,807,049	2,071,357	96 5%	98.7%
Total Dataset	10,500,844	228,417	9,254,767	222,249	275,196,395	2,290,098	88.1%	97.3%

[14] The drop thresholds were 30 for active employees and healthy retirees, and 20 for beneficiaries and disabled lives.

Table 3.1

3.7 Determination of Amount-Based Quartiles

The RP-2000 Report included amount-based tables (Small, Medium, and Large amount categories based on fixed annual benefit amounts) for Healthy Annuitants only. The current study analyzed quartile-based[15] mortality trends for both Employees and Annuitants based on annual salary for the former and annual retirement benefit amount for the latter. The quartile breakpoints summarized in Table 3.2 were all developed based on gender-specific "head count" exposure, that is, not based on exposure weighted by either salary or benefit amount.

	Quartile Breakpoints							
	Employees		Healthy Retirees		Beneficiaries		Disabled Retirees	
Percentile	Male	Female	Male	Female	Male	Female	Male	Female
25th	$ 44,916	$ 30,824	$ 8,208	$ 3,888	$ 2,304	$ 3,972	$ 5,508	$ 5,088
50th	$ 60,216	$ 46,596	$ 14,496	$ 8,784	$ 4,320	$ 6,048	$ 8,796	$ 7,584
75th	$ 77,232	$ 62,820	$ 24,756	$ 13,932	$ 6,576	$ 8,376	$ 13,068	$ 10,872

Table 3.2

So, for example, experience for a female Employee was included in Quartile 4 (also referred to as the "Top" quartile) if she was reported to have an annual salary of at least $62,820.

[15] Participants for whom no amount was submitted were excluded from the quartile-based analyses.

Section 4. Multivariate Analysis

4.1 Background on Multivariate Analysis

Although univariate analysis of mortality data is helpful in assessing the significance of individual factors one variable at a time, multivariate techniques are useful when trying to assess multiple factors for statistical significance simultaneously. Stratification of the underlying dataset can also be used to control for the interaction among various factors, but such an approach can become unstable when the number of cofactors becomes large. Even when the resulting stratified categories include enough deaths to yield credible results, it can be difficult to make sense of hundreds of cells of results, i.e., identifying patterns and determining which factors are more significant than others.

The Statistical Analysis subteam included a number of Swiss Re employees who performed all of the analyses summarized in this section. The following table summarizes the factors that the subteam analyzed for potential statistical significance with respect to differences in underlying mortality rates:

Factors	Implications
Private plan experience Public plan experience	If differences are not significant, public and private plan data could possibly be combined in the study
Retired lives experience Beneficiary lives experience	If experience is significantly different, separate tables could improve measurements
Blue collar White collar	If experience is significantly different, collar-specific tables could improve measurements
Amount (benefit/salary levels)	A consistent pattern of mortality differences between annuitants with high versus low benefits or active employees with high versus low salaries may suggest tables that vary by amount could improve measurements
Combination of Collar and Amount	If amount-specific differences within collar categories are significant, separate tables based on both collar and amount could improve measurements
Duration	If duration effects are significant, select-and-ultimate tables could produce superior measurements

4.2 Nature of Analyses

In reviewing the dataset that remained at this point, RPEC relied primarily on logistic regression techniques performed on a gender/age-specific basis. Logistic regression models the natural logarithm of the odds ratio to develop a relative risk ("RR") factor, with corresponding p-values and confidence intervals. RR values are calculated relative to a specific reference population while controlling for one or more selected cofactors. An RR value close to 1.0 indicates that the underlying mortality rates corresponding to the factor being tested are not significantly different from those of the reference population, whereas an RR value outside of a small interval around 1.0 typically indicates that the influence of the selected factor is a statistically significant predictor of a different mortality pattern from that of the reference population.

Supplementing the logistic regression analyses described above, Swiss Re modeled the number of deaths on a grouped basis using generalized linear models, alternatively assuming Poisson and Negative Binomial distributions.

4.3 Summary of Multivariate Analysis and Conclusions for Nondisabled Participants

Private Plan and Public Plan Experience

Since the final dataset did not include any active employees for the three public plans, RPEC performed a "public versus private" logistic regression on the Healthy Retiree dataset only. Using the private plan retirees as the reference population and controlling for all key cofactors (including gender, collar, and benefit amount), one of the three public plans had RR values consistently below 1.0. The other two public plans had RR values that were consistently well above 1.0, with one of these two plans often exhibiting RR values considerably higher than the other.

RPEC's conclusion was that the raw Healthy Retiree mortality rates generated by the three public plans were significantly different from the corresponding private plan rates, and, therefore, the public and private datasets should not be combined. RPEC further concluded that the mortality experience of the three public plans was so disparate that it would not be appropriate to develop separate "public plan retiree" mortality tables based on the aggregated public plan data. Hence, RPEC decided to exclude the nondisabled public plan data from the remainder of the study.

Retiree and Beneficiary Experience

A review of Tables C-5 and C-6 (in Appendix C) shows that the amount of data submitted for Male Beneficiaries was small relative to that for Female Beneficiaries. RPEC concluded that there was not enough data to perform any meaningful statistical analyses on the Male Beneficiary data.

