



Report [Pension Scheme Rating] from www.mortalityrating.com

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2. Summary statistics

Table 1 shows some summary statistics for this portfolio. It shows the number of records uploaded to mortalityrating.com, together with the number rejected and the number actually used in the rating report. Records can be rejected for a variety of reasons, including missing data (such as a missing date of birth) or invalid data (such as a date of birth after the date of pension commencement). Records with invalid postcodes are not rejected, however, and such cases are included in the report. A download file of cases with unrecognised postcodes is available in case you wish to correct them and re-rate the portfolio.

Table 1 also shows the average age of the lives behind each record, split by gender. These average ages are also shown weighted by amount. Ill-health lives are deemed to be those where the benefit started before age 50.

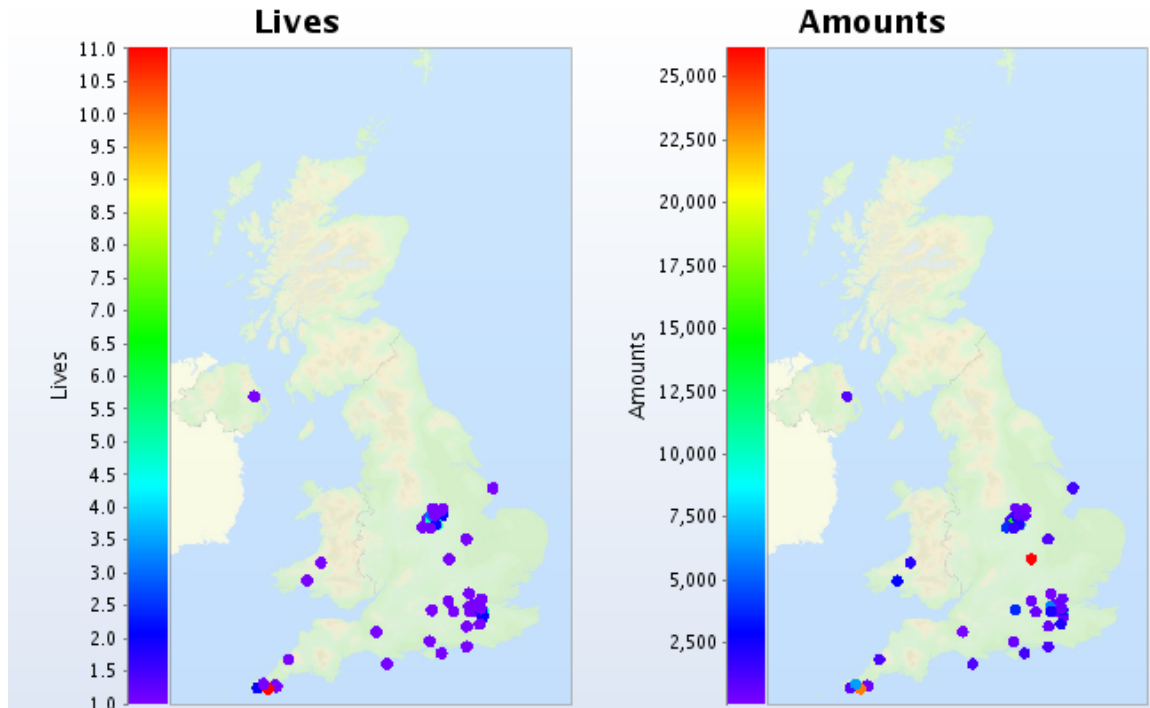
Table 1. Summary portfolio data:

Metric	Value
Records read	100
Records rejected	12
Records with second life	0
Records used in rating	88
Males	61
Females	27
Ill-health members	0
Male average age	79.10
Female average age	71.43
Amounts-weighted male average age	80.06
Amounts-weighted female average age	71.56
Pensions p.a. to males	£131076.72
Pensions p.a. to females	£33213.60
Pensions p.a. to ill-health members	£0.00
Pensions p.a. to single lives	£164290.32
Pensions p.a. to joint lives	£0.00

3. Geographic spread of liabilities

Figure 1 shows the geographic spread of lives and amounts for records with valid UK postcodes, with data aggregated and plotted at postcode district level. We present Figure 1 for interest only, since [geographical variations in longevity are mainly due to varying socio-economic mix](#). Region is not a rating factor used in this report.

Figure 1. Geographical spread of liabilities by lives (left) and amounts (right)



