



Cavanaugh Macdonald

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February 25, 2019

Mr. Jay Stoffel
Executive Director
Teacher Retirement Association of Minnesota
60 Empire Drive, Suite 400
St. Paul, MN 55103

Re: Projection of Future Actuarial Results

Dear Jay:

The Standards for Actuarial Work, as specified by the Legislative Commission on Pension and Retirement, require that a sensitivity analysis for the Teacher Retirement Association (TRA) be performed every two years. This involves modeling projections of future valuation results assuming future investment returns that are 1.5% higher and lower than the actuarial assumed rate of return. Given that the assumed rate of return is currently 7.5%, the resulting investment return scenarios are:

- (1) 6.0% for all years,
- (2) 7.5% for all years, and
- (3) 9.0% for all years.

Attached to this letter are both graphs and tables that show the estimated funded status, required and statutory contribution rates, contributions and benefit payment amounts, and the unfunded actuarial accrued liability (UAAL) under the three required investment return scenarios for the Teachers Retirement Association of Minnesota. These projections are based on the valuation assumptions in the July 1, 2018 valuation and the benefit provisions in statute.

While the actual investment returns earned in future years change under the three different scenarios, the investment return assumption of 7.5%, used in the valuation, was not changed, as specified by the LCPR Standards. As a result, the actuarial accrued liability is the same under all three scenarios. It should be noted that these projections are strictly for the purpose of sensitivity analysis, as required by the LCPR. The scenarios that reflect a rate of return of 6.0% or 9.0% do not represent likely outcomes, because neither changes to the contribution rates nor changes to the benefit structure are assumed to be implemented despite the valuation results. In reality, if the funding results in either of those scenarios were to actually occur, contributions and/or benefit provisions would most likely be adjusted.



The projections are developed by first creating a demographic profile of recent new entrants. Next, the membership population from the July 1, 2018 valuation is projected forward one year assuming all demographic assumptions are met. Members who are assumed to leave active employment are replaced with an equal number of new members from the new entrant demographic profile mentioned earlier. Then, a valuation is performed as of July 1, 2019 to determine the various actuarial accrued liabilities and cost measurements. The last two steps are repeated in each future year until projections have been performed through the July 1, 2048 valuation. In preparing these exhibits, we have followed the LCPR Standards for Actuarial Work, with the following exceptions which are permitted. Because of the expected changes in the active membership demographics over time as members of the pre-July 1, 1989 tier leave covered employment and are replaced by new employees with different retirement eligibility provisions as well as different demographic patterns, we have modeled future populations and valued them directly. We believe that this approach provides a better reflection of future valuation results than would be produced by using simplified assumptions of a constant normal cost rate and fixed growth in covered payroll.

Disclaimers, Caveats, and Limitations

The projection results are based upon the July 1, 2018 actuarial valuation results and the projection model prepared by TRA's actuary, Cavanaugh Macdonald Consulting. Significant items are noted below:

- The investment returns in all future years, as described earlier in this letter, are assumed to apply to the market value of assets.
- All demographic assumptions regarding mortality, disability, retirement, salary increases, and termination of employment are assumed to be met exactly in each year in the future. Please note that the actuarial assumption assumes that mortality will improve in the future (i.e. people will live longer).
- Changes in other programs may have an effect on future retirement patterns. For example, if changes in Social Security and/or Medicare are implemented to reduce benefits or delay eligibility for those programs, retirements from TRA are likely to also be delayed, thereby lowering the cost of the plan. However, because such changes cannot be reasonably anticipated, they are not reflected in this analysis.
- The number of active members covered by TRA in the future is assumed to remain level (neither growth nor decline in the active membership count). As active members leave employment, they are assumed to be replaced by new employees who have a similar demographic profile as recent new hires. With the departure of current active members who were hired before July 1, 1989, whose benefit structure has different retirement eligibility provisions from those of members hired since then, the demographic composition of the membership may gradually change over time.
- Plan provisions and scheduled contribution rate increases are assumed to remain unchanged from current law.
- The funding methods, including the entry age normal cost method, the asset smoothing method, and the amortization method and period, are as set out in statute.
- The current supplementary contributions made by the state are assumed to continue to be paid at approximately the same dollar amount as currently paid for the entire 30-year projection period, but are eliminated if the plan reaches 100% funded.
- The actuaries relied upon the membership data provided by TRA for the actuarial valuation. The numerical results depend on the integrity of this information. If there are material inaccuracies in this data, the results presented herein may be different and the projections may need to be revised.



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February 25, 2019
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Models are designed to identify anticipated trends and to compare various scenarios rather than predicting some future state of events. These projections are based on TRA's estimated financial status on July 1, 2018, and project future events using one set of assumptions out of a range of many possibilities. The projections do not predict the Association's financial condition or its ability to pay benefits in the future and do not provide any guarantee of future financial soundness of the System. Over time, a defined benefit plan's total cost will depend on a number of factors, including the amount of benefits paid, the number of people paid benefits, the duration of the benefit payments, plan expenses, and the amount of earnings on assets invested to pay benefits. These amounts and other variables are uncertain and unknowable at the time the projections were made. Because not all of the assumptions will unfold exactly as expected, actual results will differ from the projections. To the extent that actual experience deviates significantly from the assumptions, results could be significantly better or significantly worse than indicated in this letter. Decisions about making change to the benefit structure, funding the plan, or investment policy should not be made on the basis of these projections, but only after comprehensive analysis of alternative sets of assumptions.

We, Patrice A. Beckham and Brent A. Banister, are members of the American Academy of Actuaries and meet the Qualification Standards of the American Academy of Actuaries to render the actuarial opinion contained herein. We are available to answer any questions on the material in this letter or to provide explanations or further details as appropriate. We also meet the requirements of "approved actuary" under Minnesota Statutes, Section 356.215, Subdivision 1, Paragraph (c).

Sincerely,

A handwritten signature in cursive script that reads "Patrice Beckham".

