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The CAS *E-Forum*, Winter 2012-Volume 1

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This *E-Forum* includes reports from the CAS Risk-Based Capital Dependencies and Calibration Working Party and the CAS Underwriting Risk Working Party.

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CAS Research Working Party on Risk-Based Capital Dependencies and Calibration

Report 1
Overview of Dependencies and Calibration in the RBC Formula

Abstract At the request of the American Academy of Actuaries, the CAS formed the Risk Based Capital (RBC) Dependencies and Calibration Working Party (DCWP) to research how to handle dependencies and calibration in the NAIC P&C RBC formula (RBC or RBC formula), including the extent to which risk diversification should be reflected in the P&C formula.

The research identified a number of gaps in the current RBC formula. This paper presents results of the DCWP's work to date. DCWP research will continue and the results will be presented in a series of reports.

Keywords: Risk-Based Capital, Solvency, Capital Requirements, Insurance Company Financial Condition, Internal Risk Models, Solvency Analysis, Analyzing/Quantifying Risks, Assess/Prioritizing Risks, Integrating Risks.

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1. Introduction and Summary

1.1 Charge

DCWP was created by the CAS at the request of the American Academy of Actuaries, September 30, 2010. The committee charge is to "research how to handle dependencies and calibration in the NAIC P&C RBC formula (RBC or RBC formula), including the extent to which risk diversification should be reflected in the P&C formula."

Section 11 details of the Academy request to the CAS.

1.2 Background

This is the first of several reports from the CAS RBC Dependencies and Calibrations Working Party (DCWP). Section 10 outlines our plans.

DCWP makes no recommendations to the NAIC or any other body. DCWP material is for the information of CAS members and policy makers, actuaries, and others, who might make recommendations regarding the future of the P&C RBC formula. In particular, we expect that the material will be used by the American Academy of Actuaries.

This paper assumes the reader is generally familiar with the property/casualty RBC formula.[1]

In this paper, references to "we," "our," "the working party," and "DCWP" refer to CAS RBC Dependencies and Calibration Working Party."

The analysis and opinions expressed in this report are solely those of the Working Party members, and in particular are not those of the members' employers, the Casualty Actuarial Society, or the American Academy Actuaries.

1.3 Research Questions

The 2010 NAIC book *Risk-Based Capital Forecasting & Instructions* states (page i):

> *Risk-based capital is a method of establishing the minimum amount of capital appropriate for an insurance company to support its overall business operations in consideration of its size and risk profile. It provides an elastic means of setting the minimum capital requirement in which the degree of risk taken by the insurer is the primary determinant.*

And continues:

[1] For a comprehensive description of the formula and its initial basis, see Feldblum, Sholom, NAIC Property/Casualty Insurance Company Risk-Based Capital Requirements, Proceedings of the Casualty Actuarial Society, 1996.

A company's risk-based capital is calculated by applying factors to various asset, premium and reserve items. The factor is higher for those items with grater underlying risk and lower for less risky items.

Thus, we understand that the RBC formula is intended to provide a risk-related formula for determining minimum capital levels.

In that context, DCWP considers the following questions:

1. Is the current RBC formula appropriate "as-is" with respect to structure and risk charge calibrations?
2. Can the formula be improved[2] significantly, within the current structure,[3] through:
    a. Risk charges within the current structure and/or
    b. Improved measures of dependency within the current structure and/or
    c. Dependency represented by correlation matrices?[4,5]
3. Can the formula be improved significantly with changes beyond those in point 2 by:
    a. Using scenarios to measure risk charges, e.g., use of catastrophe modeling or disaster scenarios for catastrophe risk, revaluation of assets and liabilities based on interest rate movements for interest rate risk, large claim and catastrophe scenarios to assess of the effectiveness of the company's reinsurance program in reducing risk
    b. Increasing the number or complexity of dependency relationships?

In addition, DCWP intends to consider the extent to which the risk-based capital assessment might be improved through:

4. Use of standard "safe-harbor" models by all companies, for all of some of the RBC risks.[6]

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[2] One of the research subjects is to establish a basis for assessing the extent to which two formulas are different and potentially whether one formula is "better" than another, recognizing that there are many formulas that are "different," but not necessarily better or worse than one another with respect to a particular purpose or set of purposes.

[3] The "current structure" means using identical or similar data elements and a formula that might be the same or more complex than currently used, but one which could be applied in a spreadsheet.

[4] Use of correlation matrices compared to RBC dependency (covariance formula, 75% rule, etc.) is conceptually important and may have significant impact on results; however, correlation matrices can be easily handled in spreadsheet formulas, so, in that sense, this does not represent a major change to the present structure.

[5] As we discuss further in Section 7, the Solvency II "correlation matrices" are based on the dependency relationship at the tail of the risk distribution, reflecting a view of the aggregate risk distribution. Technically these are not correlation matrices according the assumptions required of linear correlation. These "correlation matrices" are useful approximations, but might be better described as "weighting factor matrices."

[6] Supported, perhaps, by appropriate professional opinions regarding the suitability of the model and the application to model to the company.

5. Use of own-company models, as in Solvency II Internal Models.[7]

Points 4 and 5 extend beyond the concept of RBC as currently structured, but we consider them because:

a. The analysis informs our thinking on calibration and dependencies with respect to points 1-3.

b. Those approaches might be better starting points for company development of Own Risk Solvency Assessment (ORSA).

c. While own-company models, as in Solvency II Internal Models, are not part of the current regulatory horizon in the U.S. they may become applicable in the longer term.

d. The approaches in points 4 and 5 might be useful as regulatory tools suitable for regulatory decision-making in areas such as dividend approval, merger approval, and new licensing—that is, purposes beyond the "shut-down" level produced by the RBC formula.

1.5 This report

This initial report DCWP covers the following:

Section	Content
2	RBC Design Considerations
	CURRENT METHODS
3	RBC risks and risk charges
4	Dependency
5	RBC target "safety level"
	ASSESSMENT OF ALTERNATIVES
6	RBC risk charges and calibration methods
7	RBC dependency structure and calibration methods
8	RBC safety levels
9	Mitigating Considerations
10	Next Steps
11-14	Appendices including bibliography and glossary

[7] See footnote 6.

Our analysis is based on the following:

1. Review of existing literature.
2. Consideration of Solvency II,[8] Rating Agency and ERM practices in capital modeling.[9]
3. Experience of the members of the working party.
4. New research by some working party members.
5. Results of the CAS Underwriting Risk Working Party.

1.6 Summary of DCWP Assessment to Date

Based on our work to date, we note the following deficiencies in the RBC formula, with respect to our understanding of its objectives, and we also note factors that mitigate the impact of those gaps in practice. As our work progresses, we may need to refine or even correct some of these assessments. These gaps are as follows:

A. Overall the adequacy of the RBC level is lower than the initially established level:
   1. The investment income offset in premium and reserve underwriting factors is based on 5% per annum discount in expected cash flows when current interest rates are significantly lower.
   2. Catastrophe potential is not sufficiently reflected.

B. Charges are relatively too low or too high for certain types of companies:
   3. Premium and reserve underwriting factors by line of business are not properly calibrated to the risk by line of business.
   4. Company-specific catastrophe risk is not reflected (related to point 2 above).
   5. Concentration by state or region (property,[10] liability, workers compensation) is not considered.
   6. Company size is not considered.

C. Safety level standards are not specified.

[8] We use Solvency II for comparison purpose in that Solvency II represents the results of extensive and thoughtful and analysis of capital modeling in a regulatory framework in current context. The comparison helps clarify the assumptions and methods used by NAIC RBC and Solvency II standard formulas.

[9] In making those comparisons the working party is cognizant of the difference between standard formulas, like RBC, that are applied uniformly to all companies and company specific models typical of ERM analyses.

[10] Property concentration may be sufficiently considered if the catastrophe treatment is improved.

7. There is no calibration standard to coordinate the selection of charges by risk or among the different types of risks.

D. Dependencies among risks is not properly reflected:

8. RBC includes no dependency between premium and reserve risk.

9. RBC includes no dependency between assets and underwriting risks.

E. RBC contains simplifications that do not properly reflect risk in total or differences by company:[11]

10. The "70% rule"[12] that is used in dependency by line of business for underwriting risk factors.

11. Ten percent of the ceded reinsurance credit risk charge reflects a variety of considerations.

RBC might better reflect risk by company if it allowed greater complexity.

F. There are charges that have not been updated in 20 years with indeterminate effects on the safety level implied by the RBC results.

12. Asset charges have not been reviewed since the early 1990s notwithstanding the current understanding that extreme events may have more effect than previously expected.

DCWP believes improved treatment in all of the areas listed above is technically feasible. DCWP believes the issues listed above are inter-related, but to the extent that the issues are considered separately, the importance of the issues is reflected by the ordering A, B, C... shown above.

With respect to dependency structure in the RBC formula, there are many tools for constructing aggregate distributions needed to measure dependency, but those aggregate distributions are primarily relevant in calibrating an RBC formula, but not relevant in applying RBC to a specific company.

DCWP believes that dependency structure can be applied to individual companies in an RBC formula in two ways as follows:

1. Scenario sets covering relevant risks for single or multiple tail events of interest, e.g., catastrophes, adverse loss ratios, adverse reserve developments, or adverse asset outcomes.

[11] The effect of the simplifications might be to over- or underestimate the safety level in the formula overall, or with different effects on different types of companies.

[12] The premium and reserve risk charges are adjusted for diversification or concentration though premium and loss concentration factors.

2. Sets of weighting factors (that look like correlation factors, or correlation matrices), calibrated to the tail events of interest.[13]

In either case, dependency relationships need to reflect both process risk (smaller business segments have more risk per unit of size) and parameter risk (economic, legal, and other forces create variability that is in proportion to business size). RBC and Solvency II, however, simplify the risk assessment and treat all companies as if they had the same level of process risk. In future reports, DCWP will consider the extent to which both process and parameter risk can be reflected without creating undue complexity.

To the extent that the RBC formula does not reflect difference risk levels by company, it is less effective at providing a risk-related solvency standard. Similarly, to the extent that company decisions are affected by RBC requirements, then improper setting of the RBC requirements will not support appropriate risk decisions by companies.

1.7 Mitigating Considerations

Notwithstanding these observed gaps, we note that regulatory capital management is only one element of a regulatory structure, and it can play a greater or lesser role, depending on the overall structure of the system. Even if gaps exist, the significance can be mitigated by other regulatory activities. For example, the following regulatory mitigation strategies can apply:

1. Catastrophe Risk—Regulators can, independent of capital assessment, assess company reinsurance protection including reinstatement costs and reinsurance credit risk.
2. Credit for Reinsurance—Regulators can, independent of capital assessment, verify that reinsurance risk transfer is sufficient, supporting collateral is available, if required, and provisions have been made for disputed reinsurance collections.
3. Company Size—Regulators can, independent of capital assessment, more closely supervise the company with respect to its risk approval through approval for limited lines of business, limited geography, oversight of management, rate adequacy, reinsurance arrangements, etc.

1.8 Next Steps

In the near term, DCWP plans to prepare additional reports in the following areas:

1. Description of the EU Solvency formula with respect to risks included, risk charges, dependency structure, and method of calibration.

[13] Manistre, John B., A Practical Concept of Tail Correlation, February 11, 2008, published by the Actuarial Foundation, http://www.actuarialfoundation.org/pdf/2008-practical-manistre.pdf

2. The impact and feasibility of alternative structural, calibration and dependency approaches ("what-if" testing) by applying current and possible alternative formulas to individual company data.
3. Observations based on the nature of insolvencies since RBC was implemented.

Beyond that, DCWP will:

4. Evaluate dependency structure in greater depth.
5. Further consider alternative methods of risk charge and dependency calibration, including illustrations where practical.

2. Design Features

The RBC formula is a particular type of capital model. The following table indentifies the main design decisions and our understanding of the RBC treatment in each area.

Table 2-1
Design Features for Capital Models

Design Feature	RBC Treatment
1. Intended Purpose of RBC System[14]	
1.1 "Financing a soft landing"—Prescribe a minimum capital that allows full payment of claims and other obligations with a sufficiently high probability at reasonable cost.	Primary purpose.
1.2 Protect policyholder/consumer welfare in balancing default risk against cost of higher capital requirements (or other potential impediments to innovation).	Alternative primary purpose [Similar to 1.1]
1.3 Encourage companies to manage risks.	Secondary purpose
1.4 Protect other insurers, and, theoretically, their customers, who share risk through the cost of guarantee arrangements.	Only via 1.1-1.3
1.5 Protect other stakeholders.	Only via 1.1-1.3
1.6 Prevent insolvencies.	No
2. Intended Use of RBC	
2.1 Regulatory intervention point followed by mandatory shut-down.	Yes
2.2 Management tool for risk-based decision-making, performance management, and/or company own risk solvency assessment (ORSA).	No
2.3 Regulatory permission to operate across borders (i.e., a "passport" as in Solvency II).	No
2.4 Major element in financial type regulatory decisions, e.g., dividend payment, acquisition capacity, reinsurance adequacy.	No
2.5 Rating agency assessment.	No
3. Intended Role of RBC in Regulation	
3.1 The central solvency management tool.	No
3.2 One of many regulatory tools.	Yes
3.3 The final back-stop; other mechanisms are more important.	Yes
3.4 Closely related to company risk management.	None considered necessary.
3.5 Incentives for the "right risk behaviors."	Desirable, but not a primary goal
4. Mechanism	

[14]

4.1 Standard Formula.	Yes
4.2 Standard Formula with limited own-company adjustments.	Yes, to limited degree, e.g., "50/50 rules"[15] for underwriting risk.
4.3 Own-Company model (e.g., Solvency II Internal Model).	No (note 1)
4.4 Scenario approach—RBC based on set of specified or company-selected scenarios.	No
4.5 Hybrid models (perhaps including some elements of scenario approach):	No (Note 1)
4.5.1 "Narrow"—e.g., application of approved models to measure certain risks, such as catastrophe risk.	No
4.5.2 "Broad" –e.g., standard "actuarially approved" models covering nearly all risks.	No
4.5.3 Own company model applied to specific risks (analogous to Solvency II Partial Internal Model).	No

5. Condition of Company—for Calibration purposes (Basis company)	
5.1 Assumed to be a going concern.[16]	Yes
5.2 Assumed to be a troubled company.[16]	No

6. Relationship to Accounting System	
Designed to work with statutory accounting.	Yes
Designed to work with general purpose accounting.	No

7. Other Decisions	
Applied by company or group.	By company
Judgment in selecting the structure and factors but no judgment in application of the formula.	Yes
Treatment of systemic risk.	Not within RBC system

Note (1)—For life insurance RBC, we understand that certain aspects are based on individual company models.