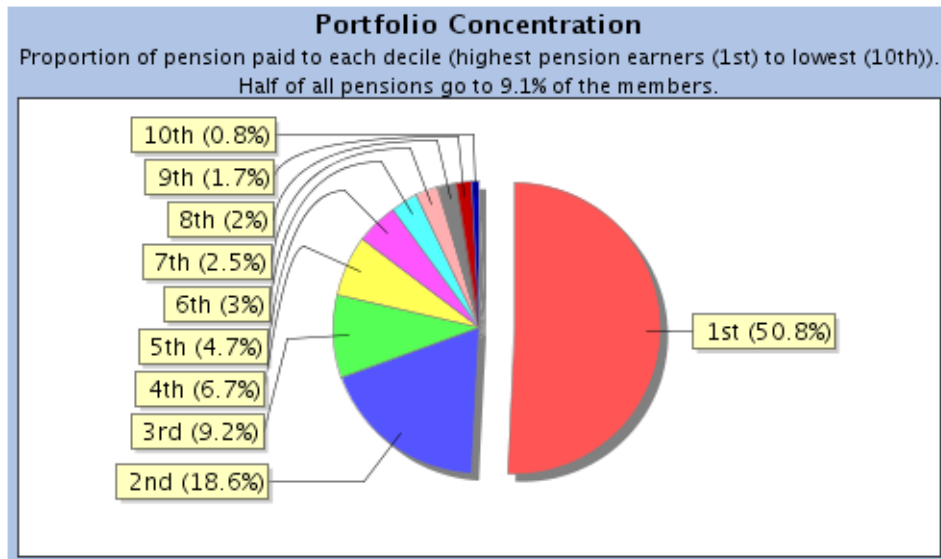
Map © Crown copyright Ordnance Survey. All rights reserved.

4. Concentration of liabilities

Liabilities within any given portfolio are rarely equal, and they usually differ widely in size. Typically, a large proportion of liabilities is concentrated on a relatively small number of lives. One measure of inequality in income distribution is the Gini Index. It ranges from 0% (perfect equality) to 100% (one person has all the income). The [Office for National Statistics](#) gave the UK as a whole a value of 34% in 2008/9, whereas the figure for this portfolio is 64.48%.

An alternative approach is to show the proportion of pensions for each decile of lives, as in Figure 2. Here we have sorted the portfolio membership by size of pension and created ten equally-sized groups (deciles) from the 10% of members with the highest pensions down to the 10% of members with the lowest pensions. Figure 2 shows the proportion of total pensions accounted for by each decile.

Figure 2. Concentration of amounts



This concentration carries an extra risk, namely that the lives with the largest proportion of liabilities have a markedly different life expectancy than the ones with the smallest proportion. To assess the mortality risk of this portfolio, we therefore need to look at its socio-economic mix.

5. Socio-economic group

People belonging to more upmarket socio-economic groups tend to live longer, as shown in Figure 3. Socio-economic differentials have proved very durable in the UK over the past thirty years, as tracked in the ONS Longitudinal Study. The Study is a complete set of census records for a sample of the population of England and Wales. The sample comprises people born on one of four selected dates of birth and was initiated at the time of the 1971 Census (and updated at the 1981, 1991 and 2001 Censuses and in routine event registrations). New study members enter through birth and immigration and existing members leave through death and emigration. The study represents a continuous sample of the population of England and Wales, rather than a sample taken at one time point only, and now includes records for over 950,000 people. More details can be found at <http://www.celsius.lshtm.ac.uk> for those interested in the background, although such data plays no role in www.mortalityrating.com.

Figure 3. Male life expectancy at age 65 by socio-economic group

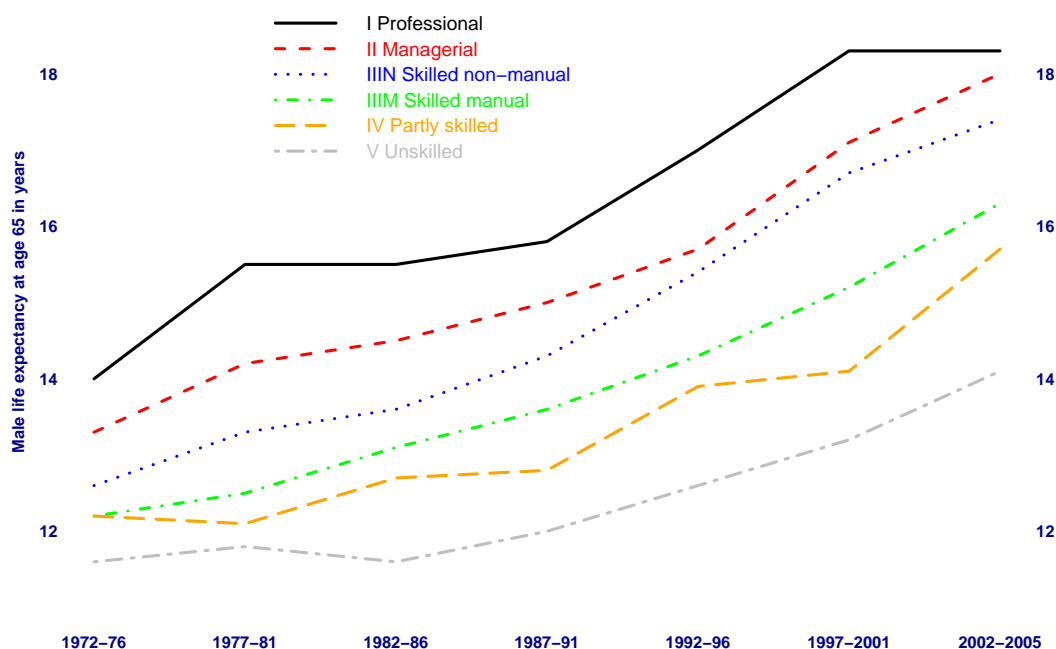


Figure 3 shows that socio-economic differentials are important for rating any portfolio. This is all the more acute if the concentration of risk shown in Figure 2 is magnified if the group with the largest proportion of liabilities is also the group with markedly different life expectancy. It is therefore critical to assess the portfolio for socio-economic differentials.