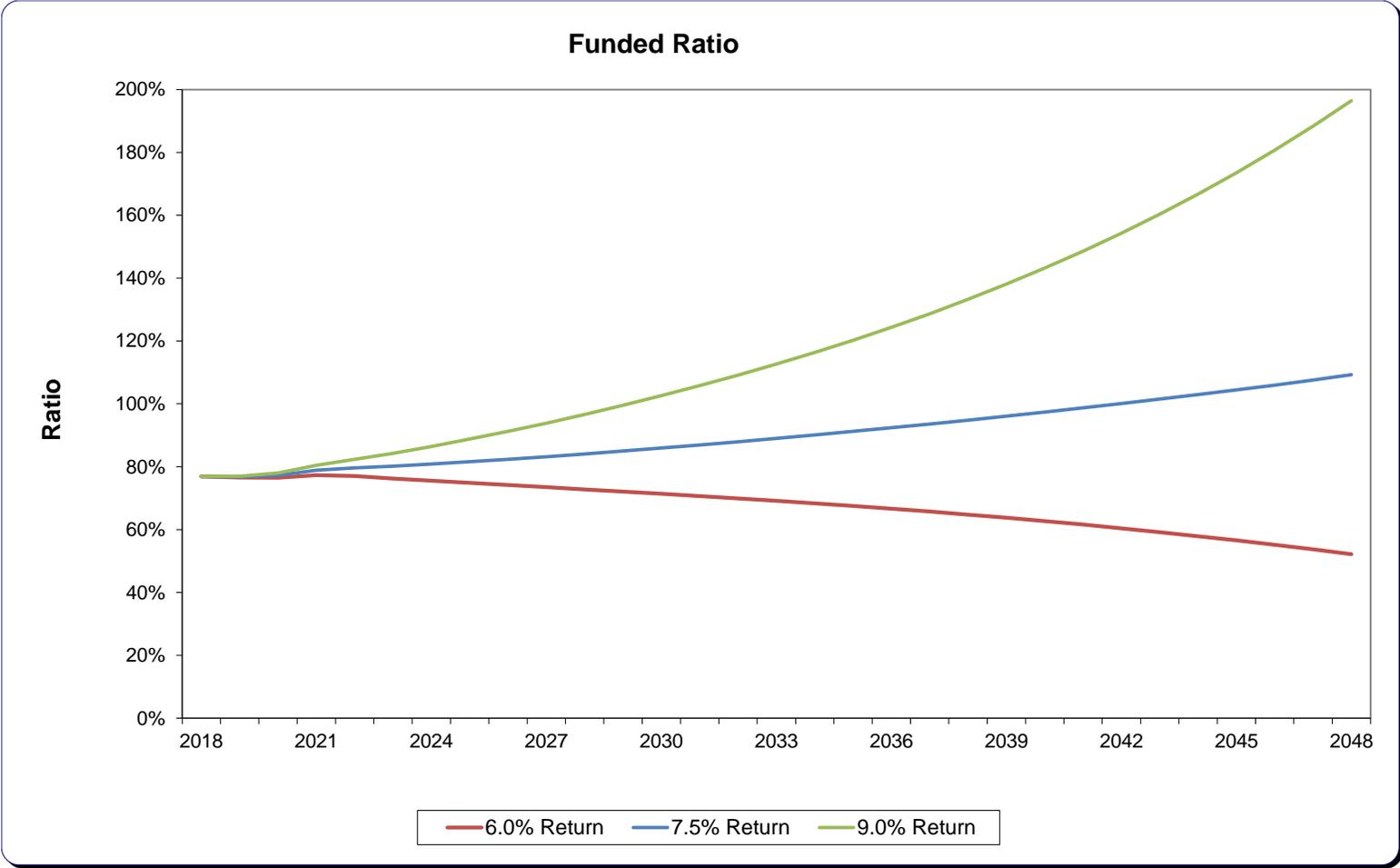
Patrice A. Beckham, FSA, EA, FCA, MAAA
Principal and Consulting Actuary

A handwritten signature in cursive script that reads "Brent A. Banister".

Brent A. Banister, PhD, FSA, EA, FCA, MAAA
Chief Actuary



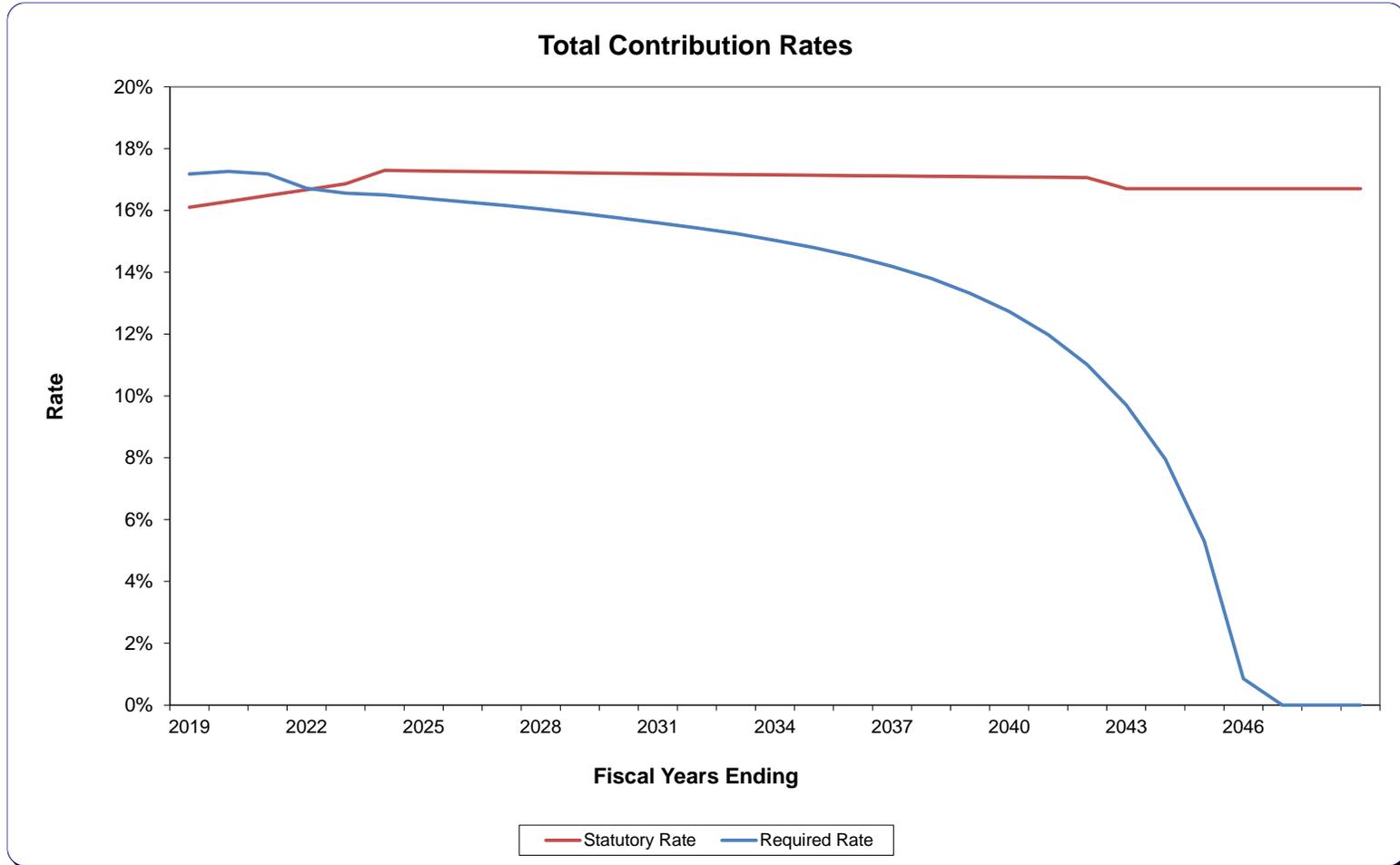
Exhibit A
All Investment Return Scenarios



Results are based on specified investment returns and all other actuarial assumptions being met each year in the future. Please refer to the accompanying letter from Cavanaugh Macdonald dated February 25, 2019 for important details regarding assumptions and methodology.