For females in private plans, a logistic regression that controlled for all key cofactors (including gender, collar, and benefit amount) indicated that Beneficiary mortality experience differed significantly from that of Healthy Retirees.[16] There are a number of reasons for different patterns in mortality between the Healthy Retiree and Beneficiary subpopulations. One is the well-documented temporary increase in relative mortality rates immediately following the death of a spouse [10]. Another likely reason in this particular instance is a bias attributable to RPEC's lack of access to any mortality information (exposures or deaths) for beneficiaries who died prior to the death of the primary retiree.

Given that most pension actuaries will likely apply these postretirement mortality tables to populations of annuitants that include some combination of retirees and surviving beneficiaries, RPEC concluded that it would be appropriate to develop "Healthy Annuitant" mortality tables that reflect the experience of the combined datasets. (This is consistent with the approach taken in the RP-2000 Tables.)

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[16] The age-specific ratios of (a) female Beneficiary mortality rates to (b) female Healthy Retiree rates decreased from approximately 2.5 at age 50 and to approximately 0.9 at age 90; the crossover point (ratio of 1.0) occurred between ages 78 and 79.

Consideration was given to providing separate tables for female Healthy Retiree and female Beneficiary populations, but concluded that their use would be too limited to justify inclusion in the report.

Variations by Collar

RPEC performed gender-specific logistic regression analyses separately for the Employee and Annuitant populations and in all cases found very clear evidence for variations in mortality rates by collar. The collar effects were found to be more pronounced in males than in females. When controlling for benefit amount, the overall RR value for Blue Collar Healthy Annuitants (relative to White Collar Healthy Annuitants) was 1.22 for males and 1.14 for females. When controlling for salary amount, the overall RR values for Blue Collar Employees (relative to White Collar Employees) were 1.42 for males and 1.20 for females. For both males and females, the differences attributable to collar tended to diminish with advancing age.

Variations by Amount

RPEC's gender-specific logistic regression analyses identified clear evidence for variations in mortality experience based on salary amount for Employees and benefit amount for Annuitants. (See subsection 3.7 for a description of RPEC's quartile breakpoints.) When controlling for collar, the overall RR value for Top Quartile Annuitants (relative to Bottom Quartile Annuitants) was 0.65 for males and 0.86 for females. When controlling for collar, the corresponding overall RR values for Employees were 0.53 for males and 0.43 for females. For both genders, the differences attributable to benefit amount tended to diminish with advancing age.

Variations by Collar and Amount

As indicated above, collar and amount are both independent predictors of mortality in models where both factors are included. By reviewing models in which only one of those factors is included, it is possible to determine whether one factor is a stronger predictor than the other. For Healthy Annuitants, collar was the more significant factor; amount tended to be more significant for Employees.

By considering the amount relationships within collar-stratified models, it can be determined if the effects are similar for white and blue collar participants. For Healthy Annuitants, the amount effects were similar but slightly stronger in the white collar models. For Employees, the amount effects were considerably stronger in the white collar models, particularly for the middle two quartiles (relative to the bottom quartile).

Although separate tables could have been developed for each collar and amount combination, RPEC decided that the extra complexity was not warranted given the high degree of correlation between collar and amount. Therefore, RPEC concluded that either collar or amount could be appropriate factors to consider in selecting a set of base mortality rates. See subsection 12.2 for a more in-depth discussion regarding the application of these findings to specific situations.

Variations by Duration

Analysis of mortality by duration since retirement depends on retirement age. Virtually all of the retirements in the final Healthy Retiree dataset occurred between ages 50 and 75. Records with retirement ages under 50 or over 75 were omitted from durational analyses.

Logistic regression analysis indicated that there was a slight variation in the overall pattern in mortality based on duration since retirement. For example, relative mortality rates for both genders tended to slope slightly upwards for the first four years after retirement (attaining an RR value of approximately 1.15 relative to "duration 1" rates) and then slope slightly downwards from that point forward, dropping a bit below 1.0 after duration year 7.

Given the relatively minor impact of duration on mortality patterns and the additional complexity required to accommodate select-and-ultimate assumptions, RPEC expects that few pension actuaries will feel the need to reflect durational effects in the valuation of Healthy Annuitant obligations. Therefore, no such select period tables were created as part of this study.

4.4 Statistical Analyses for Disabled Retirees

Public plan disabled life data was submitted by two very large plans and logistic regression analyses showed that there were significant differences in the mortality patterns between these two plans. Additional analyses identified inherent differences in mortality patterns for disabled participants in public plans relative to those in private plans. Therefore, RPEC decided to base the RP-2014 Disabled Retiree mortality rates exclusively on private plan disabled life experience.[17]

The final Disabled Retiree dataset was dominated by two large private plans that represented 61 percent of the amount-weighted exposure benefit amount. RPEC's analysis showed that relative to all other plans in the dataset the largest plan had slightly better mortality experience and the next largest plan slightly worse mortality experience. As these differences were not extreme, RPEC decided to include the two large plans in the final dataset.