[15] RBC premium and reserve factors are based 50% on factors calibrated based on industry data and 50% based on the industry data adjusted by the ratio of company experience to industry experience for the most recent 10 years (if 10 years of company data is available, otherwise, there is no adjustment).

[16] RBC factors are based on data from "normal" companies, even though risk charges and dependencies may be different for company's nearing financial difficulty.

Table 2-2 below compares the design decisions for RBC, Solvency II, and rating agency capital models.

Table 2-2
Comparison of Design Decisions

Item		RBC	Solvency II	Rating Agency
1.	**Intended Purpose**	Policyholder protection/ "soft landing"	Policyholder protection	Various stakeholders depending on rating purpose—policyholders, bondholders, equity owners
2.	**Intended Use**	Minimum criteria; One of many regulatory tools— (Note 1)	Passport to operate in other (EU) countries Minimum in certain circumstances. Significant regulatory tool. (Note 1)	Financial strength assessment. One element in assessing management's ability to manage risk.
3.	**Intended Role in regulation**	One of many tools; RBC is the final backstop	A central tool To encourage company risk management	None intended (See row 4 below)
4.	**Mechanism**	Standard formula with limited own company adjustments	Mixture of : standard formula; own company factors in standard formula; partial internal model; internal model	Review of management models. Rating agency's own models.
5.	**Condition of company for calibration purposes**	Going concern	Going concern	Going concern
6.	**Relationship to Accounting System**	U.S. Statutory	IFRS	Not applicable to any balance sheet item. Capacity to meet claim paying or other financial obligations, regardless of accounting framework.
7.	**Other Decisions**	Applied by company	Applied by company and by group	Usually only applied at group level
		Judgment in selecting the structure and factors but no judgment in application of the formula.	Same as RBC	Judgment in model design and individual company assessment
		Systemic risk not addressed by this mechanism	Same as RBC	Same as RBC

NOTE 1: Solvency II—Regulatory action on issues such as dividend paying capacity, reinsurance adequacy, acquisition approval, etc., would be resolved after considering the effect on capital relative to SCR.

3. Risks and Risk Calibration

The quantification of required capital for RBC or other purposes is based on an explicit or implicit view of the distribution of possible financial outcomes, representing the aggregate effect of all the individual component risks (aggregate risk distribution or aggregate distribution). Generally the aggregate distribution is developed by first quantifying the individual risk elements and building the aggregate distribution by reflecting how the individual risks "move together." In this section we consider the individual risk elements that are typically reflected in RBC formulas.

The RBC formula identifies the following major risk categories:

Table 3-1
RBC Risk Areas

R_0	Asset Risk – Subsidiary Insurance Cos.
R_1	Asset Risk – Fixed Income
R_2	Asset Risk – Equity
R_3	Credit
R_4	Underwriting – Reserves
R_5	Underwriting – Premium

NOTES:

There are a number of rules regarding the treatment of assets including the following:

R_1 and R_2 include risk from fixed income and equity investments held by non-insurance subsidiaries.

R_2 includes real estate and Annual Statement items "other invested assets" and "aggregate write-ins for invested assets."

Table 3-2 below provides a more detailed itemization of the risks in the RBC formula and compares the risk charge approaches for RBC and Solvency II.

As rating agency models vary, we provide no comments in Table 3-2.

Table 3-2
Comparison of Basis for Risk Charges

#		Risk Element	RBC	Solvency II
1	R0	Asset Risk—Subsidiary Insurance Cos.	RBC for subsidiary when subsidiary is subject to RBC. 22.5% for U.S. subsidiaries, not subject to RBC. 50% for non-U.S. subsidiaries	Rather than a RBC charge, for subsidiaries, the company capital is reduced to avoid "double counting" capital in subsidiaries within a group. The adjustment could reduce the value to zero for the subsidiary if the EU regulators cannot obtain enough information on the financial condition and risk profile of the subsidiary.
2	R1	Asset Risk—Fixed Income, including subsidiaries that operate as investment vehicles	Assets are valued based on a mixture of market, amortized, or other statutory values. RBC charges are determined by applying a set of factors, varying by asset type and credit quality, to statement values of those assets. Factors are based on circa 1990 analysis of variability in market values and generally the same for life and P&C.	For R1 and R2 risks, Solvency II applies a scenario approach rather than a factor approach. Assets and liabilities[17] are revalued based on alternative scenarios of market conditions. The risk charge is the change in surplus, comparing surplus at current market conditions to surplus if the scenario applies. There is a specified scenario for each of the following: (a) changes in interest rates (by duration)—one change upward/one change downward. (b) change in interest rate spread between fixed income securities with different credit ratings. (c) change in foreign exchange rate between home country and each other country. (d) change in illiquidity premium (a factor that affects reserve discount). (e) fall in market value of equities, separately for equity listed on major exchanges and equities that are not listed or listed on other exchanges.
3	R2	Asset Risk—Equity, including subsidiaries that operate as investment vehicles	15% charge based on competing studies circa 1990.	
4	R2	Asset Risk—Other long-term assets, including property and property loans	Various charges. Typically the same for life and P&C.	

[17] Assets and liabilities are valued using an IFRS fair value approach including discounting of loss reserves based on current market conditions

#		Risk Element	RBC	Solvency II
				(f) fall in property values. (g) a concentration charge for assets relying on the same entity.
5	R3	Credit Risk—Reinsurance	10% of ceded balances for claims reserves and unearned premium. 10% is judgment factor reflecting various elements of reinsurance risk	Reinsurance credit is handled as follows: First, the exposure to credit risk is the sum of: a. The best estimate of the recoverable (ceded balance for unearned premium and claims), plus b. The difference between: i. The capital required, at the target safety level, for underwriting and market risk assuming full credit for the reinsurance compared to ii. The capital required, at the target safety level, for underwriting and market risk assuming no credit for the reinsurance. Then, the risk charge is the percent Loss Given Default (LGD) times the exposure to credit risk. The percentage LGD is 50% of the credit exposure. Finally, the risk charge is adjusted for: a. Collateral, where applicable, and b. The credit rating and diversification of the creditors. However, until the number of credits is substantial, there is no benefit for credit quality or credit rating.
6	R3	Credit Risk—Other than reinsurance	Judgment values, 5% for most receivables, 10% for investment income due and accrued, and no charge for agents' balances, which are subject to statutory accounting valuation rules.	The formula described for reinsurance applies to other risks classified as "non-diversified" including securitizations and derivatives, cash at banks, certain critical LOC or and other guarantees. The LGD factor, though, differs from 50% for different sources

#		Risk Element	RBC	Solvency II
				of risk. For credit risks from "diversified sources" including agents balances, small bank accounts the credit risk charge is: a. 15% of the sum of credit exposures less amounts from intermediaries overdue by more than 3 months; plus b. 90% of receivable from intermediaries overdue by 3 months or more. The diversified and non-diversified credit risk charges are combined, assuming a 75% correlation, to produce the total credit risk charge.
7	R4/ R5	Underwriting – Reserves and Premium	Premium and reserve factors applied to year-end reserves and latest year written premium, respectively, net of reinsurance.	Reserve factor applied to technical provisions, which include unpaid claims and unearned premium, net of reinsurance. Premium factor applied to the expected future year's net written premium, but not less than the maximum of the actual prior year written or earned premium.
8	R4/ R5	Value of future investment income on assets corresponding to loss and loss adjustment expense reserves (discount)	Assumed 5% interest rate and industry payment pattern by line of business. 5% selected circa 1990 when embedded yields were greater than 5%.	Technical provisions valued on discounted basis. Reserve risk and unearned premium risk is therefore independent of investment income issues. Premium factors are applied as if risk is net of investment income.
9	R3/ R4/ R5	Treatment of reinsurance	Risk mitigation from reinsurance is reflected in that:	
			1. Risk charge percentages are calibrated to risk net of reinsurance.	Charges calibrated to risk gross of reinsurance (but net of catastrophes, which is handled separately).
			2. Risk charges are reduced, in effect, because percentages are applied to premium and reserve net of	Same as RBC

#		Risk Element	RBC	Solvency II
			reinsurance premium.	
			All types of reinsurance (quota share, excess, other) are treated the same.	There is an optional adjustment to give more credit, per unit (e.g., Euro) of gross claims, for excess insurance than for quota share reinsurance.
10	R4/ R5	Growth—feature affecting underwriting risk	Reserves—Yes Premium—Yes A percentage based on growth in excess of 10% per year.	An operational risk charge applies if forecast premium exceeds 110% of prior year premium. (Charge = 3% times forecast premium less 110% of prior year premium) Applies as if added to R0 rather than as addition to R4/R5
11	R4/ R5	Size of Company—feature affecting underwriting risk	No—charge percentages are the same for all companies, regardless of size. RBC amount increases with size of company.	No—same as RBC; geographic diversification gives some benefit to larger companies.
12	R4/ R5	Loss Sensitive Premium—feature affecting reserve risk	Yes—otherwise applicable risk charge is reduced based on study circa 1995.	No provision for P&C loss sensitive contracts, which are less common in the EU than in the U.S.
13	R4/ R5	Use of own-company data for risk charges	50/50 rule for underwriting risk	Allows use of own-company risk charges, partial internal models and full internal models.
14	R5	Catastrophe risk	Implicit in net premium risk charges	Explicit— Formula provides a set of specific disaster scenarios and requires companies to extend that if necessary. Company-specific reinsurance mitigation is applied to the gross disaster scenarios. Where a company cannot apply the disaster scenarios, the formula provides maximum gross loss ratios by line of business as an alternative. Company-specific reinsurance is applied to the loss ratio scenarios.
15	NA	Unearned Premium (UEP)	No charge. As there is no Statutory Accounting credit for Deferred Acquisition Costs, there is an automatic safety margin.	Not directly applicable as financial reporting is on written premium basis, i.e., unpaid claims includes unpaid for all "written" risks and

#		Risk Element	RBC	Solvency II
				profit/loss on "unearned" business in parted of reported profits.
16	NA	Operational Risk	Not treated	Yes. Operation risk charge is the smaller of (a) 30% of SCR before operational risk and (b) greater of (b-i) (3% EP+ growth charge) and (b-ii) 3% of technical provisions.[18]
17	NA	Group risk—from parent, affiliates, and subsidiaries (not reflected as asset risk)	No charge.	No charge
18	NA	Assumed financial reporting regime	Based on U.S. Statutory (SAP)	Based on IFRS.
			There are many differences between SAP and IFRS. Among the significant differences is that IFRS surplus is higher than SAP surplus are: 1a. IFRS Technical provisions are discounted; 1b. profit in unearned premium is effectively part of surplus. 1c. (1a) and (1b) are offset, usually, in part, in that reserves include an explicit risk margin. IFRS surplus is also higher than SAP surplus because of other conservative measures included in SAP: 3. Limited credit for uncollected salvage and subrogation 4. Schedule F penalties 5. Agents balances "written off" after 90 days IFRS values all assets at market or fair value. SAP values some assets at amortized costs, historical cost, or other specified values. SAP values might be higher or lower than IFRS values.	
19	NA	Role of judgment in determining the RBC amount	Only in model design and calibration.	In model design and calibration; Judgment also permitted in Internal Model, Partial Internal Model, or Own-Company Risk charges, if properly controlled by company and approved by regulator.

[18] Premium plus claim reserves discounted for interest plus a added risk margin

#		**Risk Element**	**RBC**	**Solvency II**
20	NA	Systemic risk beyond the scope of single company RBC.	Not considered in RBC formula.	Not considered in solvency capital required.
21	NA	Group issues	No assessment of group capital requirements.	Each company must have adequate capital on its own. In addition, RBC is calculated for groups. Group RBC reflects the degree of concentration or diversification within the group.

4. Dependency Structure

In this section we discuss the manner in which the individual risks "move together" to form the aggregate risk distribution from which capital requirements are derived. The manner in which the risks "move together" can be called dependency (or dependencies). We use the term "dependency" rather than the often used term "correlation" because correlation is often interpreted as linear correlation, which describes a specific kind of dependency that may not be appropriate for insurer risk-based capital requirements.