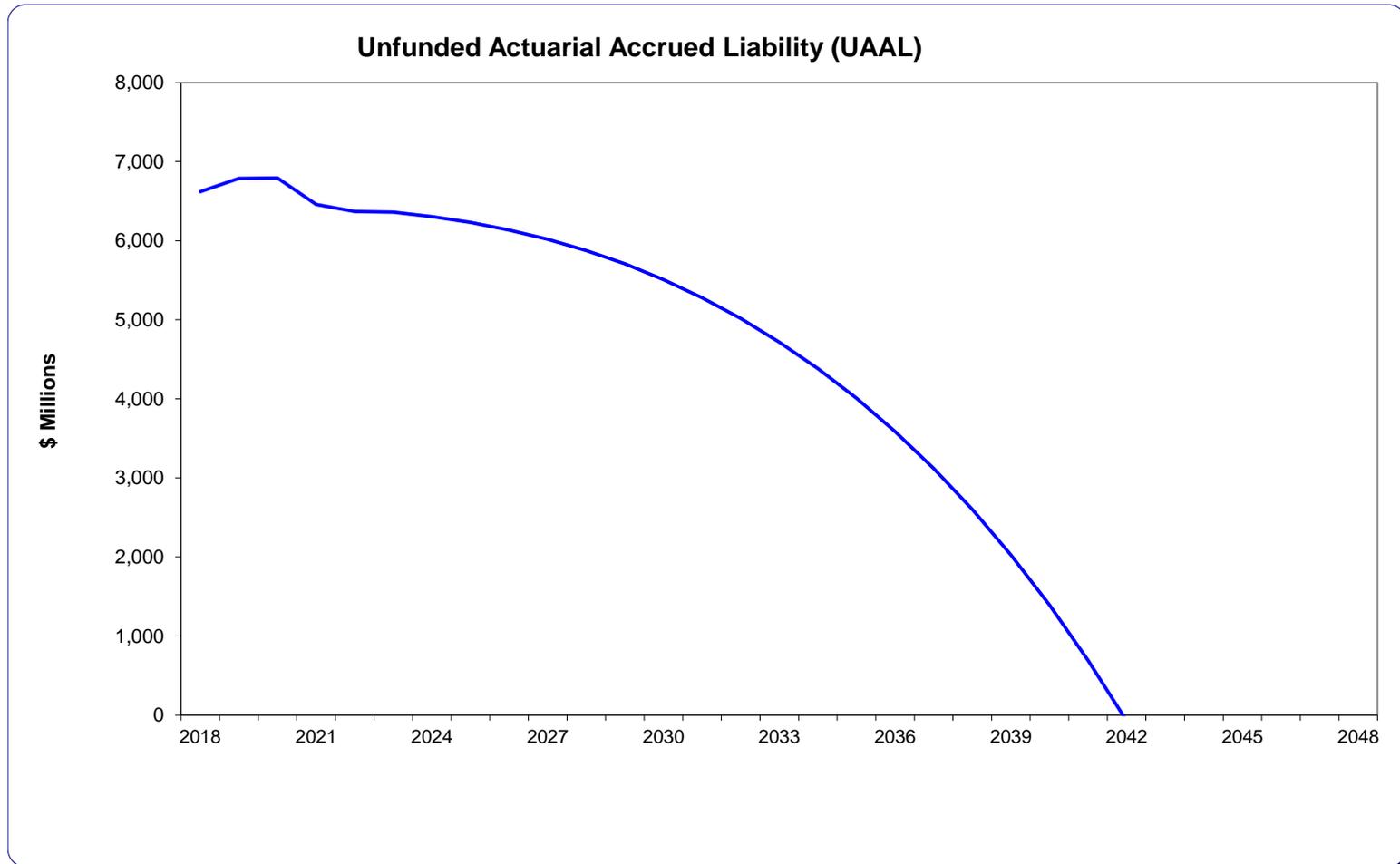
Exhibit B-1
7.5% Actual Investment Return in Future Years



Results are based on a specified investment return and all other actuarial assumptions being met each year in the future. Please refer to the accompanying letter from Cavanaugh Macdonald dated February 25, 2019 for important details regarding assumptions and methodology.



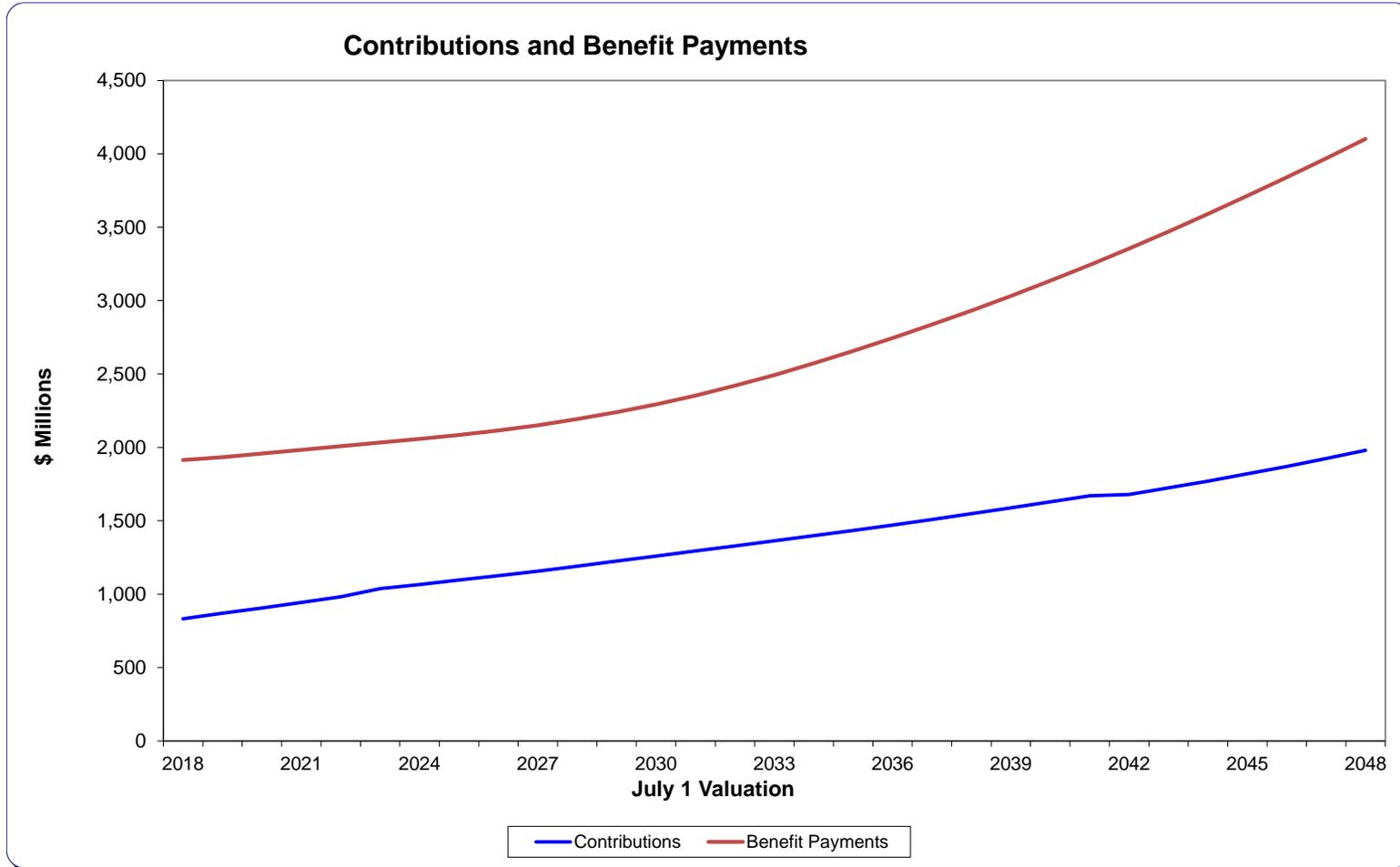
Exhibit B-2
7.5% Actual Investment Return in Future Years



Results are based on a specified investment return and all other actuarial assumptions being met each year in the future. Please refer to the accompanying letter from Cavanaugh Macdonald dated February 25, 2019 for important details regarding assumptions and methodology.