RPEC performed a number of logistic regressions on the final Disabled Retiree dataset. Although some variations in mortality by collar and amount were identified, those variations were significantly less pronounced than those found in the nondisabled populations.

As part of the initial data collection process, RPEC requested plan-specific information with respect to the eligibility criteria for disabled retirement benefits. The types of disability eligibility included Social Security award, own occupation (lifetime), own occupation (limited period), any occupation (lifetime) and any occupation (limited period). Although there was some indication that plans that require eligibility for Social Security disability benefits experience slightly higher mortality relative to those plans without such a criterion, RPEC was not able to reach any definitive conclusions based on this analysis.

RPEC's analysis of mortality by duration indicated that mortality rates in the early years of disability were considerably higher than those in subsequent years. However, because of the lack of data necessary to produce credible rates, RPEC decided against developing death rates that vary by duration. As a result of these analyses, RPEC decided to develop only one set of gender-specific mortality rates for Disabled Retirees.

[17] Hence, all of the RP-2014 tables (healthy and disabled) are based on private plan data only.

4.5 Determination of RP-2014 Base Mortality Tables to Be Developed

Based on these statistical analyses, RPEC concluded that there was sufficient evidence of variation in mortality patterns to construct the following gender-specific base mortality tables from the private plan dataset:

- *Employee Tables*
  - Total (all nondisabled data)
  - Blue Collar
  - White Collar
  - Bottom Quartile (based on salary)
  - Top Quartile (based on salary)
- *Healthy Annuitant*[18] *Tables*
  - Total (all nondisabled data)
  - Blue Collar
  - White Collar
  - Bottom Quartile (based on benefit amount)
  - Top Quartile (based on benefit amount)
- *Disabled Retiree Table*

When used without specific collar or quartile qualifiers, the "RP-2014 Employee" and "RP-2014 Healthy Annuitant" tables refer to the respective "Total (all nondisabled data)" tables above.

RPEC also analyzed Employee and Healthy Annuitant mortality rates for the middle two amount quartiles combined. As addressed more fully in subsection 12.2, the Committee believes that quartile-based mortality tables will typically provide more value as a measure of the disparity in mortality rates between the highest and lowest amount quartiles than they do as practical alternatives for the measurement of retirement plan obligations. In addition, the middle-two-quartile rates were often close to the corresponding total (nondisabled) rates, particularly at ages greater than 70 for male Healthy Annuitants and ages greater than 60 for female Healthy Annuitants, Therefore, RPEC decided that the inclusion of an additional set of middle-two-quartile tables was not necessary.

For completeness, this report also includes a set of gender-specific mortality rates for Juveniles (for ages 0 through 17) based on the most recent Social Security Administration mortality tables projected to 2014; see Section 9 for details.

[18] The term "Healthy Annuitants" refers to the combined populations of Healthy Retirees and Beneficiaries.

Section 5. Raw Rate Projection and Graduation

5.1 Overview

Three key steps were involved in the development of smoothed mortality tables as of 2014:

- Projection of raw rates to 2014
- Graduation of the projected raw rates (over age ranges for which sufficiently robust exposures existed) and
- Extension of the graduated rates to extreme (very old or very young) ages.

The next two subsections describe the projection and graduation methodologies used by the Graduation subteam. The extension methodologies varied by participant subgroup and are described in the following four sections.

5.2 Projection of Raw Rates to 2014

The first step in the process involved the projection of the raw mortality rates from 2006 (the central year of the dataset) to 2014. Each of the individual gender- and age-specific raw mortality rates was projected from 2006 to 2014 using the Scale MP-2014 mortality improvement rates [13]. The projection factor for an age-70 female in 2014, for example, is equal to 0.8234, which is equal to the product of the complements of the eight Scale MP-2014 mortality improvement rates for age-70 females for years 2007 through 2014.

Note that the projection of raw rates to 2014 was also applied to the Disabled Retiree population. As discussed in subsection 4.2 of the Scale MP-2014 report, recent experience supports the application of mortality improvement trend to the rates for both nondisabled and disabled lives.

5.3 Basic Graduation Methodology

The selection of an appropriate graduation methodology is an important aspect of mortality table construction. As with any set of statistical data, raw mortality rates usually include some random fluctuations that can mask the underlying "true" mortality rates. As has been the case with previous SOA mortality studies, the final sets of raw rates were graduated to produce smooth tables that reflect underlying mortality patterns.

A number of different graduation methods are currently available for smoothing mortality data, each of which involves a balancing of smoothness and fit. After considering some of the more recently developed techniques, RPEC decided to use the traditional Whittaker-Henderson (Type B) method, which historically has been one of the most commonly used methods for construction of pension-related mortality tables in the U.S. and Canada. RPEC decided to apply the Whittaker-Henderson method with the "Lowrie variation," a technique that improves fit when graduating mortality rates over a wide range of ages [5, 8, 9].

All of the graduated mortality tables are amount-weighted. For Employees, amount-weighting was based on annual salary; for Healthy Annuitants and Disabled Retirees, amount-weighting was based on annual retirement benefit.