4.1 RBC structure:

The combined RBC is the result of the covariance formula:[19]

RBC = R0 + square root $[(R1)^2 + (R2)^2 + (R3')^2 + (R4')^2 + (R5)^2]$

The treatment or R0 is equivalent to setting the subsidiary company RBC as if the subsidiary is identical to the parent company in risk structure, although varying by size. The treatment produces more parent company RBC than any other risk structure assumption for the subsidiary.[20]

There are four levels of regulatory action depending on the relationship between the "adjusted surplus" held by the company and the "risk-based capital" value as follows:

(1) Company Action Level (CAL), at which point a company must submit a plan to improve its capital position (CAL = 2.0 * CAL = RBC)

(2) Regulatory Action Level (RAL), at which point the insurance commissioner will issue an order specifying corrective actions (RAL = 1.5 * ACL = 0.75*RBC)

(3) Authorized Control Level (ACL), at which point the insurance commissioner is authorized to take action to protect the interests of policyholders and creditors of the company, including action to place the company under regulatory control (ACL = .5*RBC)

(4) Mandatory Control Level (MCL), at which point the company is authorized to place the company under regulatory control. (MCL = .7*ACL = .35*RBC)

Within those rules the following dependency rules are reflected:

[19] In the above formula, R3 and R4 are adjusted. Usually half of the R3 resulting from reinsurance credit risk is added to R4, giving R4´. And R3´ is half the remaining reinsurance credit risk plus all other credit risk. In the unusual case in which R3 for reinsurance credit risk is greater than R4, then R3 and R4 are not adjusted in this way.

[20] This treatment may also be intended to address that risk that fungibility of funds between companies within a group is sometimes limited, especially in times of financial or other business stress.

In R3 and R4: Premium or loss concentration adjustment—70% rule in combing lines of business in Premium and Reserve Risk.

In R1: Bond concentration adjustment

In R2: Equity concentration adjustment

In all other respects, the covariance formula treats risks as independent, i.e., having zero dependency.

4.2 Solvency II Structure

The main elements of Solvency II dependency structure and comparative comments relative to RBC are as follows:

A. Within Underwriting Risk Solvency II has:

1. A correlation matrix describes the dependency between each pair of the 12 lines of business identified in the Solvency II framework.

   This addresses the same concentration / diversification issue as the 70% rule in RBC.

2. Within each line of business the correlation between reserve risk and premium risk for each line of business is 50%.

   RBC treats premium and reserves as independent risks.

3. There is a credit for diversification across major geographic areas by line of business for premium and reserve risk separately, applied prior to application of correlation between premium and reserves, item 2 above. This is expressed with a formula similar to the RBC 70% rule.

   RBC contains no adjustment for concentration or diversification of risk by region.

4. Correlations between normal and catastrophe claims by line of business.

   RBC includes catastrophe risk charge and dependency between normal and catastrophe claims implicitly in the premium risk charge.

B. Within Market Risk Solvency II has:

5. Correlations between components of market risk—interest, equity, property, etc.

   RBC treats fixed income and equity asset risks as independent.

C. Between non-life underwriting risk and other risks Solvency II has:

6. Correlations between market risk and underwriting risk in nonlife, life, and health risk business segments, for companies with more than one of nonlife, health and life business segments.[21,22]

   RBC treats market risk as independent of underwriting risk.

   In the U.S. life, health and P&C businesses are often placed in different companies, and RBC, through R0, assumes the parent and subsidiary risks are 100% correlated even if they operate in these different types of business.

[21]Market and underwriting correlation applied only if the correlation is positive. Zero is used if expected correlation is negative.

[22] In the U.S., while health and casualty may be in the same company, generally life, nonlife, and health are underwritten in different companies. If the companies are affiliated, the R0 risk assumes the different types of insurance risks are 100% correlated.

5. Safety Levels

Table 5-1 below indentifies the main decisions in the selection of safety levels in the RBC system and compares those decisions to decisions in Solvency II and Rating Agency models.

Table 5-2
Comparisons of Safety Margin Specifications

Item	RBC	Solvency II`	Rating Agency
Time Horizon – Premium	One year of earned premium as if no UEP[23] risk (or risk included elsewhere)	Written basis – risk arises from UEP and one year written premium	Going concern
Time Horizon – Claim Reserves	Runoff	One year including risk margin at the end of the year	Going concern
Safety level structure	Implicit	VAR	Various – usually explicit
Safety level margin	Implicit	99.5%	Various – usually explicit

[23] In RBC there is no risk charge for unearned premium (UEP). A rationale is that under SAP there is a risk there is no credit for deferred expenses, and under that treatment, generally, there is no remaining risk of inadequate UEP.

6. Assessment—Risks and Risk Charge Calibration

6.1 Evaluation of Current Situation

With respect to each of the risks and calibration approaches described in Sections 3, the types of gaps that might exist are:

1. The overall RBC charge is not at the intended level.
2. Charges by company are systematically above/below the intended level, even if the overall charge is at the intended level.
3. Calibration is deficient in some respect other than the above.
4. Calibration might be correct, but it has not been reviewed since the initial RBC formulation.
5. There are risks for which there are no risk charges.
6. The risk is not measured in the same way that a company would typically assess its risks (e.g., ERM) thereby creating an unnecessary difference between regulatory and company (and probably rating agency) risk assessment.

Table 6-1 below summarizes DCWP view of the gaps in the current risk selection calibration. It is listed in a priority order, called "rank" as shown in the first column. The ranking incorporates DCWP view of the significance of the gaps and the feasibility of correcting those gaps. All risks for which the only "gap" is "not current" (type 4) are listed at the end of the table.

Table 6-1
Assessment of Risk Selection and Calibration

Rank	Item #*	Risk Element	Gap	See Note
1	8	Value of future investment income on assets corresponding to loss and loss adjustment expense reserves and future premium (Investment Income Offset or IIO)	1 – Overall charge too low 4 – Calibration is not current	URWP
2	14	Catastrophe risk	1- While there are offsets because cats are implicitly included, overall there is a shortfall 2- Shortfall larger in some companies than others 3- Calibration method can be improved. 4- The method is inconsistent with the way a company would assess the risk (cat models).	A
3	7	Underwriting—Reserve and Premium—Factors	3 - Calibration method can be improved	URWP
4	5	Reinsurance credit risk	1 - 10% factor likely too high 2 - Charges do not fit individual company circumstances; do not reflect differences between types of reinsurance, e.g., quota share vs. excess. 3 - Calibration method can be improved.	B
5	9	Treatment of Reinsurance	2 - Does not reflect differences between companies with different reinsurance programs	C
6	1	Asset Risk—Subsidiary Insurance Cos	3 - Calibration can be improved	D
6	2	Asset Risk—Fixed Income	2 - Charges do not fit individual company circumstances regarding asset duration relative to liability duration 3- Possibly calibration can be improved 4- Calibration not current	E
6	3	Asset Risk—Equity	3 - Possibly calibration can be improved 4 - Calibration not current	E
7	11	Size of Company—feature affecting reserve and premium risk	2 - No charge currently	F
8	15	Unearned Premium (UEP)	2 - Charge might be low for some (low expense) companies	G
9	10	Growth—feature affecting reserve and premium risk	4 - Calibration is not current	H
9	12	Loss Sensitive Premium—feature affecting reserve and premium risk	4 - Calibration is not current	H
10	4	Asset Risk—Other long-term assets	4 - Calibration is not current	E
9	12	50/50 Rule	Never tested for relevance	H
10	6	Credit—Other than reinsurance	4 - Calibration is not current	H
11	16	Operational Risk	1 - No charge currently	F
12	17	Group risk—from parent, affiliates, and subsidiaries not reflected as asset risk or R0	1 - No charge currently	F

*Order in which listed in Table 3-2.

Brief comments on the basis for these assessments are provided below:

Table 6-2
Notes on basis for assessment in Table 6-1

Item	Comments
URWP	**Underwriting Risk Working Party report—**reserve and premium factors and future investment income offsets
A	**Catastrophe Risk—**DCWP believes there is a shortfall in part because of increasing population and property density in catastrophe exposed areas is not reflected in historical data; in part because the calibration of UW factors may exclude some of the historically observed risk; and in part because terrorism risk in not included.
B	**Risk Mitigation and reinsurance credit risk—**DCWP believes the current factors represents risk perception relevant in early 1990s but does reflect current conditions including actuarial opinions on gross reserve, actuarial opinion reporting on financial reporting, CFO/CEO attestation regarding reinsurance risk transfer, nor available modeling capabilities.
C	**R3/R4/R5-Reinsurance Ceded—**Net risk is lower than gross risk. The reduction is determined as if all companies had equivalent reductions in risk per dollar of premium (R5) or dollar of unpaid claims (R4). We expect there are differences by company in reinsurance strategy that affect required capital.
D	**R0 risk—**The current method is a practical simplification but might be improved. Treatment as reduction to capital rather than add-on to risk charge might be considered.
E	**Fixed Income, Long term assets, Other long term assets—**The calibration is not current and conditions have changed since establishing these charges.
F	**Company size, Operational risk, Group risk, from parents and affiliates not reflecting in R0 or asset risk—**No charge.
G	**Unearned Premium—**The current approach may be too conservative for most companies and too low for low-expense, high-risk companies. Does not reflect differences between companies in distribution by line of business.
H	**Growth charge, Loss sensitive premium, Credit risk other than reinsurance, 50/50 rule—**The calibration is not current and conditions may have changed since establishing these charges.

6.2 Possible Improvements in risks and risk charge calibration

Table 6-3 describes a number of ways to address the gaps identified in Table 6-2 above. These options include:

1. Updated calibrations of risk charges.
2. Calibration based on data from new sources.
3. Use of scenarios rather than factors to determine the RBC charge.
4. Application of charges at a greater level of detail than now applicable.

Table 6-2 below identifies alternative data and calibration approaches.

Table 6-2
Alternative Calibration Approaches

Item	Calibration Approach
IIO offset	Consider method that allows factors to vary over time, reflecting current interest rates for premium risk and movements in current average returns on assets for reserve risk.
	Consider patterns based on actuarial analysis rather than IRS payment patterns.[24]
	Consider a risk measurement that considers the effect of changes in difference between (a) discounted reserves and (b) assets at market value, at specified scenarios(s) of interest rates, by duration , rating quality, etc.
Catastrophe risk	Consider use of catastrophe modeling results.
	As alternative and/or supplement for hard-to-model risks, consider Realistic Disaster Scenarios, specified by regulator or by company.
UW factors (premium and reserve)	Consider results of a principles-based actuarial analysis of premium and reserve risk reflecting a variety of methods, data sources, and appropriate professional judgment, including factors such as the approaches described in the boxes below:
	Model-based distributions of variations in loss ratio or reserves.
	More extensive schedule P analysis—more years; company group rather than company Schedule Ps, etc.
	The proper weighting of companies within the risk factor (currently weighted equally by company rather than weighted by size of company or other choice method to develop the appropriate risk charge when there are different size companies within the data set).
	Use of data beyond that available in the Annual Statement, for example line of business segmentation more refined than that available in Schedule P.
	Common Shock Models (e.g., loss ratio and loss reserve variability driven by movement in interest rates that relates to movement in medical and other insurance-related expenses). Use Economic Scenario Generators (ESGs) or other tools to develop inflation models to "drive" the common shock models.
	Calibration including an underwriting cycle model to supplement/replace empirical observation of underwriting cycle effects.[25]

[24] The IRS approach is used for all lines other than workers compensation and reinsurance liability.
[25] http://www.risklighthouse.com/papers/2011%20ERM%20Symposium%20Paper%203_22_11.pdf

Continued—[UW factors (premium and reserve)]	Calibration to reflect geographic diversification or concentration, beyond catastrophe effects, e.g., for workers compensation, automobile, medical malpractice, and other liability lines.
	Evaluate the extent to which the current reserve position of the industry or individual companies might be assessed and this information used to adjust RBC charges.[26]
	Assess whether the 50/50 rule is appropriate and where there are alternative ways to reflect differences by company.
	Other recommendations from URWP.

Reinsurance—Mitigation effectiveness and credit risk	Actuarial analysis of various elements of reinsurance risk, including extent of risk transfer, risk of reinsurance disputes, risk of reinsurer default.
	RBC reflects premium and reserve risk net of reinsurance and then considers the risks associated with ceded reinsurance. Alternatively, the risk could be assessed gross of reinsurance and the benefit of reinsurance allowed depending on the type of reinsurance and then the risk of ceded reinsurance considered. Consider alternatives such as that.

Risk Transfer	Effect of risk mitigation by type of reinsurance, e.g., quota share vs. excess vs. aggregate.

Risk Transfer	Company models of risk transfer effectiveness.

Credit Risk	Reinsurer credit quality information—from financial markets, credit agencies, or otherwise.

Assets: Fixed Income, Equity, Other long term assets	Update risk factors based on up-to-date economic scenario generators and in light of experience in the past 20 years.
	Consider the use of scenarios rather than factors. Measure the effect of changes in interest rate on the company's actuarial portfolio, probably best if done relative to the company liability duration.
	Evaluate the risk measures appropriate when variability on market values is the available data, but assets have an amortized value or other statutory non-market valuation basis.
	Consider foreign exchange and other fixed income risks to the extent those are relevant to the company.

Assets: Subsidiaries	Consider market value of subsidiaries, or fair value when market is not available, as assessing risk charge so that the combined charge for R0 and statutory accounting do not overstate risk of subsidiaries.

[26] This is a feature in some rating agency models, but not typical of standard formulas.

	Non-insurance subsidiaries may pose risks from their operations that are beyond the risk of default with by RBC. Consider the extent to which such risks can be reflected in RBC (see also group risk).
	Effect of addressing "R0" risk by adjusting capital rather than adding R0 to RBC.

Operational Risk	Identify ways to utilize operational risk databases.