Exhibit B-3
7.5% Actual Investment Return in Future Years



Results are based on a specified investment return and all other actuarial assumptions being met each year in the future. Please refer to the accompanying letter from Cavanaugh Macdonald dated February 25, 2019 for important details regarding assumptions and methodology



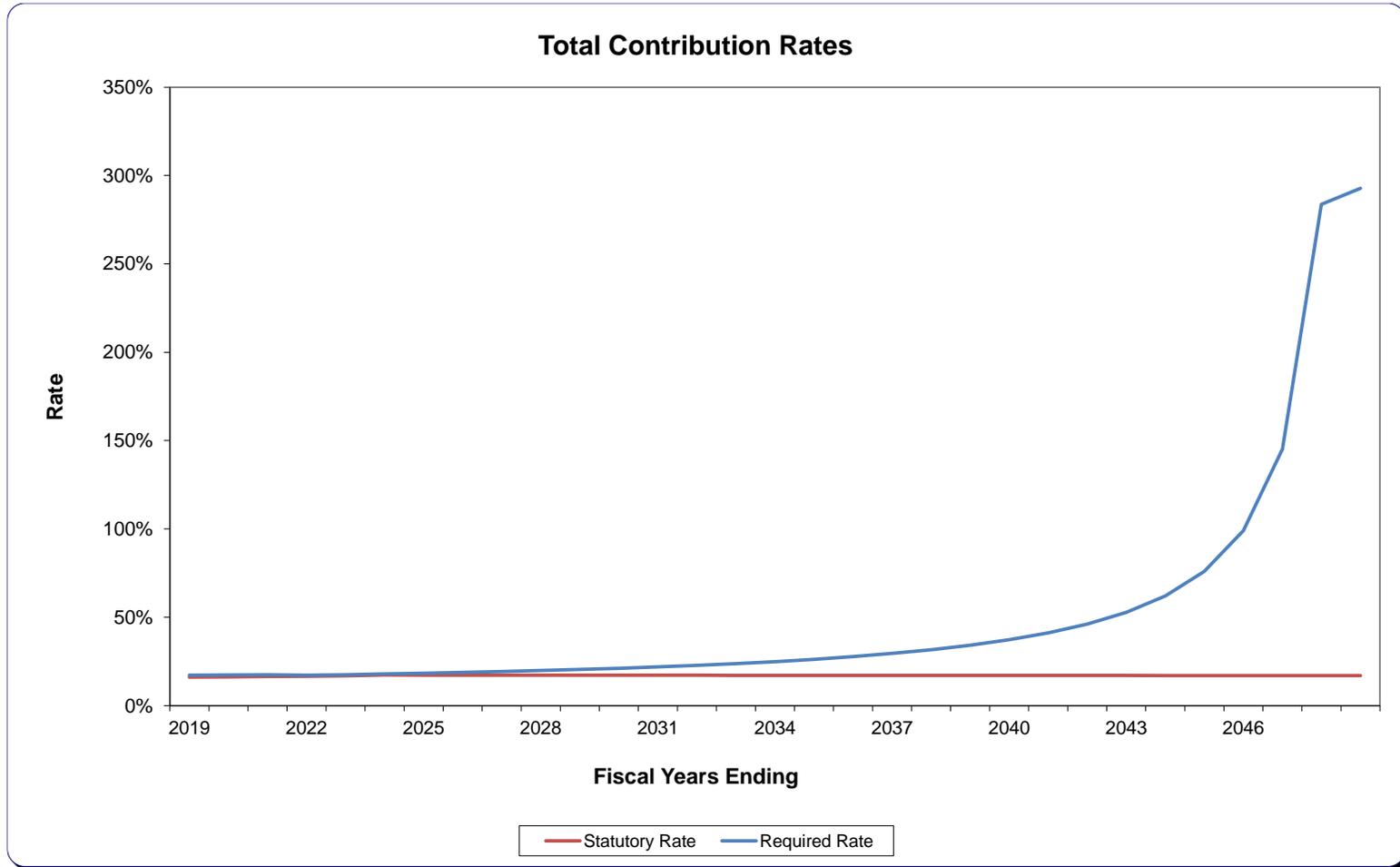
Teachers Retirement Association of Minnesota
Exhibit C
7.5% Actual Investment Return in Future Years

July 1	Asset Values		Actuarial Accrued Liability	Unfunded Actuarial Accrued Liability	Funded Ratio	Contribution Rates			Total Contributions	Benefit Payments
	Actuarial	Market				Statutory	Required	Sufficiency/ (Deficiency)		
2018	\$22,022.84	\$22,357.57	\$28,643.02	\$6,620.18	77%	16.10%	17.18%	-1.08%	\$832.87	\$1,914.99
2019	22,460.62	22,912.42	29,248.64	6,788.01	77%	16.29%	17.26%	-0.97%	870.235	1,933.76
2020	23,100.52	23,528.17	29,894.87	6,794.35	77%	16.48%	17.18%	-0.70%	905.854	1,957.78
2021	24,122.51	24,202.12	30,580.57	6,458.06	79%	16.67%	16.72%	-0.05%	943.455	1,982.87
2022	24,939.59	24,939.59	31,307.65	6,368.06	80%	16.86%	16.56%	0.30%	982.617	2,008.84
2023	25,746.05	25,746.05	32,107.53	6,361.47	80%	17.30%	16.50%	0.80%	1037.25	2,032.76
2024	26,644.84	26,644.84	32,950.40	6,305.56	81%	17.28%	16.39%	0.89%	1066.53	2,057.48
2025	27,615.76	27,615.76	33,846.50	6,230.74	82%	17.26%	16.28%	0.98%	1096.34	2,084.30
2026	28,662.60	28,662.60	34,797.71	6,135.11	82%	17.25%	16.17%	1.08%	1126.35	2,114.91
2027	29,787.33	29,787.33	35,804.61	6,017.28	83%	17.23%	16.05%	1.18%	1156.4	2,150.97
2028	30,990.19	30,990.19	36,866.01	5,875.82	84%	17.22%	15.91%	1.31%	1,190.86	2,193.10
2029	32,275.31	32,275.31	37,982.17	5,706.86	85%	17.20%	15.76%	1.44%	1,225.40	2,239.99
2030	33,644.01	33,644.01	39,152.58	5,508.57	86%	17.19%	15.60%	1.59%	1,259.91	2,293.64
2031	35,095.52	35,095.52	40,374.53	5,279.01	87%	17.17%	15.43%	1.74%	1,294.39	2,353.46
2032	36,629.61	36,629.61	41,645.98	5,016.37	88%	17.16%	15.25%	1.91%	1,328.96	2,420.32
2033	38,245.29	38,245.29	42,963.61	4,718.32	89%	17.15%	15.03%	2.12%	1,363.67	2,493.36
2034	39,942.40	39,942.40	44,324.94	4,382.54	90%	17.14%	14.80%	2.34%	1,398.91	2,572.69
2035	41,721.09	41,721.09	45,727.22	4,006.14	91%	17.13%	14.52%	2.61%	1,434.91	2,656.40
2036	43,583.69	43,583.69	47,169.67	3,585.98	92%	17.12%	14.19%	2.93%	1,471.66	2,745.36
2037	45,531.87	45,531.87	48,650.46	3,118.59	94%	17.10%	13.80%	3.30%	1,509.38	2,837.11
2038	47,570.15	47,570.15	50,170.33	2,600.18	95%	17.09%	13.32%	3.77%	1,548.25	2,931.73
2039	49,703.49	49,703.49	51,729.66	2,026.17	96%	17.08%	12.73%	4.35%	1,588.04	3,031.27
2040	51,934.88	51,934.88	53,327.06	1,392.18	97%	17.07%	11.98%	5.09%	1,628.86	3,135.25
2041	54,268.14	54,268.14	54,961.78	693.63	99%	17.06%	11.01%	6.05%	1,671.03	3,243.26
2042	56,708.13	56,708.13	56,633.31	(74.82)	100%	16.70%	9.71%	6.99%	1,678.99	3,354.87
2043	59,223.66	59,223.66	58,341.70	(881.96)	102%	16.70%	7.95%	8.75%	1,724.21	3,470.50
2044	61,854.84	61,854.84	60,086.76	(1,768.08)	103%	16.70%	5.30%	11.40%	1,771.12	3,590.28
2045	64,607.81	64,607.81	61,867.92	(2,739.89)	104%	16.70%	0.85%	15.85%	1,819.98	3,713.91
2046	67,489.73	67,489.73	63,685.10	(3,804.63)	106%	16.70%	0.00%	16.70%	1,870.94	3,840.05
2047	70,509.85	70,509.85	65,540.00	(4,969.85)	108%	16.70%	0.00%	16.70%	1,924.38	3,968.74
2048	73,678.45	73,678.45	67,434.07	(6,244.38)	109%	16.70%	0.00%	16.70%	1,980.21	4,101.22

Results are based on a specified investment return and all other actuarial assumptions being met each year in the future. Please refer to the accompanying letter from Cavanaugh Macdonald dated February 25, 2019 for important details regarding assumptions and methodology.