5.4 Selection of Whittaker-Henderson-Lowrie Graduation Parameters

The key parameters for the Whittaker-Henderson-Lowrie method are the following:

1. The order of the difference equation being used to express smoothness
2. The **h** value, which balances fit and smoothness and
3. The Lowrie **r** value, which is the assumed annual growth rate in the underlying dataset being graduated.

In addition to balancing smoothness and fit, RPEC established a number of other criteria in selecting appropriate parameters for each of the datasets being graduated:

- All graduated q_x values must be strictly greater than 0.0 and strictly less than 1.0;
- The graduated q_x values should be strictly increasing with age[19] and
- The range of ages covered by each graduation should be as large as possible, subject to exposure constraints.

The Graduation subteam estimated 90 percent confidence intervals for each of the raw datasets and used these as additional benchmarks to select final Whittaker-Henderson-Lowrie parameters. The subteam concluded that third order difference equations produced graduated rates that best met the desired criteria described above. Based on the selection of this parameter, the Whittaker-Henderson-Lowrie graduation process involved minimization of the following formula[20]:

$$\sum w_x (u_x - v_x)^2 + h\sum(\Delta^3 u_x - r\Delta^2 u_x)^2 ,$$

where
- w_x are the amount-based weights;
- v_x are the raw mortality rates;
- u_x are the graduated mortality rates; and
- Δ^n represents the n^{th} order finite difference operator.

A summary of the **h** values and Lowrie **r** values that were selected for each individual dataset is included in Appendix D. It should also be noted that RPEC used "normalized" weights in the Whittaker-Henderson-Lowrie graduation, so the **h** values are significantly smaller than those used in Whittaker-Henderson applications that did not utilize such normalization [5].

5.5 Graduation Age Ranges by Participant Subgroup

For each individual subset of (projected) raw mortality rates that required smoothing, the Graduation subteam paid close attention to corresponding exposure amounts, standard deviations and associated 90 percent confidence intervals, each on an age-specific basis. This process helped the subteam determine appropriate age ranges for graduating each of the different sets of mortality rates. The lower and upper age ranges of the various graduations performed by the subteam are listed in Appendix D.

[19] Some of the final RP-2014 rates for males in their mid-20s decrease slightly with age. This is a consequence of the process RPEC used to extend rates to the youngest Employee ages, not the graduation methodology.

[20] The most general form of the Whittaker-Henderson-Lowrie formula includes terms that make reference to a "standard table." Given that RPEC's objective was to create new pension-related mortality tables based on current data, the need for "standard table" terms in the RP-2014 graduation formula was deemed unnecessary.

Given the relatively small amount of active Employee data included in the final dataset (including only 7,635 total deaths), the Graduation subteam concluded that it would not be appropriate to graduate anything other than the two gender-specific "Total" Employee tables, and even in those two cases, the graduation process covered only ages 35 through 65. Section 7 describes how the collar- and amount-specific Employee tables were subsequently developed from the Total Employee tables. The projected raw rates for Disabled Retirees were graduated between ages 45 and 95.

Before passing these rates on to the Table Extension subteam, the Graduation subteam carefully reviewed all of the graduated rates for both external and internal consistency. This process led to some extremely small adjustments to a few of the graduated rates.

Section 6. Construction of RP-2014 Healthy Annuitant Tables

6.1 Overview

RPEC developed Healthy Annuitant mortality rates starting at age 50 and extending through age 120. As displayed in Table 3.1, the percentage of Annuitants who did not have any benefit amount submitted was relatively small. For purposes of developing amount-weighted mortality rates, RPEC imputed the average retirement benefit for those with benefit amounts submitted for each Annuitant record with missing amount.

Subsection 6.2 starts with an overview of the Table Extension subteam's deliberations in connection with the shape and ultimate level of mortality at the highest ages and concludes with a description of the methodology ultimately selected to extend the graduated rates to age 120, the end of the mortality table. Subsection 6.3 describes the process used to extend the Healthy Annuitant tables down to age 50 (for the subpopulations for which graduated rates were developed starting at some age greater than 50).

6.2 Extension of Graduated Annuitant Rates to Age 120

The first step for the Table Extension subteam was to extend the graduated Healthy Annuitant rates to the oldest ages. The process required decisions regarding the highest mortality rates and highest ages to be reflected in the tables. The RP-2000 study used 0.4 as the highest mortality rate in the tables. Since publication of the RP-2000 report, there have been extensive studies of centenarians in the 21st century as many more people are now living to age 100. Although some researchers believe that mortality rates will continue to rise with advancing age until they reach 1.0, most of the recent studies suggest that there is a highest annual mortality rate and that rate is less than 1.0 [2, 3, 7].

The subteam was persuaded by the predominance of research that indicates a highest annual rate that is less than 1.0. Recent studies suggest that the maximum annual rate is closer to 0.5 than to the 0.4 used in the RP-2000 tables. For example, both Gampe's analysis of 637 thoroughly validated supercentenarians (people aged 110 and older) in the International Database on Longevity [2] and Kestenbaum and Ferguson's study of 325 U.S. supercentenarians [7] suggest that annual mortality rates tend to level off at approximately 0.5.