Group risk	Membership in an insurance group creates risks for subsidiaries, affiliates, and parents beyond those reflected in RBC formulas. Consider the extent to which such risks can be reflected in an RBC formula.

Company/Line of business size	Actuarial analysis of the nature of risk vs. size.
	Consider the effect of "age" and homogeneity or risks as well as "size," as those other factors may be more important than size.
	Lines of business with low premium are more subject to process risk than lines of business with higher premiums companies. That fact means that for low premium businesses or segments, individual risk charges are higher, but that might partly offset by increased effect of diversification.

Growth	Update the factors with current data.
	Consider whether growth charge should be combined with underwriting risk or treated in R0 or elsewhere in the formula.

Loss Sensitive Contracts	Update the factors with current data.

Unearned Premium	Consider evaluating the extent to which profit implicit in UEP might differ by company to increase or decrease the otherwise applicable RBC.

Role of judgment	Consider the extent to which expert judgment should play in the selection of factors. [For a factor-based model like RBC, judgment has limited, if any, role in the application of the formula.]

7. Assessment—Dependency Structure and Calibration

There are many tools[27] available to construct aggregate risk distributions that describe in detail how risks "move together." The aggregate risk distribution might be expressed as a formula or as the result of random simulation of possible future events and the resulting financial outcomes for the business.

These aggregate distributions are most useful for testing multiple risk levels and multiple risk measurements (VaR, TVaR, etc., at levels of 1/10, 1/50, 1/100, 1/250, etc.) as might be useful in testing capital adequacy for business strategy, in making reinsurance purchasing decisions and the like. For RBC, however, once a safety level and safety measure is selected, the risk charges are needed only at the selected risk level. As such, the aggregate distribution and simulation approaches are primarily relevant in calibrating an RBC formula, but not relevant in determining company-specific RBC.

Rather, the dependency structure can be applied to individual companies in two ways:

1. Scenario sets covering relevant risks for single or multiple tail events of interest: catastrophes, adverse loss ratios adverse reserve events, adverse asset outcomes, etc.
2. Sets of weighting factors (that look like correlation factors, or correlation matrices), calibrated to the tail events of interest.[28]

In either case, dependency relationships need to reflect both process risk (smaller business segments have more risk per unit of size) and parameter risk (economic, legal, and other forces create variability that is proportion to business size). RBC and Solvency II, however, simplify the risk assessment and treat all companies as if they had the same level of process risk. In future reports, DCWP will consider the extent to which both process and parameter risk can be reflected without creating undue complexity.

This section evaluates the current dependency structure and calibration methods and then discusses alternative dependency structures and calibrations methods.

[27] The creation of aggregate risk discussion uses tools like copulas, common shock models, Iman-Conover methods, etc. New tools and new methods to apply the tools continue to emerge.

[28] Manistre, John B., A Practical Concept of Tail Correlation, February 11, 2008, published by the Actuarial Foundation, http://www.actuarialfoundation.org/pdf/2008-practical-manistre.pdf

7.1 Evaluation—Dependency Structure

Some of the most significant differences between the RBC and Solvency II dependency structure are in the following areas:

1. RBC does not measure geographic concentration.

   RBC risk factors have been derived largely from companies that are diversified across geography, and RBC assumes all companies are equally diversified geographically with respect to reserve and premium risks.

2. In RBC, premium risk and reserve risk (R4 and R5) are assumed to be independent of each other.

3. In RBC, underwriting risk (R4, R5) and asset and market risk (R1, R2) are assumed to independent.

4. RBC uses the 70% rule the measure diversification across lines of business. Solvency II uses a "correlation matrix" that describes how each pair of business lines "moves together."

These items represent simplification in the RBC formula. Items 1-3 probably understate the RBC required for all companies, for a given level of security. The current 70% rule might either over or understate the RBC..

Neither RBC nor Solvency II considers a number of factors, for example, variations in correlations between premium and reserves by accident year or between assets and particular lines of business (driven by common relationship to inflation).

7.2 Evaluation—Dependency Calibration

For both RBC and Solvency II, the correlation factors are constructed primarily from judgments regarding the nature of the relationships in extreme conditions.

For RBC the correlation factors are generally 0% or 100%. For Solvency II the "correlation matrix" values are always 0%, 25%, 50%, 75%, or 100%.

7.3 Possible Improvements—Dependency Structure

Areas of possible improvements to the RBC dependency structure include the following:

1. Address the simplifications 1-4 (Section 7.1) in RBC dependency structure, including the use of more extensive weighting or "correlation" matrices.[29]

[29] Correlation matrices can be implemented readily in spreadsheets like Excel.

2. Apply correlation arrangements to more detailed levels of risk factors, e.g., assets correlated more strongly to workers compensation reserves than personal automobile reserves or equity risk greater for companies with faster paying claim obligations (property) than for companies with slower paying obligations (liability), various risks affected by company size, premium risk related to reserve risk differs by accident year age, etc.
3. Assess the extent to which process risk (size related) and parameter risk (affecting all size) can be reflected in risk charges and dependency while maintaining the desired level of simplicity/complexity in the RBC formula.

7.3 Possible Improvements—Dependency Calibration

While RBC and Solvency II dependency relationships have been calibrated primarily through judgment, other methods include:

1. Modeling historical data with attention to unusual events.
2. Modeling the relationship between common drivers like interest rate driving inflation rates that affect premium and reserve risk (common shock models).
3. Determine calibrations based on integrated aggregate risk models expressed in formulas or simulation.

8. Assessment—Safety Levels

8.1 Specifying the Safety Level in the RBC Formula

As described in Section 5, the current RBC formula does not set an explicit target overall safety level.

As such, it is difficult to assess whether a particular risk margin is appropriate. The key decisions required to specify a target level, the degree to which RBC includes a specification and alternative decisions are shown in table 8.1 below.

Table 8-1
Safety margin Specifications

	Feature	Alternatives	RBC Approach
1	Time horizon—new business	No new business One or two years Long-term going concern (Also treatment of unearned premium, to the extent relevant in the underlying accounting system.)	1 year
2	Time horizon—claims	One year, including reserve risk at the end of the year Run-off	Run-off
3	Safety margin structure	Explicit (e.g., solvency 99.5%) Implicit (e.g., RBC) Mixed, different for different risk elements	Not explicit. Enough RBC to fund a "soft landing" is one cited description
4	Safety margin metric	VaR or TVaR, i.e., expected chance of failure vs. expected cost of failure.	Implicit (Note 1)
5	Safety level	Say, 5%, 1%, ½% VaR; or 10%, 2% 1% Tail VaR	Implicit (Note 1)

Note 1: The current RBC formula was set with explicit safety levels assigned to certain, but not all, risk factors. For example, underwriting factors in the recent revisions were based on an 87.5% chance that actual results will not exceed the expected value plus the risk charge.

As such, it is difficult to assess whether a particular risk margin is appropriate.

8.2 Other Issues

There are a number of issues that are not addressed directly, if at all, by current RBC systems, and which will not be addressed by our work. These include the following:

1. Systemic Risk
2. Relationship to Guarantee Arrangements
3. Real-world effects of higher capital standards.

Systemic Risk

If 1% failure rate might be acceptable if it means 1% of companies fail each year; a 1% chance that 5% or 10% or more of the industry fails in a year, due to systemic effects, would be far less acceptable. Two sources of systemic risk are:

1. There is a concentration of ceded reinsurance risk with a small number of major reinsurers. A 1% failure rate among reinsurers, particularly if resulting from an event like a catastrophe, could trigger a number of failures among other companies.
2. With the underwriting cycle, reserve and premium risk can become highly correlated across companies and further concentrated within the reinsurance industry.

Setting Safety Levels—Unintended Consequences

Company actual capital will often be set to give management sufficient confidence that surplus will not fall below the level prescribed by regulation. Thus, an increase in regulatory capital levels can lead to an increase the held capital, even if regulatory capital is well below the held capital, and even if the held capital is sufficient for policyholder protection. The result can be unnecessary excess capital within in the industry.

Relationship to Guarantee Arrangements

The existence of guarantee arrangements shifts the cost of insolvency from individual consumers to all consumers (through premiums charged by remaining solvent insurers).

We understand that RBC safety levels are not intended to consider that effect, partly to avoid cost shifting and partly because not all consumers are covered. Solvency II and Rating Agency approaches also do not consider the existence of guarantee arrangements.

9. Mitigating Considerations

Notwithstanding these observed gaps we note that regulatory capital management is only one element of a regulatory structure, and can play a greater or lesser role, depending on the overall structure of the system. Even if gaps exist, the significance can be mitigated by other regulatory activities. For example, the following regulatory mitigation strategies can apply:

1. Catastrophe Risk—Regulators can, independent of capital assessment, assess company reinsurance protection including reinstatement costs and reinsurance credit risk.
2. Credit for Reinsurance—Regulators can, independent of capital assessment, verify that reinsurance risk transfer is sufficient, supporting collateral is available if required, and provision has been for disputed reinsurance collections.
3. Company Size—Regulators can, independent of capital assessment, more closely supervise the company with respect to its risk approval through approval for limited lines of business, limited geography, oversight of management, rate adequacy, reinsurance arrangements, etc.

10. Next Steps for DCWP

In the near term, DCWP plans to prepare additional reports in the following areas:

1. Description of the EU Solvency formula with respect to risks included, risk charges, dependency structure and method of calibration.
2. The impact and feasibility of alternative structural, calibration and dependency approaches ("what-if" testing) by applying current and possible alternative formulas to individual company data.
3. Observations based on the nature of insolvencies since RBC was implemented.

Beyond that, DCWP plans to:

4. Evaluate dependency structure in greater depth than in this report.
5. Further consider alternative methods of risk charge and dependency calibration, including illustrations where practical.

11. Working Party Charge

Working Party Charge as requested by American Academy of Actuaries—September 30, 2010, is as follows:

> **CAS Dependency and Calibration Working Party: Project A:**
>
> **Research geared toward developing a solvency monitoring framework appropriate for the U.S., with a specific emphasis on (1) capturing risk interdependence and (2) proper calibration of RBC formulas.**
>
> This analysis will include validating the existing ways of capturing risk dependence in RBC frameworks and/or the development of new approaches. Calibration of RBC formulas involves careful choice of appropriate risk metrics. You may find it useful to examine the work already performed by our Committee, which we would be pleased to provide, as well as developments in other countries.
>
> The analysis need not be limited to the risks already reflected in the current RBC formula in the U.S. or the interdependence of these risks. Other risks, including those that are not directly captured in the current formula, may be taken into account.
>
> In developing a general framework for capital requirements, including methods of measuring risk interdependence, our preference is to use methodologies that may also be applied in the analysis of life and health insurance companies.
>
> We ask that the research support provided by the CAS incorporate evaluating alternative approaches, including the identification of their strengths and weaknesses, and quantitative illustrations of possible application of alternative approaches. This research is focused on solvency monitoring by regulators, which may present constraints not found in internal company modeling performed as part of enterprise risk management and capital optimization.
>
> The Academy P/C RBC Committee intends to use the results of this research to assist it in replying to the request from the NAIC to provide:
>
> *Recommendations for improving the correlation/covariance methodologies used in RBC, including the merits of replacing current formulas with correlation matrices and also the extent to which improved correlation/covariance methodologies developed by the Academy's P&C RBC Committee and Health Solvency Working Group may be applicable to Life RBC.*

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13. Glossary

50/50 rule	RBC premium and reserve factors are based 50% on factors calibrated based on industry data and 50% based on the industry data adjusted by the ratio of company experience to industry experience for the most recent 10 years (if 10 years of company data is available, otherwise, there is no adjustment).
70% Rule	For premium risk the concentration factor is 70% plus 30% times (1- premium for largest line of business/total premium). For reserve risk the concentration factor is the same formula using reserves.
ACL	Authorized control level
APD	Automobile physical damage
AY	Accident year
DAC	Deferred acquisition cost
DCC	Defense and cost-containment expense
DTA	Deferred tax asset
DCWP	Dependency and Calibration Working Party
ERM	Enterprise Risk Management
ESG	Economic Scenario Generator
IFRS	International financial reporting standards
IIO	Investment income offset
Internal Model	A risk management system including a capital calculation tool used to determine SCR, replacing the SCF
LGD	Loss Given Default, a term used in credit risk analysis.
NAIC	National Association of Insurance Commissioners
ORSA	Own-Risk Solvency Assessment
Partial Internal Model	A company model replacing the SCF for certain risks.
RBC	Risk Based Capital formula of the NAIC
Scenario Approach	Recalculation of financial statement position based on specified set of assumptions, for example regarding catastrophes, change in interest rates, or operation of reinsurance programs.
SAP	Statutory Accounting Practices
SCF	Standard Formula, or Standard Capital Formula A formula for determining SCR under Solvency II as distinct from internal models for determining SCR
SCR	Solvency capital required, produced by either the SCF, and Internal Model or combination of those tools, as approved by relevant regulatory authority
Solvency II	EU regulation and related implementing measures
UEP	Unearned premium
URWP	Underwriting risk working party

2011 Research – Short-Term Project Report

A Report of the CAS Underwriting Risk Working Party

Abstract: At the request of the American Academy of Actuaries, the CAS formed the Risk-Based Capital (RBC) Underwriting Risk Working Party (URWP) to research the current RBC formula for measuring underwriting risk and the procedures for calibrating the formula's parameters (the Current Calibration Method). The research unveiled various accuracy and consistency issues with the Current Calibration Method. Some alternatives are investigated and areas of further research are suggested, including volume of data, data filtering, curve fitting, the investment income offsets (IIO) discount rate, time horizon, and the relative impact of premium and reserve charges by line. This paper presents results of the URWP's short-term charge.