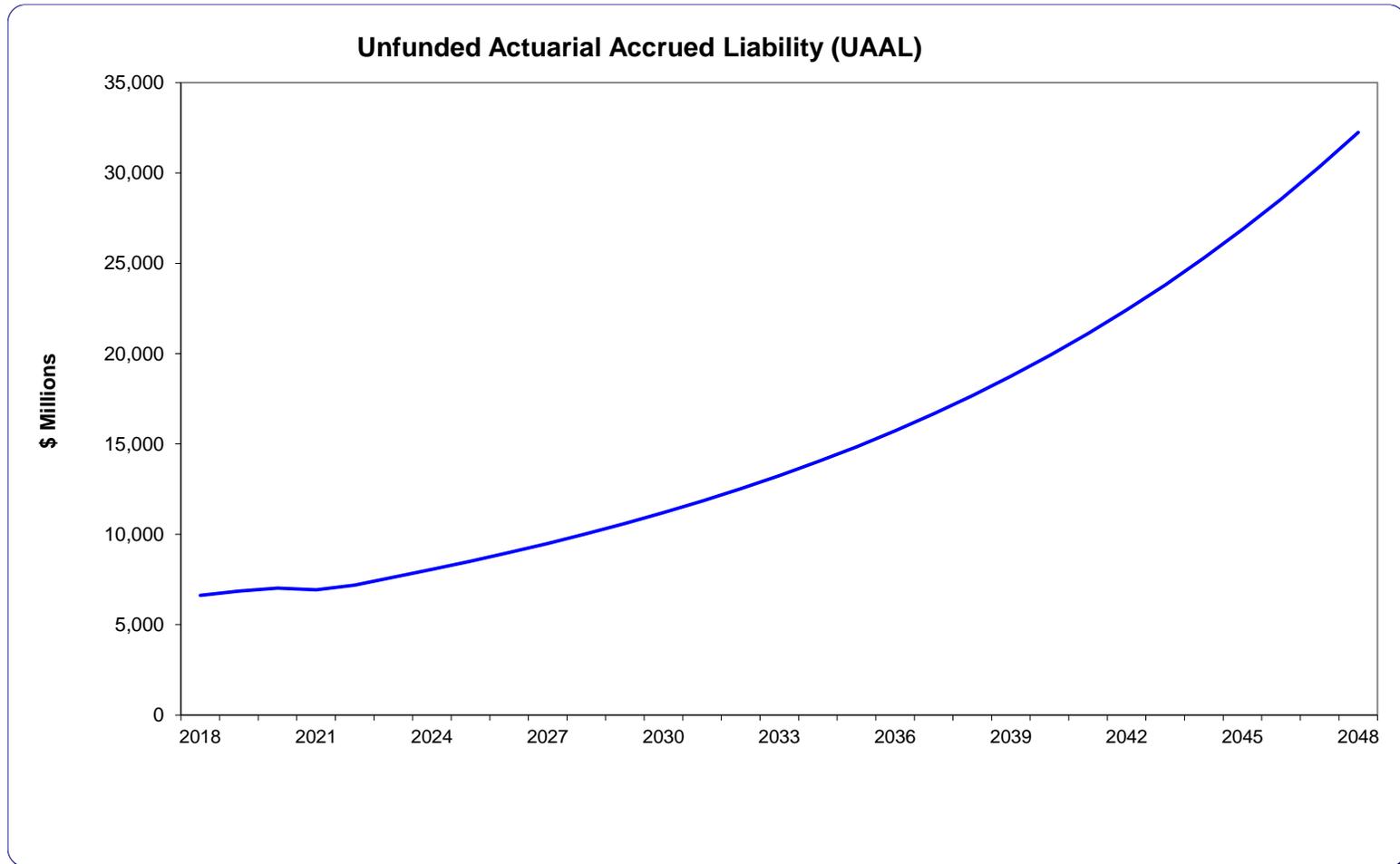
Exhibit D-1
6.0% Actual Investment Return in Future Years



Results are based on a specified investment return and all other actuarial assumptions being met each year in the future. Please refer to the accompanying letter from Cavanaugh Macdonald dated February 25, 2019 for important details regarding assumptions and methodology.



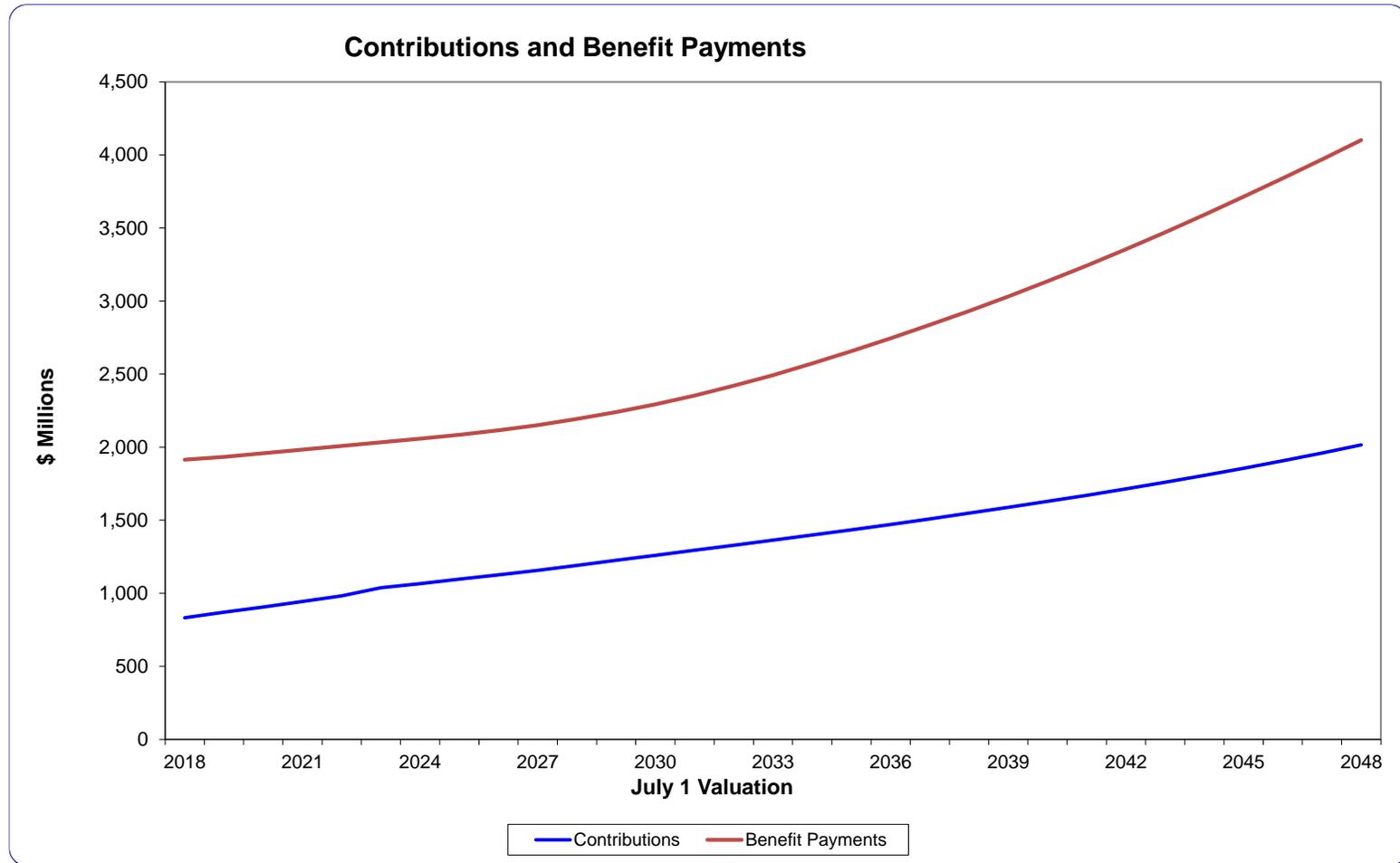
Exhibit D-2
6.0% Actual Investment Return in Future Years



Results are based on a specified investment return and all other actuarial assumptions being met each year in the future. Please refer to the accompanying letter from Cavanaugh Macdonald dated February 25, 2019 for important details regarding assumptions and methodology.