However, the drawback of socio-economic group used in Figure 3 is that it is determined by occupation. This is a semi-subjective categorisation, which is prone to misclassification or exaggeration. More practically, former occupation is not always available for pensioners. What is needed for underwriting social group is simple data that reliably predicts higher or lower mortality. One particularly helpful piece of data, the postcode, can be used to profile people for their life expectancy. We use postcode to map to one of four life expectancy groups, and we call these *lifestyle groups* to distinguish them from the socio-economic groups in Figure 3. The lifestyle groups are defined by postcode, whereas the socio-economic groups are defined by occupation.

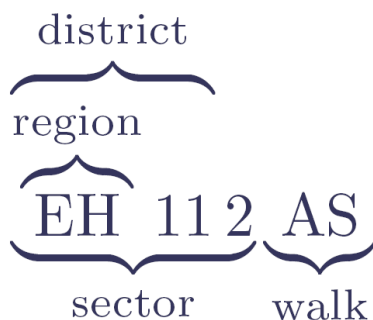
Note that www.mortalityrating.com is parameterised using the mortality experience of private pensioners, not the wider population. Figure 3 is presented for background reasons only, since ONS population data is not used in the models which lie behind the figures calculated in this report.

6. Why use postcodes?

Walking down a street will usually give quite a good impression of the socio-economic status of the people who live there. Very broadly, a postcode covers a single street (or less) in the UK, so postcodes should be useful potential indicators of socio-economic status. As a result, actuaries in the United Kingdom make use of so-called *geodemographic models* of mortality, primarily driven by the use of postcodes. The market for bulk annuities has long been driven by postcode for rating socio-economic group, and now annuity products marketed directly to individual consumers are priced using postcode (Legal and General, 2007, and Norwich Union, 2008). The methodology is detailed in a [paper presented to the Institute of Actuaries in London in 2008](#).

A geodemographic model is one where a person’s address or postcode is used to profile their socio-economic or lifestyle status. Such models have been used for mortality studies before, for example, McLoone (2000) published so-called *Carstairs Scores* for deprivation using Scottish Postcode Sectors from the 1991 Census. However, a key drawback of this approach lies in the use of the postcode sector, rather than the full postcode itself (a postcode sector would be the ‘EH11 2’ part of the full ‘EH11 2AS’ postcode shown in Figure 4). As noted in McLoone (2000), a postcode sector includes approximately three thousand households and is only a good predictor of socio-economic status where the postcode sector is relatively homogeneous. One should be wary of mortality models using postcode sector or region, sometimes describing themselves as “micro-regional” models, as they can mistakenly ascribe the wrong mortality profile to wealthy individuals who live in a mixed postcode sector.

Figure 4. Example UK postcode with labelling of hierarchical elements



mortalityrating.com derives groups from geodemographic types based on the full UK postcode. This has the advantage that the number of households covered by the same postcode is around fifteen on average, and the likelihood of the households being homogeneous with respect to socio-economic status is therefore greatly increased. Postcodes were originally introduced to the United Kingdom by the state-owned Royal Mail for the purpose of automating the sorting of mail. However, postcodes have been widely adopted beyond their original mail-sorting purpose, including consumer profiling for marketing, and premium calculations for general insurance and bulk-annuity pricing. Socio-economic group is determined by occupation, so we will call our postcode-driven categories *lifestyle groups* to distinguish the two approaches.

Note that the same hierarchical postcode structure is also used for some [Crown Dependencies](#), although they are not part of the United Kingdom and are not covered by geodemographic systems. Unlike other systems, mortalityrating.com covers not just postcodes in the United Kingdom (England, Wales, Scotland and Northern Ireland), but also in [Jersey](#), [Guernsey](#) and the [Isle of Man](#).

Table 2 shows the lifestyle mix of the portfolio weighted by pension. Note that £20826.60 of all pensions (12.68% of total) could not be profiled and were put in group 1. No profiles were overridden on the basis of pension size.

Table 2. Summary lifestyle data for first lives only:

Group	Life expectancy at 65:	(a) count	Lives:	Amounts:	
	males/females		(b) % total	(a) value	(b) % total
1	19.50/22.87	15	17.05%	£29469.12	17.94%
2	18.67/22.16	38	43.18%	£98441.16	59.92%
3	17.41/21.15	29	32.95%	£28289.64	17.22%
4	16.20/20.31	6	6.82%	£8090.40	4.92%

The values in Table 2 show the records assigned via postcode to the relevant lifestyle group. Assignment is not solely by postcode, however. If a pension exceeds £30000.00, then the postcode profile is overridden and the pension is assigned to the longest-lived lifestyle group. This is to trap cases where a postcode profile does not match the size of the pension, say if the postcode has been entered incorrectly. Finally, cases without a recognisable postcode — and where the pension is under £30000.00 — are assigned to group 1. Both the default group and the trigger value of £30000.00 are user-controlled, and the rating report can easily be re-run with different values.