Keywords. risk-based capital; RBC; underwriting risk, reserve risk; premium risk; risk horizon

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EXECUTIVE SUMMARY

In 2011 the Underwriting Risk Working Party (URWP) of the Casualty Actuarial Society (CAS) researched the potential for improvements to the calculation of underwriting risk (reserve and premium) charges within the constraints of the current NAIC RBC formula and its current parameter calibration procedures. This report summarizes the results of our short-term charge.

- The current data sources—confidential company RBC filings and the most recently available Schedule P—yield too few observations for stable estimates of RBC factors from one calibration cycle to the next. Additional data sources should be investigated.
- Filtering eliminates a significant amount of company experience from the current calibration method. For many lines of business the majority of the companies in the industry are eliminated; for two lines, all companies are eliminated. New ways to filter out questionable data should be investigated. Possible alternatives are discussed in the report.
- The method of basing the RBC reserve risk factor on empirical reserve run-off ratios is subject to high volatility due to the limited data available and to the natural behavior of mathematical ratios. We are quite confident that it is inevitable that from one calibration cycle to the next RBC factors will change to an unsatisfactorily significant degree. This volatility may be mitigated by additional data, alternative filtering procedures, basing charges on statistics from fitted curves rather than from the empirical data alone, or designing

structural changes to RBC's reserve risk calculation.

- There is evidence that the current calibration method understates the indicated reserve risk charge for companies with smaller booked reserves and overstates the charge for companies with larger booked reserves. Some method of varying the factor by size of booked reserve could be investigated.
- The Investment Income Offset (IIO) discount factor of 5% that has always been in place is inconsistent with the current environment. Although selecting the most appropriate discount rate and allowing it to float with the market is not without controversy, research is warranted to improve the implied safety margin of the RBC's underwriting risk. This research should be coordinated with other RBC risk areas.
- There are many differences between the NAIC RBC and the Solvency II approach to risk-based capital. One difference is the time horizon for measuring reserve risk. The Solvency II Standard Formula measures reserve risk over a one-year time horizon while RBC measures reserve risk over the claim run-off period. We illustrate RBC reserve risk factors on the basis of a one-year risk horizon from the RBC data currently available. An analysis of the relative strengths and weaknesses of the current run-off horizon versus a one-year horizon is beyond the scope of the URWP's short-term charge.
- Procedures for comparing the performance of alternative RBC formulas and calibration methods should be investigated. One useful approach investigated in the report is based on pro forma premium to Company Action Level RBC underwriting risk ratios.
- A comparison of RBC premium and reserve risk factors suggests that companies entering a line of business may have a lower RBC charge per dollar of premium than established companies.

1. INTRODUCTION

We present a summary of the research as of mid-2011 conducted by the Underwriting Risk Working Party (URWP) of the Casualty Actuarial Society (CAS).

1.1 Research Context

At the request of the American Academy of Actuaries the CAS formed the Underwriting Risk Working Party (URWP) to conduct research regarding the Underwriting Risk (Premium and Reserves) components of the NAIC's Risk-Based Capital (RBC) formula. The Academy requested the research to take place in two stages, through a long-term and a short-term charge.

1.1.1 Long-Term Charge

> *Provide general research that identifies better ways to quantify reserve and premium risks in solvency monitoring, and to determine capital charges to account for those risks.*

The measurement of underwriting risk would involve identification of an amount of capital for each company that specifically reflects the company's underwriting risk profile to the extent practical in an RBC context. To accurately reflect risk, detailed measurements might use techniques that differ from the current RBC formula, and development of such techniques is left as a long-term research subject.

1.1.2 Short-Term Charge

> *Research ways to improve the calculation of reserve and premium charges within the constraints of the current NAIC RBC formula and the current parameter calibration procedures.*

The URWP recognizes that accurate measurement of risk may require structural changes to the measurement formula. However, in the short term, we analyze some of the assumptions and implications in the current RBC formula and propose possible improvements within the existing framework.

1.2 Objective

We provide details on our investigation into the short-term charge and explain the long-term issues that we may address in future research.

1.3 Disclaimers

The analysis and opinions expressed in these pages are solely those of the Working Party members, and in particular are not those of the members' employers, the Casualty Actuarial Society, or the American Academy Actuaries.

Equivalent values in separate tables may differ due to rounding.

1.4 Outline

The remaining sections in this report are as follows:

Section 2: Background and Methods

Section 3: Results and Discussions (Short-Term Issues addressed in this report)

Section 3.1 Filtering

Section 3.2 Risk Charge Measurement

Section 3.3 Investment Income Offset (IIO)

Section 3.4 Observations Regarding Solvency II

Section 3.5 Pro Forma Premium to Company Action Level (CAL) RBC Underwriting Risk Ratios

Section 4: Conclusions and Areas of Further Research

Acknowledgements and Appendices

2. BACKGROUND AND METHODS

2.1 Introduction to the Current Calibration Method

When RBC was established in 1993, premium and reserve risk charges were based on analysis and judgment. The factors were updated in 2008, 2009, and 2010. The RBC factors are currently based on an approach we call the Current Calibration Method. The selected factors adopted for 2008, 2009 and 2010 were the factors indicated by the Current Calibration Method subjects to limitations ("caps") in movement of ±15% each year for 2008 and 2009. In 2010, the cap was ±5%.

The Current Calibration Method begins with 10x10 triangles (ten accident years by ages 1 through 10 years) for all lines of business for all companies. The source is Schedule P data for long-tailed lines and the RBC filing for short tail lines[1]. Data for certain companies is removed from this data set and extreme values for some data points are limited based on criteria which we discuss below. We refer to this data editing as "filtering." Filtering in the Current Calibration Method is described in section 3.1.

Reserve Risk

For calculation of the reserve charges, the Current Calibration Method uses nine data points for each selected company by RBC line of business. The first of these data points is the total reserve development on total reserves from the oldest evaluation date to the current statement date, representing nine years of development. The next data point is total reserve development from the second-oldest evaluation date to the current statement date, representing eight years of development. The subsequent points follow the same pattern.

The Current Calibration Method then calculates a statistic, currently the 87.5th percentile, from these data, which, after investment income offset, is considered the indicated "INDUSTRY LOSS & EXPENSE RBC%" factor that would otherwise appear in Line 04 in report PR016 for the relevant line of business. This indicated factor is subject to the following limitations before becoming the final selected factor (or "RBC charge") for that line:

- The selected INDUSTRY LOSS & EXPENSE RBC% cannot be less than 5% (the "5% minimum charge").
- The change in the selected factor from year to year is "capped."
- Other potential NAIC overrides.

[1] It is not uncommon for companies to complete their RBC filings for short tail lines with only the most recent evaluation (i.e., the list diagonal of the accident year triangle). Since incomplete triangles flag companies to be eliminated in the filtering process (see Section 3.1), such "shortcut" company practices curtail the volume of data for short tail line RBC calibration.

Premium Risk

For calculation of the premium charges, the Current Calibration Method uses the ten accident year loss ratios evaluated at the current date by RBC line of business. The maturity of this loss ratio for the oldest accident year in Schedule P is ten years; for the second-oldest accident year, nine years; and so forth.

The Current Calibration Method then calculates a statistic, currently the 87.5th percentile, from these data, which, after investment income offset, is considered the indicated "INDUSTRY LOSS & EXPENSE RATIO" factor that would otherwise appear in Line 04 in report PR017 for the relevant line of business. This indicated factor is subject to the following limitations before becoming the final selected factor (or "RBC charge") for that line:

- The selected INDUSTRY LOSS & EXPENSE RATIO plus the industry average company operating expense ratio (27.5% currently) less unity cannot be less than 5% (the "5% minimum charge").
- The change in the selected factor from year to year is "capped."
- Other potential NAIC over-rides.

3. RESULTS AND DISCUSSION

3.1 Filtering

Filtering in the Current Calibration Method is primarily accomplished by eliminating entire companies from the RBC database according to the following rules.

For reserve risk, a company is eliminated if it has:

- negative paid values in any AY as of any statement date.
- negative reserve values in any AY as of any statement date.
- negative incurred loss and DCC in any AY as of any statement date.
- fewer than ten accident years with non-zero loss data as of some evaluation date.

For premium risk, a company is eliminated if it has:

- average AY earned premium less than $500,000.
- any AY loss ratio <= 0%.
- less than eight AYs with net earned premium greater than 20% of its average earned premium for all AYs.
- fewer than ten years of earned premium.

For companies that remain, filtering takes the form of constraints on the observations that appear in the RBC database:

- For the calculation of premium risk, loss ratios are capped at 300%.
- For reserve risk, reserve run-off ratios, expressed as the ratio of reserve development to booked reserves, are constrained to lie between -100% and 400%.

Filtering in the Current Calibration Method eliminates a large portion of industry data for all lines of business. In most lines, less than 50% of available industry observations are used in developing reserve and premium charges, as shown in Exhibit 1 below.[2]

[2] Unless otherwise noted the RBC data used in this report is as of 12/31/2008.

Exhibit 1: Current Company Filtering

Percentage of Industry Data Utilized					
Line	**Line Letter**	**Reserve Dollars**	**Reserve Companies**	**Premium Dollars**	**Premium Companies**
(1) H/F	A	81.7%	39.0%	95.7%	57.0%
(2) PPA	B	85.1%	42.5%	95.6%	57.0%
(3) CA	C	80.6%	40.2%	90.5%	53.7%
(4) WC	D	82.5%	41.4%	91.1%	54.9%
(5) CMP	E	71.0%	40.3%	93.0%	56.7%
(6) MM Occurrence	F1	43.0%	10.7%	74.0%	20.3%
(7) MM CM	F2	59.2%	14.2%	71.9%	21.3%
(8) SL	G	64.5%	18.7%	83.3%	31.2%
(9) OL	H	64.4%	27.7%	89.8%	43.5%
(11) Spec Prop	I	29.9%	26.9%	89.0%	51.8%
(12) Auto Phys Damage	J	31.3%*	12.8%*	95.8%	56.9%
(10) Fidelity & Surety	K	29.8%	8.6%	88.9%	31.2%
(13) Other	L	25.7%	10.5%	68.7%	22.6%
(15) International	M	20.5%	1.4%	28.9%	1.9%
(16) Reins Property & Financial	N&P	34.3%	7.7%	63.3%	20.9%
(17) Reinsurance Liab	O	15.9%	4.4%	49.9%	13.8%
(18) Products Liability	R	48.4%	19.7%	75.1%	31.0%
(14) Fin & Mort	S	**	**	**	**
(19) Warranty	T	**	**	**	**
Average		67.1%	31.7%	91.3%	51.6%

*Salvage and subrogation development often produces negative reserves which result in many companies being excluded from the reserve data by the current filter.
** Not enough data
Dollar measure is based on total reserve dollars utilized divided by total reserve dollars for industry
Company measure is based on number of companies utilized divided by total number of Companies
Average is weighted average using 2008 industry data

To measure the effect on risk charges of the filtering in the Current Calibration Method, we tested the effect of an alternative filtering process that eliminates individual data points rather than entire companies.

Exhibit 2 shows the charges that would result from the use of a filter based on the size of the underlying data which targets use of 90% of industry premium dollars or reserve dollars, as appropriate. In the case of the Homeowners/Farmowners line, for example, the alternative filter eliminated all reserve run-off ratio observations where total booked reserves (the denominators of the reserve run-off ratios) are less than $9.4 million for calculating the reserve charges, and eliminated all loss ratios where the earned premium is less than $30.5 million for calculating the

premium charges. As a result, 90% of Homeowners/Farmowners industry dollars are used in the calibration calculations (a *decrease* from the Current Calibration Method for premium). Appendix A shows the thresholds and the dollar utilization percents by line of business.

The alternative filter ensures that 90% of industry dollars are used for all lines of business. Filtering by data point also allows data from insolvent, run-off, withdrawn, and new companies to be reflected in the RBC charges.

Lines of Business with Insufficient Data Post-Filter

For International and Financial/Mortgage Guarantee there was not enough data after the Current Filter to calibrate factors. The NAIC judgmentally set the 2010 International charge equal to its previous value prior to application of the IIO. The Financial/Mortgage Guarantee charge was also set equal to its previous value and then increased due to the housing market collapse by the maximum amount allowable under the post-IIO 5%-cap constraint. The Indicated values for these two lines are shown as "N/A" (not available) in column (4) of Exhibit 2.

The Alternative Filter keeps enough data to calibrate factors for International but not for Financial/Mortgage Guarantee.

The "Average" values include no adjustment for loss sensitive business or diversification by line of business. The averages also do not include provision for the other quantities included in the RBC's R4 and R5 calculations – reinsurance (R4 only), excessive premium growth, and A&H business.