Exhibit D-3
6.0% Actual Investment Return in Future Years



Results are based on a specified investment return and all other actuarial assumptions being met each year in the future. Please refer to the accompanying letter from Cavanaugh Macdonald dated February 25, 2019 for important details regarding assumptions and methodology.



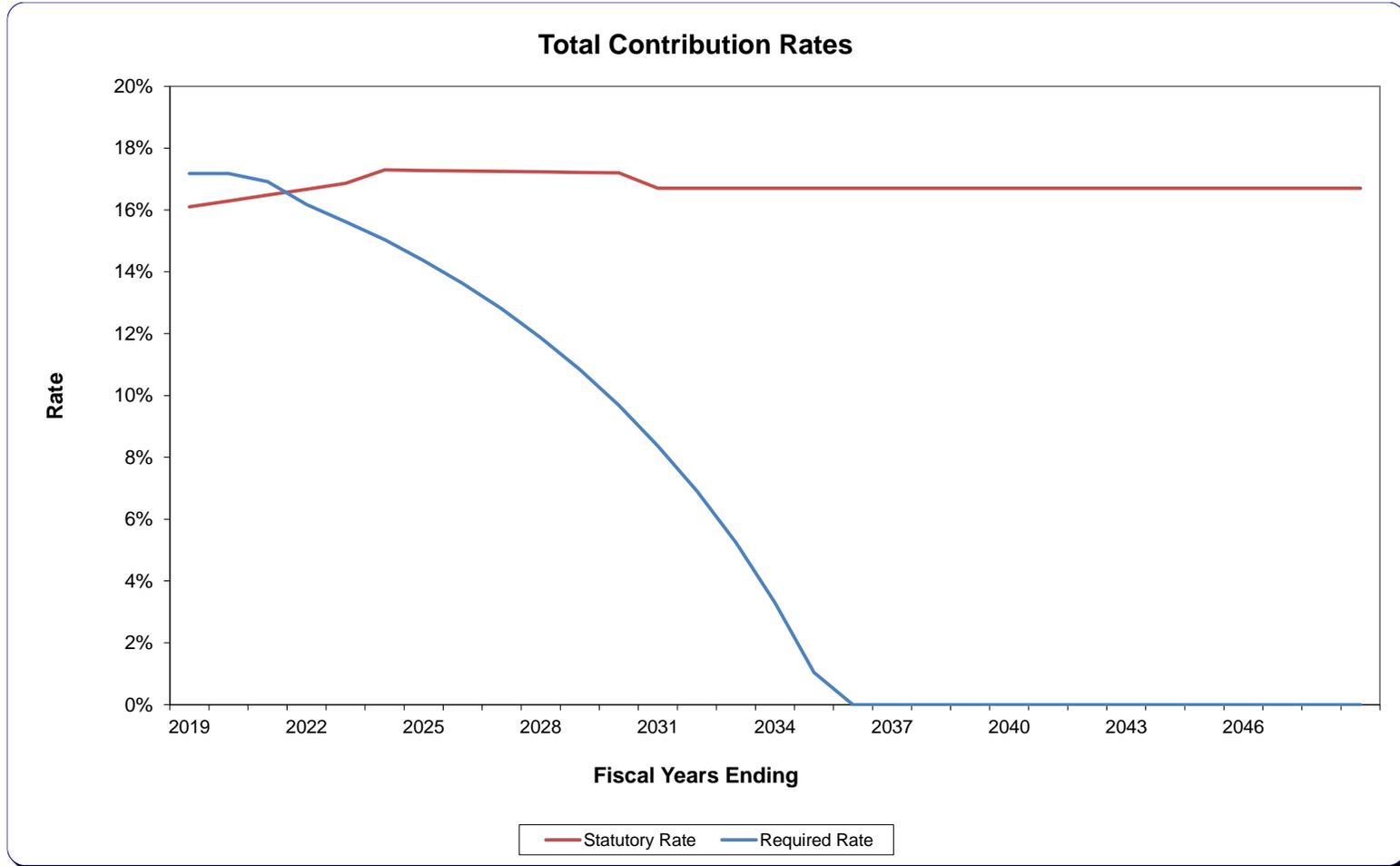
Teachers Retirement Association of Minnesota
Exhibit E
6.0% Actual Investment Return in Future Years

July 1	Asset Values		Actuarial Accrued Liability	Unfunded Actuarial Accrued Liability	Funded Ratio	Contribution Rates			Total Contributions	Benefit Payments
	Actuarial	Market				Statutory	Required	Sufficiency/ (Deficiency)		
2018	\$22,022.84	\$22,357.57	\$28,643.02	\$6,620.18	77%	16.10%	17.18%	-1.08%	\$832.87	\$1,914.99
2019	22,395.12	22,584.91	29,248.64	6,853.51	77%	16.29%	17.33%	-1.04%	870.235	1,933.76
2020	22,878.75	22,845.05	29,894.87	7,016.12	77%	16.48%	17.43%	-0.95%	905.854	1,957.78
2021	23,650.78	23,132.72	30,580.57	6,929.79	77%	16.67%	17.25%	-0.58%	943.455	1,982.87
2022	24,121.05	23,450.54	31,307.65	7,186.61	77%	16.86%	17.47%	-0.61%	982.617	2,008.84
2023	24,480.36	23,801.02	32,107.53	7,627.17	76%	17.30%	17.90%	-0.60%	1037.25	2,032.76
2024	24,893.34	24,204.14	32,950.40	8,057.06	76%	17.28%	18.31%	-1.03%	1066.53	2,057.48
2025	25,336.31	24,636.13	33,846.50	8,510.18	75%	17.26%	18.77%	-1.51%	1096.34	2,084.30
2026	25,809.33	25,097.13	34,797.71	8,988.39	74%	17.25%	19.29%	-2.04%	1126.35	2,114.91
2027	26,310.33	25,585.18	35,804.61	9,494.28	73%	17.23%	19.86%	-2.63%	1156.4	2,150.97
2028	26,835.25	26,096.31	36,866.01	10,030.76	73%	17.22%	20.46%	-3.24%	1,190.86	2,193.10
2029	27,383.68	26,630.22	37,982.17	10,598.49	72%	17.20%	21.13%	-3.93%	1,225.40	2,239.99
2030	27,952.10	27,183.45	39,152.58	11,200.48	71%	17.19%	21.89%	-4.70%	1,259.91	2,293.64
2031	28,534.60	27,750.17	40,374.53	11,839.93	71%	17.17%	22.76%	-5.59%	1,294.39	2,353.46
2032	29,125.47	28,324.80	41,645.98	12,520.51	70%	17.16%	23.76%	-6.60%	1,328.96	2,420.32
2033	29,717.88	28,900.67	42,963.61	13,245.73	69%	17.15%	24.89%	-7.74%	1,363.67	2,493.36
2034	30,305.51	29,471.62	44,324.94	14,019.42	68%	17.14%	26.20%	-9.06%	1,398.91	2,572.69
2035	30,881.96	30,031.44	45,727.22	14,845.26	68%	17.13%	27.72%	-10.59%	1,434.91	2,656.40
2036	31,442.65	30,575.72	47,169.67	15,727.02	67%	17.12%	29.50%	-12.38%	1,471.66	2,745.36
2037	31,981.87	31,098.91	48,650.46	16,668.59	66%	17.10%	31.60%	-14.50%	1,509.38	2,837.11
2038	32,496.34	31,597.87	50,170.33	17,673.99	65%	17.09%	34.13%	-17.04%	1,548.25	2,931.73
2039	32,982.69	32,069.37	51,729.66	18,746.97	64%	17.08%	37.23%	-20.15%	1,588.04	3,031.27
2040	33,435.06	32,507.63	53,327.06	19,892.01	63%	17.07%	41.11%	-24.04%	1,628.86	3,135.25
2041	33,847.80	32,907.17	54,961.78	21,113.98	62%	17.06%	46.09%	-29.03%	1,671.03	3,243.26
2042	34,215.67	33,262.89	56,633.31	22,417.64	60%	17.06%	52.72%	-35.66%	1,714.68	3,354.87
2043	34,533.73	33,570.00	58,341.70	23,807.97	59%	17.05%	62.01%	-44.96%	1,759.91	3,470.50
2044	34,796.37	33,823.03	60,086.76	25,290.38	58%	17.04%	75.91%	-58.87%	1,806.82	3,590.28
2045	34,997.68	34,016.23	61,867.92	26,870.24	57%	17.03%	99.05%	-82.02%	1,855.68	3,713.91
2046	35,131.94	34,144.04	63,685.10	28,553.16	55%	17.02%	145.26%	-128.24%	1,906.64	3,840.05
2047	35,194.65	34,202.11	65,540.00	30,345.35	54%	17.01%	283.73%	-266.72%	1,960.07	3,968.74
2048	35,181.40	34,186.18	67,434.07	32,252.67	52%	17.00%	292.76%	-275.76%	2,015.91	4,101.22