The subteam considered three different methods for extension of death rates beyond the last graduated rate. Two of these were the Gompertz [4] and Kannisto [6] mortality laws. The third was to fit a cubic polynomial to the data. The Gompertz method was eliminated once the subteam decided on a maximum annual rate of 0.5, because the Gompertz force of mortality increases exponentially with age.[21] Both the cubic polynomial and Kannisto methods can accommodate a maximum less than 1.0.

The subteam fit Kannisto's logistic model to the RPEC data using raw exposures and death rates starting at ages 75 through the last age at which there were at least 10 deaths.[22] The model's two parameters were estimated using the weighted nonlinear least squares procedure (Gauss-Newton algorithm) in SAS, and the force of mortality was converted to death rates in Excel [1]. Lagrange interpolation was used to transition smoothly from the graduated rates to the extended (Kannisto) rates. The resulting annual mortality rates were capped at 0.5.

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[21] The Gompertz method produced annual mortality rates greater than 0.5 at ages below 110.

[22] Through age 104 for males and age 106 for females.

The subteam also developed extended rates based on the cubic polynomial method. Although the extended rates produced using the cubic polynomial and Kannisto methods were very similar, the subteam concluded that the Kannisto approach produced an overall more appealing fit to the raw rates. Therefore, the subteam decided to proceed with the Kannisto extension methodology (with a maximum annual rate of 0.5) through age 119.

RPEC discussed whether the Annuitant tables should continue the 0.5 maximum rate through age 120 or whether the age 120 rate should be set equal to 1.0. Fully aware of the miniscule financial impact of this decision, the Committee concluded that reflecting the certainty of death at some very advanced age would likely be preferred by users; hence the rate at age 120 was set equal to 1.0.

6.3 Extension of Graduated Annuitant Rates Down to Age 50

The underlying exposures were large enough for the Graduation subteam to graduate almost all of the Healthy Annuitant tables down through age 50. For those subgroups for which the youngest graduated age was greater than 50, the rates down to age 50 were extended by reference to the total plan rates for that category. For example, the female Healthy Annuitant White Collar rates were extended between ages 50 through 59 by reference to the female Total Healthy Annuitant rates at those ages.

Section 7. Construction of RP-2014 Employee Tables

7.1 Overview

The RP-2014 Employee mortality tables start at age 18 and extend through age 80.[23]

The sparseness of Employee data at ages less than 35 and ages greater than 65 in the final dataset, in conjunction with data that were submitted without salary information created a number of challenges for the Graduation and Table Extension subteams. As a result, the graduation/extension techniques described in this section are considerably more complex than for any of the other participant subgroups.

Subsection 7.2 describes how the Graduation subteam first used the subpopulation of Employees for whom salary information was submitted to extrapolate amount-weighted mortality rates for the entire Employee dataset. Subsection 7.3 first describes the techniques used to extend the graduated Total Employee rates from age 35 down to age 18, and then how those rates were used to develop rates between ages 18 and 35 for the other (collar- and quartile-based) Employee tables. The last part of subsection 7.3 describes the methodology used to extend each of the five sets of gender-specific Employee tables from age 65 to age 80.

7.2 Treatment of Employee Data Submitted Without Salary Information

As can be seen from Table 3.1, the percentage of Employee records submitted without any salary information was not insignificant. Rather than simply using the imputed salaries to develop amount-weighted mortality rates or excluding large segments of data from the study, the Graduation subteam used the following five-step process (separately for males and females) for the Total Employee, Blue Collar Employee, and White Collar Employee datasets:

1. Raw *amount-weighted* mortality rates were developed for those Employees who had salary information submitted within the dataset to be graduated;
2. Raw *head-count-weighted* mortality rates were developed for those Employees who had salary information submitted within the dataset to be graduated;
3. Raw *head-count-weighted* mortality rates were developed for *all* Employees within the dataset to be graduated;
4. The raw rate from Step 1 was divided by the raw rate from Step 2 on an age-by-age basis; and
5. The ratios from Step 4 were applied to the raw *head-count-weighted* mortality rates developed in Step 3.

This process was not required for the amount-weighted Employee mortality rates for either the Bottom Quartile or Top Quartile datasets since those raw rates reflected deaths and exposures for only those records for which salaries were submitted.

7.3 Construction and Extension of Graduated Employee Rates

As noted in subsection 5.5, the Graduation subteam concluded that only the two gender-specific Total Employee datasets were suitable for graduation, and those two sets of rates were graduated

[23] Given the increasing levels of active employment at older ages, RPEC thought that it would be helpful to extend the Employee mortality tables through age 80, rather than stopping at age 70 as was the case with the RP-2000 tables.

between ages 35 and 65. All of the other (collar and quartile) Employee tables were developed from the gender-specific Total Employee tables, as described below.