Exhibit 2: Effect of Alternative Company Filtering

		Reserving RBC charge				Premium RBC Charge		
(1)	(2)	(3)	(4)	(5)		(6)	(7)	(8)
		2010	Current Filter	Alternative Filter		2010	Current Filter	Alternative Filter
Line	Line Letter	Actual	Indicated	Indicated		Actual	Indicated	Indicated
(1) H/F	A	0.127	0.127	0.080		0.169	0.152	0.149
(2) PPA	B	0.106	0.050	0.050		0.171	0.138	0.118
(3) CA	C	0.121	0.121	0.120		0.154	0.099	0.106
(4) WC	D	0.099	0.111	0.092		0.142	0.125	0.111
(5) CMP	E	0.283	0.283	0.214		0.100	0.069	0.055
(6) MM Occurrence	F1	0.238	0.053	0.213		0.672	0.572	0.541
(7) MM CM	F2	0.153	0.156	0.118		0.178	0.392	0.352
(8) SL	G	0.119	0.050	0.100		0.087	0.075	0.066
(9) OL	H	0.287	0.303	0.479		0.125	0.093	0.094
(11) Spec Prop	I	0.151	0.231	0.244		0.168	0.050	0.067
(12) Auto Phys Dam	J	0.085	0.050	0.191		0.094	0.065	0.050
(10) Fidelity & Surety	K	0.246	0.229	0.821		0.073	0.160	0.050
(13) Other	L	0.133	0.115	0.268		0.121	0.119	0.153
(15) International*	M	0.160	N/A	0.155		0.333	N/A	0.270
(16) Reins Property & Financial	N&P	0.159	0.424	0.150		0.480	0.823	0.536
(17) Reinsurance Liability	O	0.482	0.975	0.554		0.446	0.601	0.424
(18) Products Liability	R	0.382	1.030	0.899		0.215	0.272	0.110
(14) Fin & Mort*	S	0.111	N/A	0.111		0.585	N/A	0.585
(19) Warranty**	T	0.246	0.229	0.821		0.073	0.160	0.050
Average		0.201	0.254	0.255		0.155	0.135	0.116

* Not analyzed. Factors judgmentally set. Refer to text.

** Set equal to Fidelity & Surety due to limited data.

Charges are shown after IIO and are subject to the 5% minimum charge.

Average is weighted average using 2008 industry data. For the purpose of averaging, N/As in columns (4) and (5) were replaced by the column (3) value; in columns (7) and (8) by column (6).

Premium RBC charges in this and all other exhibits based on industry average expense ratio of 27.5%.

Note: In this and subsequent exhibits the "2010 Actual" factors reflect the cap on changes in the factors selected by the NAIC to be 5% in 2010. Factors labeled as "indicated" reflect no such caps.

We note that the current filtering was intended to avoid distorting effects due to new companies and run-off companies; we believe the distortions, if any, might not be as large as feared and could be eliminated by other means.

We also note that the current filtering was intended to generate a database of companies that all have the same number of loss ratio observations (ten) and the same number of reserve run-off ratio observations (nine). With alternative filtering that eliminates data points rather than entire

companies, companies that remain will have different numbers of years represented in the RBC database. This may be a concern if the distribution of the maturities of the RBC data has a significant impact on the value of the calibrated underwriting risk charge. We did not investigate the impact of data maturity in the current work.

As might be expected, the effect of the alternative filtering is significant for lines in which the volume of data used increased the most. For reserve risk these are Special Property, Auto Physical Damage, Fidelity & Surety, Other, International and Reinsurance Property and Liability—lines where 30% or less of industry reserves are included in the Current Calibration Method. For premium risk, lines with large increases in the volume of data used are Other, International, and Reinsurance Property and Liability—lines where less than 70% of data is used in the Current Calibration Method.

However, there are also changes in lines with smaller—and opposite—differences in total volume used. For example, in Private Passenger Automotive the reserve charge decreased from 0.106 to 0.050 (the smallest charge allowed) with an increase from 85% to 90% in the total volume of reserve data used. The corresponding premium charge decreased from 0.138 to 0.118 (a nearly 20% decrease), but with a decrease from 95.6% to 90% in the total volume of premium data used.

These changes show that the filtering method has a significant impact on the risk charge.

3.1.1 Pools

We also considered the treatment of pooling in the current filtering method. In the Current Calibration Method, pro rata pool participants each record the same values for reserve run-off ratios and loss ratios. This results in duplicate values being counted multiple times, which overstates the impact of a pool on the calibration of the reserve and premium charges. In other cases, this could result in the elimination of an entire pool if participation percentages drop all individual members below the $500,000 minimum premium threshold.[3] An alternative mechanism where each pool, rather than each pool member, is viewed as a single entity would more appropriately reflect the distribution of observed, historical experience. We did not test the effect of aggregating pool representation in our current work.

[3] The risk of potentially excluding all companies in a pool might be more significant with the alternative filtering discussed above than with the current filtering for those lines of business for which the size threshold is larger in the alternative filtering (see Appendix A) than the current threshold ($½ million).

3.2 Risk Charge Measurement

3.2.1 Observed data upon which charges are based

The selected risk charges in the Current Calibration Method are based on the empirical 87.5th percentiles of the filtered data.[4] For the premium charges, the data are loss ratios while for the reserve charges the data are reserve run-off ratios.

Ratio-based data tends to be highly volatile—the smaller the denominator, the greater the expected volatility. In the case of reserve run-off ratios the denominator is booked reserves—thus, the smaller the booked reserve, the greater the expected volatility. The greater volatility of reserve run-off ratios for companies with smaller booked reserves is evident in the graphs of 12/31/2008 RBC reserve run-off ratio data by line of business (see Appendix B). However, the fundamental nature of ratio volatility as a function of the denominator of the underlying is data is not captured in the current RBC formula. The current formula applies the same factor to every company's carried reserve regardless of reserve size, using a factor derived from all companies in the industry. As a result, the dollar amount of capital resulting from the current RBC formula can be expected to understate the indicated dollar charge for companies with smaller booked reserves and overstate the dollar charge for companies with larger booked reserves.

We did not calculate the volatility of 12/31/2008 RBC loss ratio data as a function of earned premium in this short-term project, but we would expect to observe greater loss ratio variability for companies with smaller earned premiums than for companies with greater earned premiums. Subject to verification, the premium component of the RBC underwriting risk calculation is expected to understate the dollar volatility charge for companies with smaller earned premium and overstate the dollar volatility charge for companies with higher earned premiums.

3.2.2 Statistic upon which charges are based

As mentioned above, the selected risk charge in the Current Calibration Method is based on the empirical 87.5th percentile of the filtered data.

High empirical percentiles tend to be highly volatile and can be sensitive to the volatility of the underlying data as well as the number of observations. The volatility of the data underlying the Current Calibration Method of the current RBC formula was addressed in the section above. We next address the number of observations.

We believe that the observed changes in indicated 87.5th percentiles from one RBC calibration cycle to the next was the motivation for instituting caps on changes in the factors (see Section 2.1). For the lines with few observations, the 87.5th percentile of reserve run-off ratios can be especially

[4] This data includes judgmental selections for some lines along with the above-mentioned caveats on investment income offsets and possible caps on changes in factors.

volatile over time. The number of observations of filtered reserve run-off ratios varies by line of business—with at most approximately 4,000 observations and as few as 20 observations.[5] In Appendix C we show 90% confidence intervals for the "true 87.5th percentile" given the filtered sample of statement year 2008 observations. For almost all lines of business the width of the interval is greater than ±5%, the current cap.. For some lines the width is greater than ±35%, the cap originally recommended by the American Academy of Actuaries.[6] The widths of these confidence intervals leads us to conclude that it is should not be surprising for many lines of business to experience significant changes in RBC factors from one calibration cycle to the next.

It is likely that increasing the number of years of data would reduce the volatility. In Schedule P there are only 9 reserve run-off ratio observations per company; with 20 years of data there would be 19 observations. Also, with more years of data, the effect of the underwriting cycle would more fully be reflected in the data. Increasing the number of years of data could be accomplished by supplementing the current Schedule P with data from older Schedule Ps, with data from special calls, or both. However, even doubling the volume of data may be ineffective in stabilizing the changes in the factors for some lines. We did not test the stabilizing effectiveness of using additional data in this short-term project.

3.2.3 Curve Fitting

Regardless of the number of years of data used, curve fitting could provide an alternative measure of the risk charge compared to relying solely on empirical statistics. We did not investigate the effectiveness of curve fitting in stabilizing the volatility of changes in RBC factors in this short-term project, but we did investigate its impact on specific indicated values. In Exhibits 3 and 4, we demonstrate the effect of curve fitting for factor selection for premium and reserve risk factors, respectively.

The factors in the columns labeled "Percentile Function" (5) are the empirical 87.5th percentile values of the loss ratio and reserve run-off ratio data but using more observations than the Current Calibration Method via the alternative filtering approach discussed above. The factors in the Normal and Lognormal Distribution columns are the 87.5th percentiles from the respective theoretical distributions fit to the line of business loss ratio and reserve run-off ratio data points under the alternative filtering using the method of moments technique.

Assuming no change in the security level (the 87.5th percentile) the industry-wide effects of the alternative filtering and curve fitting for premium and reserve risk are shown in the "Average" rows of Exhibits 3 and 4, respectively.

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[5] Exhibit C-1 in Appendix C shows the number of observations by line of business based on a database that is approximately equivalent to the spreadsheet of data underlying the current calibration calculation.

[6] *An Update to P/C Risk-Based Capital Underwriting Factors: September 2007 Report to the National Association of Insurance Commissioners P/C Risk-Based Capital Working Group*, American Academy of Actuaries' P/C Risk-Based Capital Committee, September 2007, p. 3.

For the premium risk charge (Exhibit 3), column (4) shows the indicated factors under the Current Calibration Method if there were no limits on movements in factors; limiting movements in factors results in an increase in the actual factor used for some lines and a decrease for others. The alternative filter with the current empirical percentile function shown in column (5) indicates a reduction in average charge to 0.116. Indicated (overall) charges based on fitting normal and lognormal curves to the data would be 0.155 and 0.147 (columns (6) and (7), respectively), compared to the current charge of 0.155. Variations are more significant by individual line of business.

Exhibit 3: Premium Risk Charges based on Curve Fitting

			Current Filter	Alternative Filter		
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Line	Line Letter	2010 Current	Indicated Current Methodology	Percentile Function	Normal Distribution	Lognormal Distribution
(1) H/F	A	0.169	0.152	0.149	0.232	0.228
(2) PPA	B	0.171	0.138	0.118	0.125	0.126
(3) CA	C	0.154	0.099	0.106	0.153	0.151
(4) WC	D	0.142	0.125	0.111	0.131	0.131
(5) CMP	E	0.100	0.069	0.055	0.096	0.093
(6) MM Occurrence	F1	0.672	0.572	0.541	0.511	0.478
(7) MM CM	F2	0.178	0.392	0.352	0.389	0.369
(8) SL	G	0.087	0.075	0.066	0.097	0.088
(9) OL	H	0.125	0.093	0.094	0.154	0.141
(11) Spec Prop	I	0.168	0.050	0.067	0.140	0.123
(12) Auto Phys Dam	J	0.094	0.065	0.050	0.062	0.063
(10) Fidelity & Surety	K	0.073	0.160	0.050	0.165	0.056
(13) Other	L	0.121	0.119	0.153	0.317	0.281
(15) International	M	0.333	0.333	0.270	0.425	0.378
(16) Reins Property & Financial	N&P	0.480	0.823	0.536	0.576	0.493
(17) Reins Liability	O	0.446	0.601	0.424	0.462	0.426
(18) Products Liability	R	0.215	0.272	0.110	0.233	0.192
(14) Fin & Mort*	S	0.585	0.585	0.585	0.585	0.585
(19) Warranty**	T	0.073	0.160	0.050	0.165	0.056
Average		0.155	0.135	0.116	0.155	0.147

See Notes to Exhibit 2.

Exhibit 4 is similar to Exhibit 3 but addresses the reserve risk charge. The alternative filter with the current empirical percentile function indicates an average charge of 0.255 (column (5)), similar to the indicated charge if movements in factors by line were not limited. If curve fitting were used the indicated overall charges would be higher: 0.318 and 0.305 (columns (6) and (7)), for normal and lognormal curves, respectively. Variations are more significant by individual line of business.

Exhibit 4: Reserve Risk Charges based on Curve Fitting

			Current Filter	Alternative Filter		
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Line	Line Letter	2010 Current	Indicated Current Methodology	Percentile Function	Normal Distribution	Lognormal Distribution
(1) H/F	A	0.127	0.127	0.080	0.143	0.143
(2) PPA	B	0.106	0.050	0.050	0.142	0.144
(3) CA	C	0.121	0.121	0.120	0.243	0.242
(4) WC	D	0.099	0.111	0.092	0.100	0.101
(5) CMP	E	0.283	0.283	0.214	0.323	0.316
(6) MM Occurrence	F1	0.238	0.053	0.213	0.290	0.278
(7) MM CM	F2	0.153	0.156	0.118	0.229	0.217
(8) SL	G	0.119	0.050	0.100	0.222	0.214
(9) OL	H	0.287	0.303	0.479	0.513	0.493
(11) Spec Prop	I	0.151	0.231	0.244	0.364	0.341
(12) Auto Phys Dam	J	0.085	0.050	0.191	0.402	0.313
(10) Fidelity & Surety	K	0.246	0.229	0.821	1.131	0.952
(13) Other	L	0.133	0.115	0.268	0.588	0.544
(15) International	M	0.160	0.160	0.155	0.306	0.284
(16) Reins Property & Financial	N&P	0.159	0.424	0.150	0.343	0.319
(17) Reinsurance Liability	O	0.482	0.975	0.554	0.595	0.576
(18) Products Liability	R	0.382	1.030	0.899	0.973	0.902
(14) Fin & Mort*	S	0.111	0.111	0.111	0.111	0.111
(19) Warranty**	T	0.246	0.229	0.821	1.131	0.952
Average		0.201	0.254	0.255	0.318	0.305

See notes to Exhibit 2.