To get a feel for the differentials amongst these lifestyle groups, Table 2 shows specimen life-expectancy figures for males and females at age 65. The broad spread of life expectancies is similar to that shown in Figure 3, despite the considerable differences in their calculation. The most obvious exception is social class V in Figure 3, which covers people who are either casual labourers or unemployed. We do not have a rating group for these people, as they are only rarely holders of financial products.

7. Other summary information

Table 3 shows the size-band distribution of the portfolio weighted by pension size.

Table 3. Summary size-band data for first lives only:

Size-band (lower to upper)	Lives:		Amounts:	
	(a) count	(b) % total	(a) value	(b) % total
£0.00–550.00	40	45.45%	£14064.48	8.56%
£550.00–1500.00	24	27.27%	£24039.36	14.63%
£1500.00–6200.00	18	20.45%	£54673.44	33.28%
£6200.00–99999999.00	6	6.82%	£71513.04	43.53%

Table 4 shows the breakdown of the portfolio by presumed health status. Lives retiring before age 50 are presumed to be ill-health early retirals. Whether these lives are assumed to have higher mortality than those retiring at later ages depends on your choice of rating model.

Table 4. Summary health statuses for first lives only:

Health status	Lives:		Amounts:	
	(a) count	(b) % total	(a) value	(b) % total
Normal	88	100.00%	£164290.32	100.00%
Ill	0	0.00%	£0.00	0.00%

One other important risk factor in U.K. longevity is year of birth, or *birth cohort*. This is a phenomenon whereby people born in the late 1920s and 1930s have noticeably longer life expectancies than previous generations. The current version of this report does not include cohort as a rating factor, but it is useful to tabulate the liability breakdown in order to decide what adjustments might need to be made to the figures elsewhere in this report. Table 5 shows the year-of-birth or cohort mix of the portfolio weighted by pension size.

Table 5. Summary cohort data for first lives only:

Years of birth	Lives:		Amounts:	
	(a) count	(b) % total	(a) value	(b) % total
up to 1919	0	0.00%	£0.00	0.00%
1920-1929	25	28.41%	£58448.28	35.58%
1930-1939	40	45.45%	£74152.08	45.13%
1940-1949	22	25.00%	£31401.72	19.11%
1950 onwards	1	1.14%	£288.24	0.18%

If your liabilities are biased towards later years of birth, for example, you may want to put in extra margins for prudence in the figures in Table 6, for example.

8. Combined ratings of portfolio

The rating system behind this report uses sixty-four mortality tables: there are four lifestyle groups, four pension-size bands and two health statuses, with separate tables for males and females. However, actuaries often require to use so-called *standard tables* for their calculations. It is therefore necessary to express the profiling used in this report in terms of a standard actuarial table. Table 6 shows the various initial ratings for this portfolio.

These ratings use a system with an effective date in the middle of calendar year 2008. Thus, further deductions from these percentages are required to allow for the mortality improvements which have occurred since then. One approach is to use your chosen improvements basis to roll forward the given tables and percentages from the middle of 2008 to 2011-10-14. A further adjustment may be required to the figures in Table 6 in respect of the cohort effect if the portfolio is very old or very young.

Note that if you have other reliable information which would lead you to use different percentages than shown here, then you should adjust as necessary for prudence.

Table 6. Ratings: do not use without further adjustment

Table	Table modification	$1000 \times q_{65}$: male/female	Disc. rate	Esc. rate	Ratings: male/female
PCA00Base		10.87/6.82	5.00%	2.50%	87.44%/85.53%
S1NA		10.39/7.17	5.00%	2.50%	82.34%/84.13%
S1PA		11.24/7.94	5.00%	2.50%	83.31%/83.27%
S1PAheavy		18.33/9.18	5.00%	2.50%	68.82%/73.79%
PNA00Base		10.40/6.54	5.00%	2.50%	87.72%/87.04%

Reminder: www.mortalityrating.com should only be used to rate pensions in payment in the United Kingdom, and not deferred pensions or pensions outside the U.K. The use of www.mortalityrating.com for deferred pensions or pensions outside the U.K. is entirely at the user's own risk. Further adjustment for the cohort effect may be required for portfolios with particularly old or young pensioners, or for annuity portfolios experiencing anti-selection.

9. Methodology

The rating methodology used here is the so-called *equivalent-reserve method*, as described in the 2004 SIAS paper *Financial aspects of longevity risk* by S. J. Richards and G. L. Jones. This method uses the actual individual liability values, and effectively weights the calculation not just towards cases with the largest pension, but also to cases with the largest reserve value. For example, a sixty-year-old and an eighty-year-old might each have the same size of pension, but the weighting for the former is much larger because the reserve is bigger.