Extension of Total Employee Rates Between Ages 18 and 35

Given the downward trend in active participation in private defined benefit plans in the United States over the past 15 years, it was not surprising that the total life-years of Employee exposure included in the final RP-2014 dataset was smaller than that included in the RP-2000 Tables. The sparseness of active Employee data under age 35 was of particular concern to the Graduation subteam. Graduating the collar and quartile Employee subpopulations created an additional challenge since the exposures and deaths within each of those subpopulations were obviously smaller—sometimes much smaller—than those for the Total Employee group.

Rather than developing graduated Employee rates at ages below 35 based on sparse data, RPEC decided it would be preferable to make use of an existing SOA table, namely the gender-specific 2008 Valuation Basic Tables[24] (2008VBT; nonsmoker, age nearest birthday), as reference tables upon which the youngest RP-2014 Employee rates could be based [15]. The underlying data used in developing the 2008 VBT was the SOA's Individual Life Experience Committee's 2002-2004 Intercompany Study, which contained considerably more exposures and deaths between ages 18 and 35 than did the final RP-2014 Employee dataset.

The Graduation subteam first projected the 2008VBT rates to 2014 using the Scale MP-2014 mortality improvement rates. The subteam then determined two gender-specific "scaling factors" (based on a ratio of actual deaths to expected deaths calculated using the projected 2008VBT rates) that were then applied to the respective projected 2008VBT rates for ages 18 through 25. The subteam then filled in the gap between ages 25 and 35 using cubic polynomials that matched the gender-specific rates at ages 24, 25, 35, and 36.

In summary, the Total Employee rates for ages 18 through 65 were developed in three steps:

1. Ages 35 through 65: Standard Whittaker-Henderson-Lowrie graduation
2. Ages 18 through 25: Scaled version of the 2008VBT rates projected to 2014 and
3. Ages 26 through 34: Cubic polynomial interpolation.

Construction of the Collar- and Quartile-Based Rates Between Ages 18 and 65

Given RPEC's concerns with the relatively small size of the Employee subpopulations, the Committee decided to develop each of these four sets of collar- and quartile-based rates (between ages 18 and 65) as appropriately scaled versions of the Total Employee rates. Each of these scaling factors were calculated so that the expected number of dollar-weighted deaths using the "scaled" Total Employee rates for ages 18 through 65 was equal to the sum of actual dollar-weighted deaths between those ages included in the final dataset for that subpopulation.
For example, the sum of actual dollar-weighted deaths between ages 18 and 65 for White Collar males between the ages of 18 and 65 was approximately $77.7 million, and the expected number of dollar-weighted deaths based on the unadjusted male Total Employee table between ages 18 and 65 was approximately $99.5 million. Therefore, the constant scaling factor used to construct the White Collar males rates between ages 18 and 65 was approximately 0.78.

[24] The 2008VBT was developed (without margins) for the valuation of individual life insurance products that reflect standard and preferred underwriting criteria.

Extension Between Ages 65 and 80

The extension methodology selected by the subteam was based on analysis of the ratios of Employee rates to the corresponding Healthy Annuitant rates. Studies performed by the Office of Personnel Management indicated that these "Employee/Healthy Annuitant" (Ee/HA) mortality rate ratios for participants in the U.S. Civil Service Retirement System remained fairly consistent—at levels approximately equal to 40 percent for both genders—through age 75.

The subteam developed corresponding Ee/HA ratios for ages 50 through 65 based on the RP-2014 data. Although the ratios for the female tables hovered fairly consistently around the 40 to 50 percent level throughout the 50 to 65 age range, the ratios based on the male rates all exhibited upward trends. For example, the Ee/HA ratios based on the Total (nondisabled) male tables increased from approximately 40 percent at age 50 to approximately 75 percent at age 65.

Based on these results, the Graduation and Table Extension subteams thought it reasonable to extend the Employee rates beyond age 65 by assuming that the mortality rates between ages 65 and 80 increase at a constant exponential rate that would—if extended all the way to age 90—equal a certain percentage of the corresponding age 90 Healthy Annuitant rate. Based on the Ee/HA ratio analysis described in the previous paragraphs, the subteams selected age-90 Ee/HA target ratios of 50 percent for females and 80 percent for males.

For example, the age-65 mortality rate for a female White Collar Employee is 0.003382, and the age-90 mortality rate for a female White Collar Healthy Annuitant is 0.100207. The constant factor that when applied to 0.003382 for 25 years produces a value of 0.0501035 (i.e., 50 percent of 0.100207) is 1.11385. Hence, the female White Collar Employee mortality rate for each of the ages 66 through 80 was calculated as 1.11385 times the rate at the preceding age.

Section 8. Construction of RP-2014 Disabled Retiree Tables

RPEC developed Disabled Retiree rates starting at age 18 and extending through age 120.

The Graduation subteam first produced smoothed Disabled Retiree rates between the ages of 45 and 90. The Disabled Retiree rates between ages 18 and 44 were set equal to a gender-specific constant factor times the Total Employee rates. These factors (approximately 17.5 for males and 13.8 for females) were determined by taking the ratios of the graduated age-45 Disabled Retiree rate to the Total Employee age-45 rate. Cubic polynomial interpolation was used to develop smoothed rates between age 90 and age 105, the age at which the Disabled Retiree rates were assumed to converge to the Healthy Annuitant rates.