3.3 Investment Income Offset (IIO)

We investigated the sensitivity of the RBC calculation to the assumption of a 5% risk-free rate. In Exhibits 5 and 6, we show the indicated R4 (reserve risk) and R5 (premium risk) factors under alternative discount rate assumptions, prior to application of the 5% minimum charge. For illustration, we base the values on the averages of U.S. Treasuries as of 12/31/2008, 12/31/2009,

and 12/31/2010 for three-, five-, and ten-year securities minus a "risk margin" of 0.5%, or 50 basis points. Fifty basis points is not a recommendation but illustrates the application of a risk margin. We note that when the original 5% discount rate was selected in the early 1990s, actual yields on five- and ten-year treasury securities were about 100 basis points higher than the 5% selection.[7] Some working party members suggest that the discount rate could be *higher* than the risk-free rate because a going-concern insurance enterprise is expected to earn more than the risk-free rate.

To maintain a constant safety level in the RBC formula, the discount rate should be updated periodically rather than using a constant value of 5%. Possible alternatives include selecting a rate based on recent short term rates in yield (such as government instruments) for premium, and embedded asset returns for reserves. The rate could vary by line of business, and could be coordinated with the R1 and R2 calibrations (beyond the scope of this working party's charge.)

We note that according to the Center on Federal Financial Institutions in its 2004 discussion of discount rates for the Pension Benefit Guarantee Corporation, "Current law provides for a discount rate based on the average yield of long-term corporate bonds of high credit quality."[8] Thus, the U.S. Treasury recommended both using a discount rate that is higher than the risk-free rate and varying that rate according to the duration of the liability. The issue of a floating rate, however, is also not without controversy (see page 6 of the footnoted report).

As shown in Exhibits 5 and 6, use of a 10-year treasury rate minus 0.5% implies increases in the underwriting factors averaging 32.7% for reserve risk and 30.4% for premium risk – column (7) in the Average row for Exhibits 5 and 6, respectively. Use of the five-year treasury rate minus 0.5% implies increases in the underwriting factors averaging 48.8% for reserve risk and 45.2% for premium risk – column (6) in the Average row.

Payout Pattern

The "IRS Procedure" used in the current formula to determine the payout pattern can introduce unintended payment pattern distortions depending on the line of business. This procedure bases payment patterns on paid-to-date dollars by line from Best's Aggregates and Averages. For Workers Compensation and Reinsurance Liability the payment pattern was extended to 15 years in contrast to the 10 years used by the IRS Procedure. An alternative actuarial procedure could be investigated, but we did not do so in this project.

[7] At the beginning of 1993 five-year treasury notes were yielding 5.90%, ten-year notes 6.60%. See http://www.treasury.gov/resource-center/data-chart-center/interest-rates/Pages/TextView.aspx?data=yieldYear&year=1993.

[8] Elliott, Douglas J., "PBGC: A Yield Curve Primer", Sep. 10, 2004, http://www.coffi.org/pubs/Primer%20on%20Yield%20Curve%205.pdf.

Exhibit 5: Indicated R4 (Reserve) Factors Under Selected Discount Rates

		Discount rate *				Percentage difference		
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
Line of Business	Line Letter	Current 5.00%	3 year 0.74%	5 year 1.58%	10 year 2.63%	0.74%	1.58%	2.63%
(1) H/F	A	0.127	0.189	0.176	0.160	49.4%	39.0%	26.5%
(2) PPA	B	0.043		0.097	0.079		124.1%	83.9%
(3) CA	C	0.121		0.193	0.169		59.8%	40.3%
(4) WC	D	0.111		0.257	0.208		132.3%	88.2%
(5) CMP	E	0.283		0.402	0.363		41.8%	28.1%
(6) MM Occ	F1	0.053		0.160	0.125		203.4%	136.6%
(7) MM CM	F2	0.156		0.256	0.224		64.5%	43.6%
(8) SL	G	0.036		0.120	0.092		232.5%	156.7%
(9) OL	H	0.303		0.449	0.400		48.3%	32.3%
(11) Spec Prop	I	0.231	0.267	0.260	0.250	15.9%	12.6%	8.6%
(12) Auto Phy Dam	J	-0.024	-0.004	-0.008	-0.013	-84.6%	-67.2%	-45.9%
(10) Fidelity & Surety	K	0.229	0.295	0.281	0.264	28.9%	22.9%	15.6%
(13) Other	L	0.115	0.147	0.141	0.133	28.1%	22.5%	15.6%
(15) International	M	0.160		0.268	0.232		67.7%	45.3%
(16) Reins Property & Financial	N&P	0.424		0.514	0.485		21.4%	14.5%
(17) Reins Liability	O	0.975		1.222	1.141		25.4%	17.0%
(18) Products Liability	R	1.030		1.279	1.197		24.2%	16.2%
(14) Fin & Mort	S	0.065		0.122	0.104		87.7%	60.0%
(19) Warranty		0.229		0.281	0.264		22.9%	15.6%
Average		0.252		0.376	0.335		48.8%	32.7%

Factors are based on three-year treasury rates not shown for the longer tailed lines of business.
Average is 2008-reserve-weighted average.
Factors are indicated prior to application of the 5% minimum charge, as that would distort the measurement of the stand-alone effect of the change in interest rate assumption.

Exhibit 6: Indicated R5 (Premium) Factors Under Selected Discount Rates

Line of Business	Line Letter	Discount rate *				Percentage difference		
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
		Current	3 year	5 year	10 year			
		5.00%	0.74%	1.58%	2.63%	0.74%	1.58%	2.63%
(1) H/F	A	0.152	0.187	0.180	0.171	23.5%	18.6%	12.7%
(2) PPA	B	0.138		0.184	0.170		33.7%	22.9%
(3) CA	C	0.099		0.166	0.144		67.4%	45.5%
(4) WC	D	0.125		0.229	0.194		83.6%	55.6%
(5) CMP	E	0.069		0.129	0.109		87.0%	58.3%
(6) MM Occ	F1	0.572		0.825	0.741		44.3%	29.5%
(7) MM CM	F2	0.392		0.544	0.494		38.8%	26.0%
(8) SL	G	0.075		0.134	0.115		79.0%	53.1%
(9) OL	H	0.093		0.212	0.172		126.8%	84.3%
(11) Spec Prop	I	0.021	0.055	0.048	0.039	161.6%	128.2%	87.4%
(12) Auto Phy Dam	J	0.065	0.085	0.081	0.076	30.6%	24.5%	16.9%
(10) Fidelity & Surety	K	0.160	0.239	0.223	0.203	49.4%	39.1%	26.7%
(13) Other	L	0.119	0.159	0.151	0.141	33.6%	26.8%	18.4%
(15) International	M	0.333		0.405	0.381		21.7%	14.5%
(16) Reins Property & Financial	N&P	0.823		0.945	0.905		14.8%	10.0%
(17) Reins Liability	O	0.601		0.842	0.760		40.3%	26.6%
(18) Products Liability	R	0.272		0.458	0.395		68.4%	45.3%
(14) Fin & Mort	S	0.513		0.620	0.586		21.0%	14.3%
(19) Warranty		0.160		0.223	0.203		39.1%	26.7%
Average		0.133		0.193	0.173		45.2%	30.4%

Factors are based on three-year treasury rates not shown for the longer tailed lines of business.
Average is 2008-Net Written Premium-weighted average.
Factors are indicated prior to application of the 5% minimum charge, as that would distort the measurement of the stand-alone effect of the change in interest rate assumption.

3.4 Observations Regarding Solvency II[9]

In the course of our work, we considered certain features of the Solvency II Standard Formula[10] as they compare to RBC.

3.4.1 Quantitative Assessment of Required Capital

Solvency II prescribes a formulaic calculation of the required solvency capital, which all companies may adopt. This is called the Standard Formula.

Alternatively, a company can develop its own model (internal model) or calibrate the parameters of the standard formula so that they are more appropriate for that company (partial internal model). The use of internal models or partial internal models is subject to regulatory approval.

Our work focused on the Standard Formula.

3.4.2 Own-Risk Solvency Assessment (ORSA)

In addition to the required solvency capital assessment, Solvency II requires a self-assessment of the economic capital required to run the business (own-risk solvency assessment or ORSA). This includes a qualitative assessment of risk, which examines an entity's exposure to various risk factors and discusses the risk management processes in place at the company.

Our work focused on the Standard Formula, and not on ORSA.

3.4.3 Calibration of the Standard formula

In the case of Solvency II, calibration of parameters uses data provided voluntarily, as a full set of industry data is not available as it is in the U.S.

The promulgators of Solvency II examined several statistical approaches to calibrate the standard parameters, and these were augmented by expert judgment.

3.4.4 Alternate Valuation of Technical Provisions (Loss Reserves)

Under Solvency II, loss reserves are evaluated on a discounted basis. An explicit margin, termed a risk margin, is incorporated into the valuation.

RBC is part of U.S. statutory financial reporting, so loss reserves are normally[11] presented on the balance sheet on an undiscounted basis. Within the RBC system, however, there is credit for

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[9] This section discusses only certain features of Solvency II as those relate to RBC. The discussion is not a complete analysis of Solvency II and is not a complete comparison of RBC to Solvency II.

[10] https://eiopa.europa.eu/fileadmin/tx_dam/files/consultations/QIS/QIS5/Spreadsheets&IT-Tools/10.06-update/QIS5-V6-20101006.xls

[11] Certain exceptions exist for workers compensation line of business and other cases with permission by state regulators.

investment income in the risk charge (through the investment income offsets). Therefore, while expressed differently, both RBC and Solvency II measure capital adequacy on a discounted basis, but RBC does not include an explicit risk margin.

3.4.5 Risk Horizon: One-Year versus Full Run-off

In the Standard Formula, Solvency II calibrates the reserve risk charge to the risk so that the reserve, including risk margin, one year after the valuation date will be higher than was predicted at the valuation date. This is referred to as a one-year time horizon.

We understand that RBC intends to calibrate the reserve risk charge to the risk such that ultimate claim payouts, when all claims are settled, will be higher than predicted at the valuation date. This is referred to as a run-off time horizon.

In Exhibit 7, we present the results of applying the calibration procedures discussed in section 3.2 on a one-year basis and a run-off basis. Columns (3) and (4) show the 2010 RBC charges and the charges indicated by the Current Calibration Method, the same as the values in Exhibit 2. The averages for all lines of business combined are .201 and .254, respectively.

Column (5) shows the results of applying a one-year, run-off time horizon rather than a run-off time horizon using the 87.5th percentile approach and the current filter. The average for all lines of business is .071, compared to the .254 in Column (4) which is same approach but with a run-off time horizon. Columns (6) and (7) show the one-year and run-off time horizons using the alternative filter and 87.5th percentile approaches. These values, averaged for all lines of business are .255 and .058. The effect of using the one-year time horizon, at either the 87.5th or 95th percentile safety levels, is a reduction in the overall reserve risk charge and in the risk charge for long-tailed lines compared to short-tailed lines.

Columns (8) – (10) show the one-year time horizon charge with a higher safety margin, 95% rather than 87.5%, and use three approaches to measure the charge—the empirical approach, the fitted normal distribution, and the fitted lognormal distortion—which are comparable to the alternative approaches shown in Exhibit 3. A higher safety level for the RBC result might be considered an offset to the fact that the one-year time horizon, when applied in Solvency II, is applied to an accounting system that includes a risk margin in reserves while RBC does not. We have not considered whether the 95th percentile is an appropriate safety level for the risk margin.

The effect of the using the one-year time horizon—even at 95th percentile safety levels—is a reduction in the overall reserve risk charge and in the risk charge for long-tailed lines compared to short-tailed lines. This is shown in comparing columns (4) and (7) (at the 87.5th percentile) or columns (8) and (10) (at the 95th percentile).

Exhibit 7: Alternative Reserve Charges Under Current Multi-Year and One-Year Horizons

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Filter		2010 Current	Indicated	Current	Alt	Alt	Alt	Alt	Alt
Safety Level				87.5	87.5	87.5	95	95	95
Empirical/Curve Fit				Empirical	Empirical	Empirical	Empirical	Normal	Log Normal
Time Horizon				One Yr	Runoff	One Yr	One Yr	One Yr	One Yr
(1) H/F	A	0.127	0.127	0.050	0.080	0.050	0.158	0.201	0.228
(2) PPA	B	0.106	0.050	0.050	0.050	0.050	0.050	0.089	0.098
(3) CA	C	0.121	0.121	0.050	0.120	0.050	0.116	0.135	0.150
(4) WC	D	0.099	0.111	0.050	0.092	0.050	0.050	0.050	0.050
(5) CMP	E	0.283	0.283	0.050	0.214	0.050	0.096	0.142	0.162
(6) MM Occurrence	F1	0.238	0.053	0.050	0.213	0.050	0.214	0.225	0.260
(7) MM CM	F2	0.153	0.156	0.050	0.118	0.050	0.142	0.157	0.182
(8) SL	G	0.119	0.050	0.050	0.100	0.050	0.166	0.266	0.307
(9) OL	H	0.287	0.303	0.050	0.479	0.050	0.078	0.158	0.183
(11) Spec Prop	I	0.151	0.231	0.164	0.244	0.147	0.351	0.451	0.523
(12) Auto Phys Dam	J	0.085	0.050	0.059	0.191	0.075	0.278	0.446	0.552
(10) Fidelity & Surety	K	0.246	0.229	0.242	0.821	0.358	0.683	1.023	1.172
(13) Other	L	0.133	0.115	0.157	0.268	0.157	0.291	0.415	0.471
(15) International	M	0.160	0.160	0.053	0.155	0.130	0.301	0.377	0.436
(16) Reins Property & Financial	N&P	0.159	0.424	0.135	0.150	0.086	0.298	0.290	0.337
(17) Reins Liability	O	0.482	0.975	0.191	0.554	0.050	0.180	0.269	0.310
(18) Products Liability	R	0.382	1.030	0.196	0.899	0.103	0.424	0.396	0.456
(14) Fin & Mort*	S	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111
(19) Warranty	T	0.246	0.229	0.242	0.821	0.358	0.683	1.023	1.172
Average		0.201	0.254	0.071	0.255	0.058	0.116	0.161	0.183

See notes to Exhibit 2.