The procedure for calculating the percentages in Table 6 is as follows:

1. A postcode-driven socio-economic rating has been applied to the members, and a four-level socio-economic mortality table used.
2. Liability cash flows were projected annually using the given pension.
3. Liability cash flows were discounted using the given discount rate, and assuming the given indexation rate.
4. The same process as steps 2 and 3 was followed, but using the given standard tables instead of the different socio-economic mortality tables.
5. The total reserves from steps 3 and 4 were equated using an equivalent-reserve calculation to get the percentage of the given standard table which gave the same reserves in step 3.

10. Caveats and exclusions

- Deferred benefits should be excluded from the calculations.
- Where a member was aged below the minimum age in the mortality table, the mortality rate for the minimum age is used.
- Where no postcode was available, or where the postcode could not be recognised, the member was assigned to the default category provided at run-time.
- No allowance was made for any geographic variations in mortality.
- No allowance was made for any temporary initial selection.
- No explicit allowance was made for the cohort effect.

11. Future mortality improvements

The assessments in Table 6 are for current rates of mortality only, whereas any reserve for pensions requires an assumption of future mortality improvements. Our current preferred method of setting a basis for mortality improvements for pensions in payment only is the P-spline methodology using age-cohort penalties. Many other projection methodologies are possible, and the [Projections Toolkit](#) makes it easy to fit and project all sorts of stochastic models. The output from the [Projections Toolkit](#) is automatically integrated with www.mortalityrating.com, enabling you to customise your reports.

If you have a large portfolio with several years' experience, another possibility is to use [Longevitas](#) to do projections. This has the advantage of there being no basis risk, i.e. you are using projections for the portfolio concerned and not projections derived from another population.

Note that we do not consider the short- or medium-cohort projections for future improvements to be adequate when valuing pensions in payment. We do not regard reserves calculated using these projections to be prudent.

12. Impact of stochastic variation

Mortality is a stochastic process, by which we mean that we cannot predict who will die when. Even if we knew exactly what the underlying mortality rates were, and even if investment returns were certain, the portfolio will still have variable cashflows resulting from random variation.

Table 7 shows the impact of stochastic variation for this portfolio. We simulate the entire portfolio in run-off, record-by-record, until the last person is dead. We then calculate the present value of the cashflows for each simulation of the portfolio. For pensions in payment, the extra capital is that required to be sure that there will be enough money to pay all benefits at the given probability level. The higher the required probability level, the more extra capital will

be required. For small portfolios, high values of the extra capital can be a sign that a pension scheme should consider buying annuities or reinsuring.

Table 7. Impact of stochastic variation

Scenario	Discount rate p.a.	Escalation rate p.a.	Simulations	p-value	Extra capital
1	5.00%	2.50%	1000	99.00%	24.42%
2	5.00%	2.50%	1000	99.00%	23.94%
3	5.00%	2.50%	1000	99.00%	25.00%
4	5.00%	2.50%	1000	99.00%	22.68%
5	5.00%	2.50%	1000	99.00%	26.23%

13. Impact of heterogeneity

As Section 3 shows, not everyone has the same size of liability. This is one important driver of the extra capital in Table 7. Table 8 shows the equivalent figures assuming everyone has the same size of pension

Table 8. Impact of heterogeneity

Scenario	Extra capital if pensions are:	
	(a) Actual	(b) Homogeneous
1	24.42%	11.38%
2	23.94%	12.06%
3	25.00%	10.68%
4	22.68%	12.28%
5	26.23%	12.19%

For small portfolios of pensions in payment, a large difference between columns (a) and (b) in Table 8 can suggest that reinsuring the benefits for the largest pensions can reduce the overall volatility and mortality risk.

14. Impact of trend variation

Mortality trends cannot be predicted with certainty, and we can explore the financial impact of mortality trends for this portfolio. In Table 9 we show the extra capital assuming improvement projections generated from a P-spline model for the mortality of males in England & Wales based on age-cohort penalties for ages 40–100. The same improvements for males are applied to females, ages under 40 assumed to have improvements of 40-year-olds and ages over 100 assumed to have improvements of 100-year-olds. In each case in Table 9 the baseline is a reserve assuming no future improvements, and the columns show the impact of various percentiles of the projections. For example, there is a 10% probability that the figures are at least as large as those in the 90th percentile column.

Table 9. Impact of trend variation

	Discount rate p.a.	Esc. rate p.a.	Extra capital for given p-value:				
			1%	10%	50%	90%	99%
1	5.00%	2.50%	8.36%	9.95%	11.95%	13.97%	15.61%
2	5.00%	2.50%	6.55%	8.18%	10.24%	12.32%	14.02%
3	5.00%	2.50%	6.66%	8.55%	10.92%	13.33%	15.31%
4	5.00%	2.50%	8.36%	9.95%	11.95%	13.97%	15.61%
5	5.00%	2.50%	6.55%	8.18%	10.24%	12.32%	14.02%

The details of the projection bases used for each scenario are listed below:

	Projection method (males)	Projection method (females)
1	Age-cohort penalties (Males)	Age-cohort penalties (Females)
2	Age-cohort penalties(CMI - Males)	Age-cohort penalties (Females)
3	Age-period penalties(CMI - Males)	Age-cohort penalties (Females)
4	Age-cohort penalties (Males)	Age-cohort penalties (Females)
5	Age-cohort penalties(CMI - Males)	Age-cohort penalties (Females)

- Age-cohort penalties is a P-spline regression on population data (for the specified gender) from mortality.org using age-cohort penalties. Only data between ages 40 and 100 are used, with the reduction factors for age 40 being used for all ages below 40, and the factors for age 100 being used for all ages above 100.