Results are based on a specified investment return and all other actuarial assumptions being met each year in the future. Please refer to the accompanying letter from Cavanaugh Macdonald dated February 25, 2019 for important details regarding assumptions and methodology.



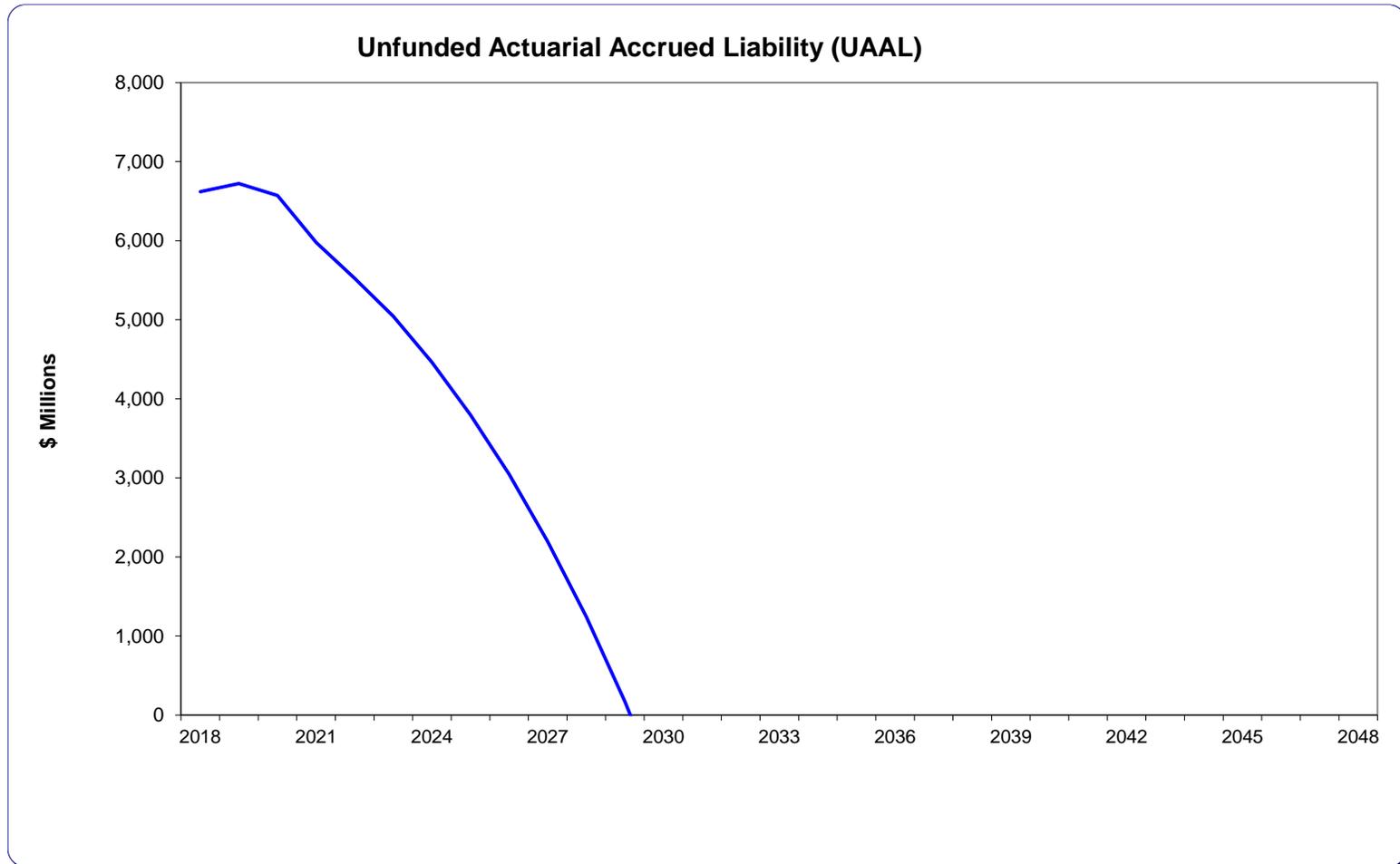
Exhibit F-1
9.0% Actual Investment Return in Future Years



Results are based on a specified investment return and all other actuarial assumptions being met each year in the future. Please refer to the accompanying letter from Cavanaugh Macdonald dated February 25, 2019 for important details regarding assumptions and methodology.