Section 9. Construction of RP-2014 Juvenile Rates

For completeness, RPEC has also included a set of gender-specific Juvenile mortality rates for ages 0 through 17[25]. The rates of ages 0 through 12 were set equal to the projected 2014 rates developed by the Social Security Administration. The gender-specific Juvenile rates for ages 13 through 17 were calculated using two cubic polynomials (one for each gender) that reproduced the SSA rates at ages 11 and 12 and reproduced the Total Employee rates at ages 18 and 19.

[25] RPEC recommends the use of the RP-2014 Employee tables for Beneficiaries between the ages of 18 and 50.

Section 10. Comparison of Projected RP-2000 Rates to RP-2014 Rates

10.1 Overview

It is helpful to compare annualized rates of mortality *improvement* for Scale AA and Scale MP-2014 over the period 2000 through 2014 prior to comparing projected RP-2000 and RP-2014 mortality rates. Figures 10.1(M) and 10.1(F) compare Scale AA rates (which do not vary by calendar year) to the annualized mortality improvement over the 14 year period produced using MP-2014 rates.[26]

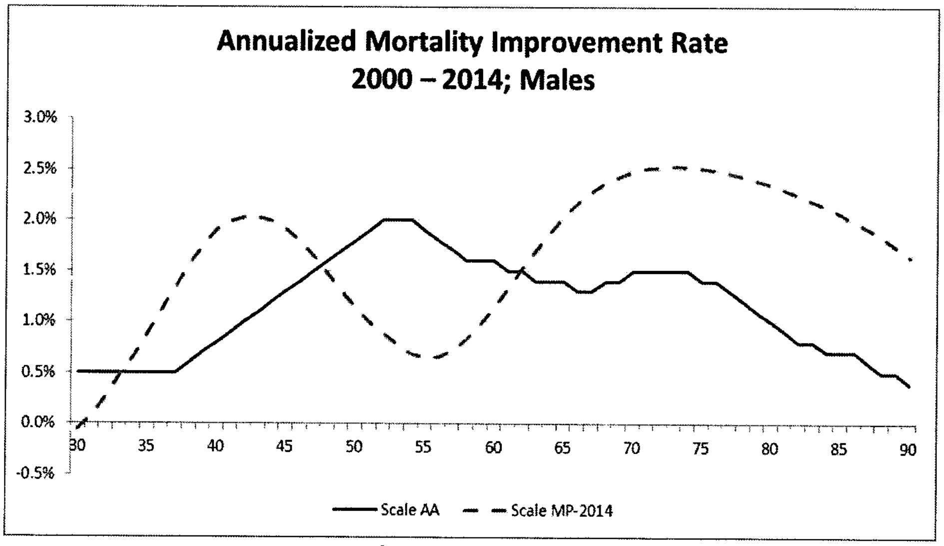

Figure 10.1(M)

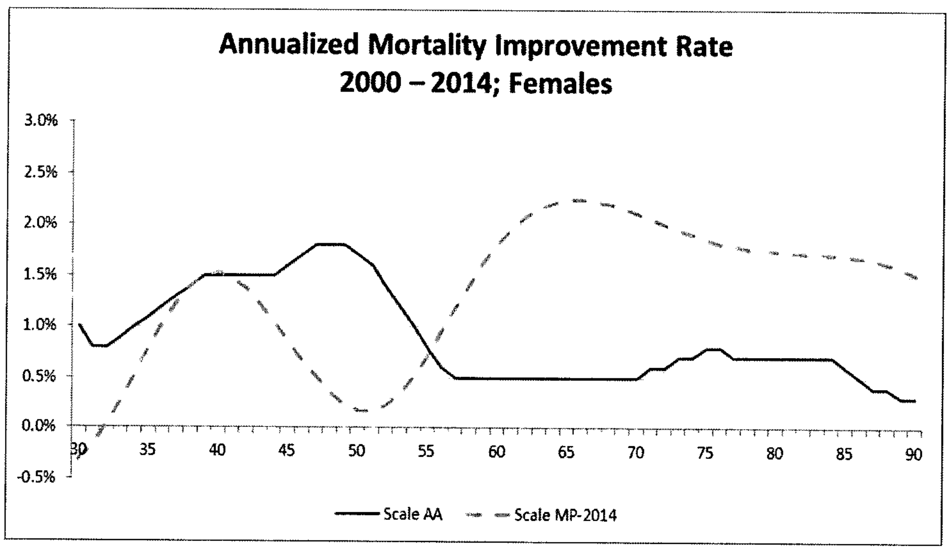

Figure 10.1(F)

Figures 10.1(M) and 10.1(F) highlight one of the key advantages of the two dimensional Scale MP-2014 over the "age-only" Scale AA; specifically, the ability to capture and project year-of-

[26] The annualized MP-2014 rate of mortality improvement at age x is calculated as 1.0 minus P^(1/14), where P is the product of 14 terms (one for each calendar year 2001 through 2014) of the form {1.0 minus Scale MP-2014 rate at age x in calendar year y}.

birth cohort effects. The valleys (around age 50 for females and around age 55 for males) represent the relatively low levels of mortality improvement experienced by the "baby boom" generation between 2000 and 2014, while the surrounding hills represent the relatively higher levels of mortality improvement experienced by the "Silent" and "Gen X" generations over that period.