- Age-cohort penalties (CMI) is a P-spline regression on assured-lives data from the CMI using age-cohort penalties. Only data between ages 40 and 100 are used, with the reduction factors for age 40 being used for all ages below 40, and the factors for age 100 being used for all ages above 100. Note that the CMI data has very little exposure for females, so the male projections are used for both genders.

- Age-period penalties (CMI) is a P-spline regression on assured-lives data from the CMI using age-period penalties. Only data between ages 40 and 100 are used, with the reduction factors for age 40 being used for all ages below 40, and the factors for age 100 being used for all ages above 100. Note that the CMI data has very little exposure for females, so the male projections are used for both genders.

- Other projection descriptions identify a bespoke projection or piggyback projection created within the projection toolkit.

15. Combined impact of stochastic risk and trend variation

Here we illustrate the combined effect of the stochastic risk and trend risk. We assume that the central scenario is the 50th percentile from Section 12, and simulate both the trend and the stochastic scheme experience. Note that the figures in Table 10 assume a baseline where mortality trends follow the 50th percentile, whereas the figures in Table 9 assume a baseline of no improvements. The figures in the two tables are therefore not comparable.

Table 10. Combined impact of stochastic risk and trend variation

Scenario	Discount rate p.a.	Escalation rate p.a.	Simulations	p-value	Extra capital
1	5.00%	2.50%	1000	99.00%	27.59%
2	5.00%	2.50%	1000	99.00%	25.31%
3	5.00%	2.50%	1000	99.00%	26.97%
4	5.00%	2.50%	1000	99.00%	29.16%
5	5.00%	2.50%	1000	99.00%	24.89%

The details of the projection bases used for each scenario are listed below:

	Projection method (males)	Projection method (females)
1	Age-cohort penalties (Males)	Age-cohort penalties (Females)
2	Age-cohort penalties(CMI - Males)	Age-cohort penalties (Females)
3	Age-period penalties(CMI - Males)	Age-cohort penalties (Females)
4	Age-cohort penalties (Males)	Age-cohort penalties (Females)
5	Age-cohort penalties(CMI - Males)	Age-cohort penalties (Females)

16. Mortality shocks and stress tests

Standards like QIS4 specify that reserves must be large enough to accommodate a 25% permanent reduction in mortality rates. In Table 11 we illustrate the extra capital required under various shock scenarios.

Table 11. Impact of mortality shocks

Scenario	Discount rate p.a.	Escalation rate p.a.	Shock	Extra capital
1	5.00%	2.50%	25.00%	12.88%
2	5.00%	2.50%	25.00%	12.88%
3	5.00%	2.50%	25.00%	12.88%
4	5.00%	2.50%	25.00%	12.88%
5	5.00%	2.50%	25.00%	12.88%

17. Marital-status profile

Pension benefits are often paid to a surviving spouse, so higher reserves are required where a pensioner member is married. People of more up-market groups are more likely to be formally married, and the lifestyle profile of this portfolio suggests the proportions shown in Table 12:

Table 12. Indicative marital-status breakdown. Not to be relied on for pricing on reserving.

Marital status	Proportion measured by:	
	(a) Lives	(b) Amounts
Married	43.59%	43.65%
Single	47.86%	43.20%
Unknown	8.55%	13.15%

These profiles are based on all-age data, whereas older people are more likely to be married than young adults. The profiling done for Table 12 is based on a broad postcode-driven geodemographic type using population data. However, holders of private pensions are a select sub-group of the population and are more likely to be married, so the percentages shown as married in Table 12 should therefore be treated as *minimum* proportions married, and for financial calculations we recommend a proper detailed analysis of likely marital status, which requires names and addresses. Also note that the definition of spouse varies between pension schemes, so more liberal definitions will require an even higher proportion-married assumption.

18. Other options

The analysis in this report is suitable for portfolios where the experience data is too small to be statistically credible for a bespoke analysis. By definition, it is taking a general model for mortality by age, gender and lifestyle and applying it to a specific portfolio. The results in this report can only be a good first assessment as to the risks in the portfolio itself.

For larger portfolios with credible experience data, it will usually be preferable to carry out a bespoke mortality analysis using a tool like [Longevity](#). [Longevity](#) was used to create the rating model behind this report, and it can be used to analyse a wide variety of risk factors, including:

- Age
- Gender
- [Lifestyle \(via postcode\)](#)
- [Region \(via postcode\)](#)
- Ill-health status
- [Benefit size](#)
- Birth cohort
- [Time trends](#)
- [Period effects](#)
- Select period
- Marital status
- Duration

In each case, [Longevity](#) is capable of modelling not just the effect of each rating factor, but also how it varies by age, duration or calendar time. To get more information on [Longevity's](#) capabilities, [view our web video](#).