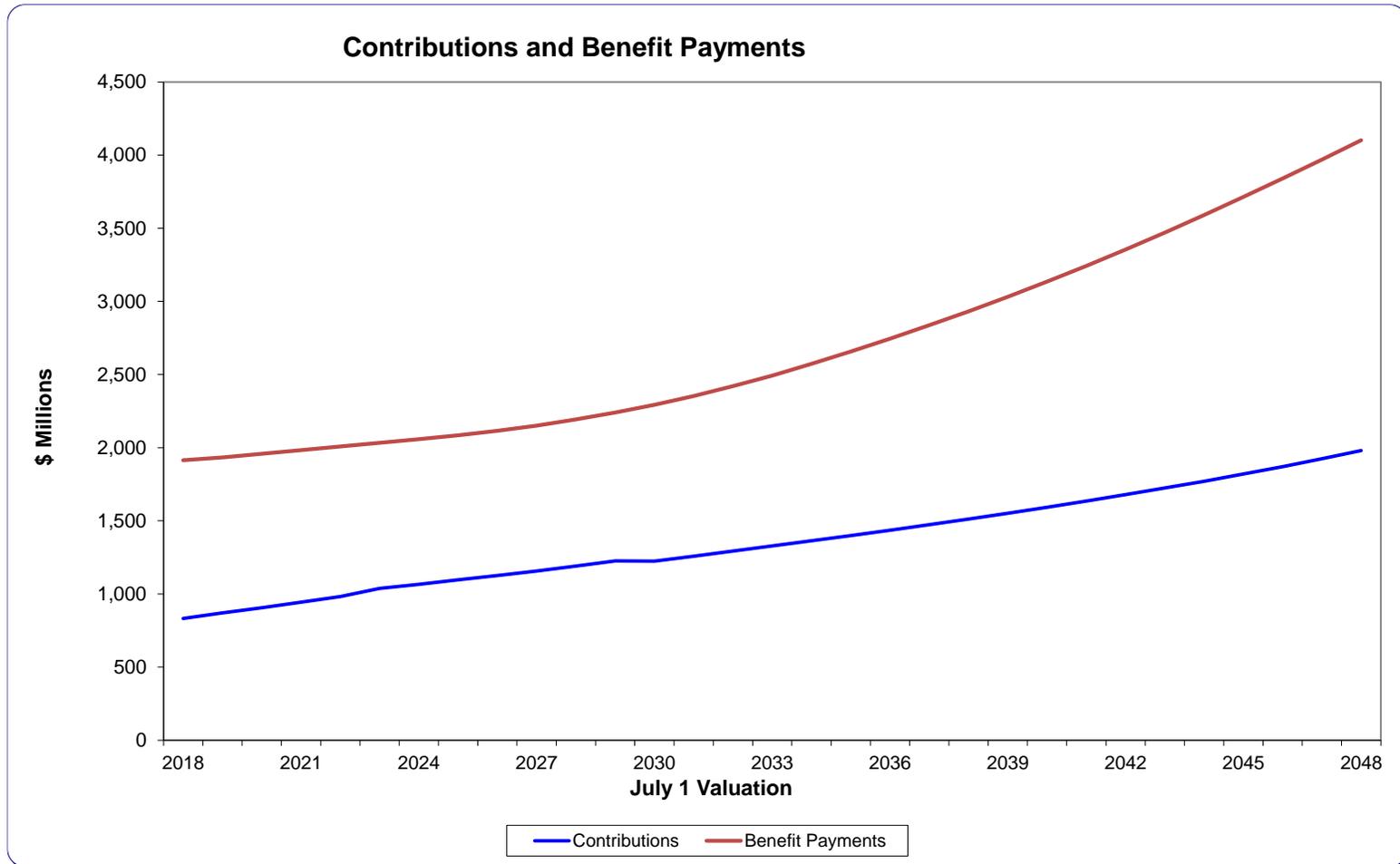
Exhibit F-2
9.0% Actual Investment Return in Future Years



Results are based on a specified investment return and all other actuarial assumptions being met each year in the future. Please refer to the accompanying letter from Cavanaugh Macdonald dated February 25, 2019 for important details regarding assumptions and methodology.



Exhibit F-3
9.0% Actual Investment Return in Future Years



Results are based on a specified investment return and all other actuarial assumptions being met each year in the future. Please refer to the accompanying letter from Cavanaugh Macdonald dated February 25, 2019 for important details regarding assumptions and methodology.



Teachers Retirement Association of Minnesota
Exhibit G
9.0% Actual Investment Return in Future Years

July 1	Asset Values		Actuarial Accrued Liability	Unfunded Actuarial Accrued Liability	Funded Ratio	Contribution Rates			Total Contributions	Benefit Payments
	Actuarial	Market				Statutory	Required	Sufficiency/ (Deficiency)		
2018	\$22,022.84	\$22,357.57	\$28,643.02	\$6,620.18	77%	16.10%	17.18%	-1.08%	\$832.87	\$1,914.99
2019	22,526.14	23,239.98	29,248.64	6,722.50	77%	16.29%	17.18%	-0.89%	870.235	1,933.76
2020	23,324.30	24,221.24	29,894.87	6,570.57	78%	16.48%	16.92%	-0.44%	905.854	1,957.78
2021	24,603.11	25,302.90	30,580.57	5,977.45	80%	16.67%	16.18%	0.49%	943.455	1,982.87
2022	25,782.01	26,494.98	31,307.65	5,525.64	82%	16.86%	15.62%	1.24%	982.617	2,008.84
2023	27,062.39	27,808.12	32,107.53	5,045.14	84%	17.30%	15.04%	2.26%	1037.25	2,032.76
2024	28,489.57	29,271.51	32,950.40	4,460.83	86%	17.28%	14.36%	2.92%	1066.53	2,057.48
2025	30,049.43	30,871.36	33,846.50	3,797.07	89%	17.26%	13.62%	3.64%	1096.34	2,084.30
2026	31,752.42	32,618.32	34,797.71	3,045.30	91%	17.25%	12.80%	4.45%	1126.35	2,114.91
2027	33,607.83	34,521.88	35,804.61	2,196.78	94%	17.23%	11.87%	5.36%	1156.4	2,150.97
2028	35,623.90	36,590.49	36,866.01	1,242.10	97%	17.22%	10.84%	6.38%	1,190.86	2,193.10
2029	37,813.51	38,837.26	37,982.17	168.66	100%	17.20%	9.68%	7.52%	1,225.40	2,239.99
2030	40,187.48	41,273.35	39,152.58	(1,034.90)	103%	16.70%	8.37%	8.33%	1,224.22	2,293.64
2031	42,718.40	43,871.45	40,374.53	(2,343.87)	106%	16.70%	6.91%	9.79%	1,258.69	2,353.46
2032	45,451.50	46,676.90	41,645.98	(3,805.52)	109%	16.70%	5.24%	11.46%	1,293.27	2,420.32
2033	48,397.81	49,701.15	42,963.61	(5,434.20)	113%	16.70%	3.30%	13.40%	1,327.97	2,493.36
2034	51,570.30	52,957.56	44,324.94	(7,245.36)	116%	16.70%	1.04%	15.66%	1,363.22	2,572.69
2035	54,983.38	56,461.01	45,727.22	(9,256.16)	120%	16.70%	0.00%	16.70%	1,399.21	2,656.40
2036	58,655.04	60,229.96	47,169.67	(11,485.36)	124%	16.70%	0.00%	16.70%	1,435.97	2,745.36
2037	62,604.01	64,283.61	48,650.46	(13,953.54)	129%	16.70%	0.00%	16.70%	1,473.69	2,837.11
2038	66,853.47	68,645.68	50,170.33	(16,683.14)	133%	16.70%	0.00%	16.70%	1,512.55	2,931.73
2039	71,428.74	73,342.14	51,729.66	(19,699.08)	138%	16.70%	0.00%	16.70%	1,552.34	3,031.27
2040	76,355.06	78,398.89	53,327.06	(23,028.00)	143%	16.70%	0.00%	16.70%	1,593.17	3,135.25
2041	81,660.56	83,844.81	54,961.78	(26,698.79)	149%	16.70%	0.00%	16.70%	1,635.34	3,243.26
2042	87,376.65	89,712.12	56,633.31	(30,743.35)	154%	16.70%	0.00%	16.70%	1,678.99	3,354.87
2043	93,538.17	96,036.54	58,341.70	(35,196.47)	160%	16.70%	0.00%	16.70%	1,724.21	3,470.50
2044	100,182.72	102,856.65	60,086.76	(40,095.96)	167%	16.70%	0.00%	16.70%	1,771.12	3,590.28
2045	107,351.27	110,214.49	61,867.92	(45,483.35)	174%	16.70%	0.00%	16.70%	1,819.98	3,713.91
2046	115,089.09	118,156.49	63,685.10	(51,403.99)	181%	16.70%	0.00%	16.70%	1,870.94	3,840.05
2047	123,447.02	126,734.77	65,540.00	(57,907.01)	188%	16.70%	0.00%	16.70%	1,924.38	3,968.74
2048	132,480.82	136,006.51	67,434.07	(65,046.75)	196%	16.70%	0.00%	16.70%	1,980.21	4,101.22

Results are based on a specified investment return and all other actuarial assumptions being met each year in the future. Please refer to the accompanying letter from Cavanaugh Macdonald dated February 25, 2019 for important details regarding assumptions and methodology.