The remainder of this section contains a number of graphs that display the ratios of projected RP-2000 rates to RP-2014 rates. With the exception of the Disabled Retiree rates discussed in subsection 10.4, all of the RP-2000 rates are projected from 2000 to 2014 in two different ways; once using Scale AA and a second time using the two-dimensional Scale MP-2014. Note that a ratio *greater* than 1.0 means that the projected RP-2014 mortality rate is *smaller* than the corresponding projected RP-2000 rate.

10.2 Comparison of Employee Rates

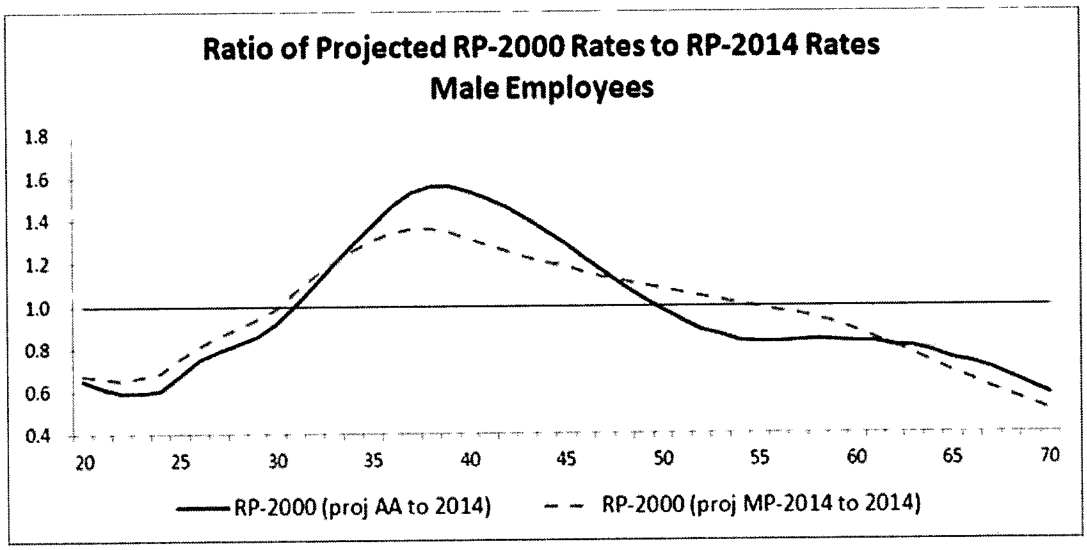

Figure 10.2(M)

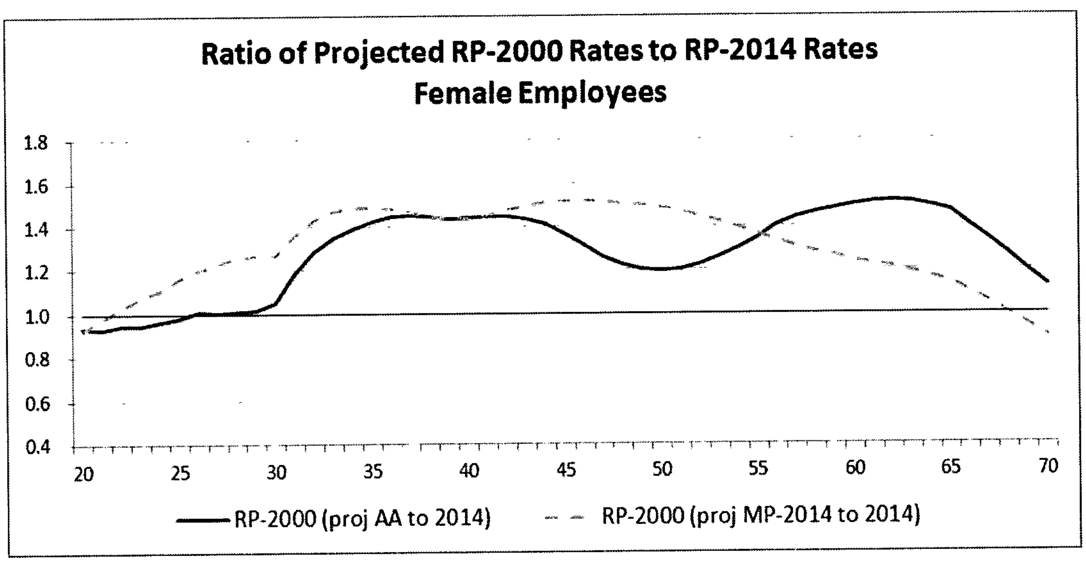

Figure 10.2(F)