For those particularly interested in longevity trend risk, the [Projections Toolkit](#) is an easy-to-use tool for generating stochastic mortality projections. These projections are integrated with mortalityrating.com so you can create your own stochastic models for use in rating reports.

19. Background reading on longevity risk

We publish a regular [online journal on longevity risk and pensions](#). Some of our recent postings include:

- [Why pension size is insufficient to rate for socio-economic status](#)
- [Why regional mortality patterns are less than they seem](#)
- [Why we use stochastic mortality projections](#)

We also recommend looking at [our selection of presentations, articles and papers](#) at www.longevity.co.uk

20. TAS-D

This section is designed to help users who have to adhere to the standard for data used in actuarial work, [TAS-D](#), laid down by the [Board of Actuarial Standards](#) in the United Kingdom. It may be useful for users in other territories. The data used in generating this report might form part of actuarial work to which the stipulations of TAS-D will apply. The information that follows is to assist in the creation of such TAS-D-compliant material.

20.1 Data definitions (TAS-D C.5.3)

The data used are the exact date of birth, the gender of the pensioner, the exact date of commencement (retirement), the annual pension in sterling and the UK postcode (if available).

20.2 Validation (TAS-D C.5.6)

The data used in this report were validated when uploaded. The checks carried out include:

- Dates of birth lie in a valid range.
- Gender codes are either M for male or F for female.
- Pension commencement dates are valid and consistent with the date of birth.
- Pension amounts are valid numbers and are non-negative.

Records failing the above checks are excluded from the calculations in this report. Note that records with missing or invalid postcodes **are** included in all calculations, and such records are assigned a user-controlled default lifestyle group.

21. TAS-R

This section is designed to help users who have to adhere to the standard for actuarial reports, [TAS-R](#), laid down by the [Board of Actuarial Standards](#) in the United Kingdom. It may be useful for users in other territories. Material within this report might form part of a component report within the definitions of TAS-R, and may therefore be used to assist in the creation of an aggregate report to which the stipulations of TAS-R will apply. The information that follows is to assist in the creation of such TAS-R-compliant material.

21.1 Relevance (TAS-R C.3)

The purpose of this report is to describe the calculations used in assessing mortality and longevity risk for pensions in payment. There are various facets to this risk:

- Underwriting risk, i.e. what are current mortality rates likely to be?
- Trend risk, i.e. what is the impact of uncertainty over the direction of future trends?
- Stochastic risk, i.e. if current and future mortality rates are known, what is the impact of not knowing who dies when?

This report seeks to provide illustrative answers to these aspects of longevity risk for pensions in payment.

21.2 Data (TAS-R C.4.1)

The data used in generating this report are summarised in Table 1, Figure 1 and Figure 2. The data have undergone basic validation checks as follows:

- Dates of birth lie in a valid range.
- Gender codes are either M for male or F for female.
- Pension commencement dates are valid and consistent with the date of birth.
- Pension amounts are valid numbers and are non-negative.

21.3 Assumptions (TAS-R C.4.4)

The model uses a proprietary model for mortality differentials amongst pensioners. The individual pensioner mortality experience is fitted using a Makeham-Beard survival model using the [method of maximum likelihood](#). The details of this model-building process are set out in [Richards \(2008\)](#).

The projection models fitted in this report are statistical ones for the number of deaths at each age, x , in a given year, y , $D_{x,y}$. This number is assumed to be a random variable following a [Poisson process](#):

$$D_{x,y} \sim \text{Poisson} \left(E_{x+\frac{1}{2},y+\frac{1}{2}}^c \times \mu_{x+\frac{1}{2},y+\frac{1}{2}} \right)$$

where $E_{x+\frac{1}{2},y+\frac{1}{2}}^c$ is the central exposed-to-risk, i.e. the mid-year population estimate in year y of lives at risk of dying aged x last birthday. $\mu_{x+\frac{1}{2},y+\frac{1}{2}}$ is the corresponding force of mortality (hazard rate). Each model assumes a specific structure for $\mu_{x,y}$ which is documented in Section 14.

21.4 Rationale (TAS-R C.4.6)

Each pensioner record is profiled using the given postcode and assigned a lifestyle group. Pensioners without a postcode, or where the postcode is unrecognised, are assigned to a user-specified default lifestyle group. The pension amount is used to assign a wealth band, and if the pension size exceeds a user-controlled limit then the lifestyle group is overridden. The age at commencement is used to estimate whether the pensioner retired in ill health or normal health. The pensioner's age and gender are then also used to map the pensioner onto a bespoke set of mortality tables which account for the impact of the various risk factors, thus effectively creating a bespoke mortality table for each pensioner. These bespoke tables are then used for rating the portfolio, and also for simulating future lifetimes.

21.5 Uncertainty (TAS-R C.5.2)

Uncertainty is measured in many ways in this report. Table 7 shows the impact of uncertainty over who dies when in terms of the extra capital required at outset to be confident to a particular level that all benefits can be met. This extra capital is expressed as a percentage of the median simulated value. Table 8 does something similar, but it shows the extra capital required if all pensioners have the same benefit. Contrasting column (a) with column (b) in Table 8 allows the reader to assess the extra cost due to unequal distribution of benefits amongst the portfolio members.

The calculations in Tables 7 and 8 assume the underlying current and future rates of mortality are known perfectly, and that the only uncertainty lies in who happens to die when. In contrast, Table 9 assumes that there is no uncertainty over who dies when and that the current mortality rates are known perfectly, but that it is the future trend in mortality which is unknown. The percentiles of a stochastic projection model are used to assess the extra capital required relative to assuming current mortality rates apply forever. The extra capital required is expressed as a percentage of the reserves assuming no change. Where available, the details of the stochastic projection models are listed underneath Table 9.

Table 10 seeks to provide a combined statement of both the main sources of uncertainty: trend risk and the uncertainty over who dies when. The extra capital shown is that required to be confident of having enough reserves to meet all benefits with the stated probability. Here the extra capital required is expressed as a percentage of the median cost.

21.6 Probabilities (TAS-R C.5.13)

This report contains the probabilities of reserves being adequate to meet all benefits in the face of the stated uncertainty. Note that these probabilities relate to the uncertainties surrounding mortality and longevity, and therefore exclude other important risks such as uncertain investment returns and inflation.

21.7 Projections (TAS-R C.5.20)

This report contains results calculated using projections of possible future mortality trends. The projection models are documented underneath Table 9.

There are two important additional risks which are beyond the scope of this report:

1. Scheme-specific underwriting risk. The model used to classify pensioners into lifestyle groups and wealth groups is general. It is therefore vulnerable to specific occupational risks (in the case of lifestyle group) and particularly low or high benefit levels compared to pensioners in general (in the case of pension size-band).

2. Model risk. There is no way of knowing if a stochastic projection model is correct. The way to deal with this is to explore using different projection models, which will give an idea of the impact of model risk even if it can never be entirely quantified.

22. TAS-M

This section is designed to help users who have to adhere to the standard for actuarial models, [TAS-M](#), laid down by the [Board of Actuarial Standards](#) in the United Kingdom. It may be useful for users in other territories.

22.1 Checks (TAS-M C.3.5)

The data used in parameterising the rating model behind Table 6 was subjected to numerous individual checks:

- Dates of birth lie in a valid range.
- Gender codes are either M for male or F for female.
- Pension commencement dates are valid and consistent with the date of birth.
- Pension amounts are valid numbers and are non-negative.
- End dates (including dates of death) are valid and consistent with the date of birth and the commencement date.

22.2 Neutral measures (TAS-M C.3.10)

The ratings in Table 6 are intended as best-estimates within the limitations of using the actuarial tables listed. Note that the ratings are intended to be neutral measures as at the stated date, and that modifications are required if they are to be used at any other date.

22.3 Parsimony (TAS-M C.3.14)

Different rating models may be used to generate the figures in Table 6. However, even the most complicated five-factor model is still parsimonious as all five rating factors used are highly significant predictors of mortality and longevity.

22.4 Reproducibility (TAS-M C.3.17)

Extensive use is made of simulations to show the cost of uncertainty of trend and individual risk, including Tables 7–10. Each time a rating report is run the seed for the pseudo-random number generator is set to the same initial value, thus ensuring reproducibility.

22.5 Assumptions (TAS-M C.4.18)

There are three key assumptions underlying the results in this report:

1. In the case of Table 6, the rating process assumes that the portfolio being rated in this report has the same mortality levels and differentials as the reference group used to parameterise the rating model. If the portfolio has different mortality levels, or different risk factors, then the ratings may not be appropriate.

2. In the case of the individual stochastic risk included in Tables 7, 8 and 10, the simulation process assumes that each pensioner record is independent. If the records are not independent, say because some pensioners have two or more records, then the true stochastic risk will be greater than shown in this report.

3. In the case of the trend risk included in Tables 9 and 10, the projection process assumes (a) that the projection model is correct, and (b) that the mortality trend for the portfolio covered by this report is the same as that of the data set used to parameterise the projection model.

23. References

RICHARDS, S. J. (2008). [Applying survival models to pensioner mortality data](#), *British Actuarial Journal* **14**, II, 257–326.

24. System environment

The system configuration used in generating this report is detailed in Table 13.

Table 13. System environment

Description	Value
Version	v1.625 2011-10-11
Model	ExtendedFactors
Mortality law	Makeham-Perks
q_x interpolation	linear
Random-number generator	Knuth
Tracking	2 6472 15244
Effective Date	2011-10-14
Run Date	2011-10-14
Validation Rejects	12
Gini Coefficient	64.48
Liability Type	pension
Spouse Records Uploaded	0
Rating Includes Spouses	NO
Spouse Allocation Type	Adjust Benefit Proportion
Spouse Percentage Married	100
Spouse Female Age Difference (years)	-3
Spouse Benefit Percentage	50
Generate Cashflows	YES
Generate R Integration File	NO

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