3.5 Pro Forma Ratios: Premium to Company Action Level (CAL) Underwriting RBC Ratios

In this section we show the implications of the discussions in prior sections in terms of Pro Forma Premium to CAL Underwriting RBC Ratios. To calculate these ratios, premium is divided by a consolidated (using the covariance rules) R4 and R5 underwriting charge at the Company Action Level (CAL). These ratios are loosely equivalent to a "premium to minimum required surplus ratio." We note that although these ratios are calculated using the minimum risk-based capital that triggers a company action requirement to the regulator—100% of RBC or 200% of the Authorized Control

Level (ACL)—the industry and most companies operate at surplus levels well in excess of these minimum thresholds.

The Pro Forma Premium to CAL Underwriting RBC Ratio is the reciprocal of the "pro forma underwriting RBC factor" for each line (see Appendix E for proforma underwriting RBC factors).

3.5.1 Ratios Based on the Current Charges

Exhibit 8 shows the separate premium and reserve charges, the pro forma underwriting RBC factors, and the corresponding Pro Forma Premium to Company Action Level (CAL) Underwriting RBC Ratios.

The pro forma underwriting RBC factor is 0.305 for all lines combined, as shown in the Average/Total row of column (9). The current RBC structure and factors indicate that the dollar amount of surplus that the industry must carry for underwriting risk to reach the Company Action Level (defined in Appendix D) is a factor of 0.305 times total premium. This corresponds to a premium to required surplus ratio of 328%, or $3.28 of premium for each dollar of surplus. At the Authorized Control Level, the RBC ratio is halved or 153% and the premium to surplus ratio is doubled or 656%. Among the lines of business that constitute more than 5% of premium or reserves, the charges are lowest for the PPA and Special Property lines and highest for Reinsurance Liability and Other liability (Other Liability is much lower than Reinsurance Liability).

Exhibit 8: Premium Charge versus Reserve Charge – Consolidated RBC Charge

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Line	Line Letter	Current Reserving RBC Charge	Current Premium RBC Charge	Loss & LAE Reserves 2008	Net Written Premium 2008	Reserve Charge	Prem Charge	Pro forma RBC Factor	Prem/ CAL Ratio
(1) H/F	A	0.127	0.169	$ 22.3	$ 59.0	$ 2.8	10.0	0.176	570%
(2) PPA	B	0.106	0.171	87.3	94.5	9.3	16.2	0.197	507%
(3) CA	C	0.121	0.154	26.5	17.8	3.2	2.7	0.237	423%
(4) WC	D	0.099	0.142	130.8	39.5	12.9	5.6	0.357	280%
(5) CMP	E	0.283	0.100	38.7	30.2	11.0	3.0	0.377	265%
(6) MM Occ	F1	0.238	0.672	10.9	2.0	2.6	1.4	1.438	70%
(7) MM CM	F2	0.153	0.178	18.4	7.3	2.8	1.3	0.425	235%
(8) SL	G	0.119	0.087	7.5	6.2	0.9	0.5	0.169	592%
(9) OL	H	0.287	0.125	126.0	40.2	36.2	5.0	0.909	110%
(11) Spec Prop	I	0.151	0.168	16.4	33.5	2.5	5.6	0.184	545%
(12) Auto Phys Dam	J	0.085	0.094	5.7	70.1	0.5	6.6	0.094	1066%
(10) Fidelity&Surety	K	0.246	0.073	4.9	6.1	1.2	0.4	0.208	480%
(13) Other	L	0.133	0.121	0.0	3.6	0.0	0.4	0.121	829%
(15) International	M	0.160	0.333	0.5	0.3	0.1	0.1	0.424	236%
(16) Reins Property & Financial	N&P	0.159	0.480	7.9	6.7	1.2	3.2	0.515	194%
(17) Reins Liability	O	0.482	0.446	40.1	7.2	19.4	3.2	2.728	37%
(18) Products Liability	R	0.382	0.215	16.6	2.8	6.4	0.6	2.297	44%
(14) Fin & Mort*	S	0.111	0.585	0.1	0.6	0.0	0.3	0.585	171%
(19) Warranty**	T	0.246	0.073	0.2	2.1	0.1	0.2	0.077	1291%
Average / Total		0.201	0.155	$560.8	$429.5	$112.9	66.4	0.305	328%

See notes to Exhibit 2.
Columns (5)-(7): billions of dollars
Column (9) = Square root (Column (7) squared plus Column (8) squared)/Column (6)
Column (10) = 1/Column (9)

3.5.2 Ratios Based on Alternative Charges

We observe in Exhibit 8 that the current RBC formula produces smaller charges for premium relative to reserves for many lines of business. This affects all companies, but, in particular, new companies with no reserves at start-up will have a lower RBC requirement than comparable mature companies under the current formula. This premium/reserve risk charge relativity changes significantly under alternative approaches.

In Exhibit 9, we compare the current Pro Forma Premium to CAL Underwriting RBC Ratios from

Exhibit 8 column (10) with those implied by RBC charges under alternative approaches discussed earlier in this report. The pro forma premium to RBC underwriting risk ratios are reasonable statistics to consider, by line and for the industry overall, when investigating alternatives to the current RBC formula.

An explanation of the contents of Exhibit 9 follows, phrased here in terms of the dollar amount of premium supported by a dollar of surplus and illustrated based on the average in the Average/Total row.

Run-off Basis – Columns (3) - (7)

Col (3) Overall, $3.28 of premium can be supported per $1 of surplus (same values as shown in Exhibit 8) based on the current RBC parameters.

Col (4) The *indicated* factors using current filtering and the empirical 87.5th percentile risk charge, before capping parameter swings and without a change in the IIO discount rate, suggest that $2.79 of premium can be supported per $1 of surplus overall.

Col (5) Indicated with alternative filter and 87.5th percentile: $2.84 can be supported.

Col (6) Indicated with alternative filter and curve fitting using a normal distribution: $2.26.

Col (7) Column (6) but using lognormal distribution: $2.36.

One-Year Basis – Columns (8) - (11)

Col (8) Under the Alternative Filter and the one-year time horizon approach described above, the empirical 87.5th percentile indicates that $7.23 of premium can be supported per $1 of surplus overall.

Col (9) Column (8) at the 95 percentile: $3.37.

Col (10) Column (9) but using a normal distribution rather than empirical percentile: $3.05.

Col (11) Column (10), using the lognormal rather than normal distribution: $2.65.

Exhibit 9 is calculated as the reciprocal of Exhibit E (Appendix E) in the same way that in Exhibit 8 column (10) is the reciprocal of column (9).

Exhibit 9: Premium to CAL Underwriting RBC Ratios

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Filter				**Alt**	**Alt**	**Alt**	**Alt**	**Alt**	**Alt**	**Alt**
Safety Level				**87.5**	**87.5**	**87.5**	**87.5**	**95**	**95**	**95**
Empirical/Curve Fit		**2010 Cur**	**Indicated**	**Emp**	**Norm**	**Log Norm**	**Emp**	**Emp**	**Norm**	**Log Norm**
Risk Horizon				**Runoff**	**Runoff**	**Runoff**	**Rsrv: One Yr, Prem: Runoff**	**Rsrv: One Yr, Prem: Runoff**	**Rsrv: One Yr, Prem: Runoff**	**Rsrv: One Yr, Prem: Runoff**
(1) H/F	A	570%	629%	658%	420%	427%	666%	338%	281%	246%
(2) PPA	B	507%	687%	791%	551%	547%	791%	544%	515%	481%
(3) CA	C	423%	488%	483%	255%	257%	771%	317%	312%	274%
(4) WC	D	280%	259%	308%	281%	279%	502%	347%	363%	330%
(5) CMP	E	265%	270%	357%	235%	240%	1188%	431%	374%	317%
(6) MM Occurrence	F1	70%	157%	79%	61%	64%	166%	71%	72%	62%
(7) MM CM	F2	235%	180%	217%	144%	152%	268%	145%	146%	127%
(8) SL	G	592%	1033%	720%	347%	362%	1111%	343%	259%	219%
(9) OL	H	110%	105%	66%	62%	64%	547%	256%	175%	150%
(11) Spec Prop	I	545%	809%	728%	441%	482%	1015%	300%	285%	236%
(12) Auto Phys Dam	J	1066%	1526%	1912%	1435%	1480%	1986%	1000%	800%	702%
(10) Fidelity & Surety	K	480%	413%	153%	109%	132%	346%	137%	112%	97%
(13) Other	L	829%	842%	654%	316%	356%	654%	305%	203%	172%
(15) International	M	236%	236%	270%	152%	167%	291%	97%	113%	98%
(16) Reins Property & Financial	N&P	194%	104%	177%	142%	161%	183%	89%	112%	97%
(17) Reins Liability	O	37%	18%	32%	30%	31%	197%	77%	61%	53%
(18) Products Liability	R	44%	16%	19%	17%	19%	160%	39%	42%	36%
(14) Fin & Mort*	S	171%	171%	171%	171%	171%	171%	171%	171%	171%
(19) Warranty	T	1291%	618%	1019%	496%	888%	1610%	202%	265%	225%
Average		328%	279%	284%	226%	235%	723%	337%	305%	265%

See notes to Exhibit 2.

Exhibit E shows further examples of the pro forma underwriting ratio under alternative safety margins and reserve time horizon combinations.

The premium/reserve risk relativity deserves further study, including consideration of alternatives to the current approach for new companies.

4. CONCLUSIONS AND AREAS OF FURTHER RESEARCH

The URWP found that the current formula is too restrictive to support the determination of risk-responsive capital amounts by company.

Our short-term work identified potential improvements to the Current Calibration Method that could be researched within the framework of the current RBC formula:

Data

1. Filtering strategies.
2. Additional or extended (number of years) data sources.
3. Improved treatment of data from pooled companies.
4. Analysis of the extent to which alternative filtering is affected by run-off and startup companies, and including procedures mitigating that affect, if any.

Analysis

5. Curve fitting procedures.
6. Change in interest discount for IIO.
7. Changes to the (IRS) method for calculating the payment pattern used to determine IIO.
8. Evaluation of better methods to reflect RBC for new companies showing little reserve risk, even though that is temporary.

In addition to the points noted above, our investigation into risk charge measurement procedures raised other questions that could be subjects of longer-term study.

9. Does serial correlation within each company's nine reserve development ratios impact the predictive ability and the swing in the 87.5th percentile-based charges?
10. Would percent of ultimate paid be a better indicator of future development potential than total carried reserves?
11. Should the reserve risk factor be based on exposure measures such as premium, other than, or in addition to, carried reserves?
12. As an enhancement to the alternative filtering illustrated above, could the RBC factors be calibrated from a weighted average of companies' AY development, particularly for companies with less than ten accident years of experience?
13. Should the RBC reserve charge be a function of accident year development rather than a function of total reserve development?
14. Reserve charges are not calibrated to run-off, but rather to a combination of multi-year time

horizons—nine years, eight years, and so forth. If the measurement objective is run-off, can the calibration be more closely aligned with that objective?

15. The current practice of capping data points (section 2.1) has some undesirable consequences: it limits the variability of the data underlying the empirical percentile calculations, potentially understating the line of business charges for the industry as a whole, and it affects the ability to apply curve-fitting. Is there a more robust way to handle outliers in the data?
16. We find that the NAIC de minimus test instructions are ambiguous (see PR017, Line 02).[12] Is there a way to clarify these instructions? This issue may be irrelevant under the alternative filtering discussed in this report where data points rather than entire companies are filtered out.

Additional questions raised by the URWP include:

17. RBC and the Underwriting Cycle: The underwriting cycle and RBC parameter estimates appear to be related, evidenced by apparent correlation in industry reserve development by line, prompting two questions:
    a. Could RBC parameter calibration be improved by explicitly accounting for the underwriting cycle?
    b. Do changes in the RBC parameters impact the underwriting cycle?
18. Are the discounts for direct (30%) and assumed (15%) loss sensitive business appropriate?
19. Risk Measures: Would the purpose of RBC be better served by a risk measure other than value at risk (VaR), e.g., Tail Value at Risk (TVaR) or Expected Policyholder Deficit (EPD)?[13] What should the theoretical basis for any particular security level (e.g., "worst case" or the 87.5 percentile)?
20. Has the formula been a reliable indicator of company trouble or insolvency?
21. Does the formula result in a reasonable total risk charge for the industry as compared to other industries (e.g., banking)?

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[12] The NAIC RBC instructions for 2010, pp. 21-22, contain the following two sentences:
(1) "If more than one year's net earned premium is less than 20 percent of the average net earned premium, a company is not eligible for an experience adjustment and Row 02 is set equal to Row 01." That means that nine out of 10 or 10 out of 10 years must have NEP greater than 20% of the average NEP for the company to be eligible for an experience adjustment.
(2) "If less than eight years' net earned premiums are greater than 20 percent of the average net earned premium, a company is not eligible for an experience adjustment and Row 02 is set equal to Row 01." That means that, additionally, if eight out of 10 years have NEP greater than 20% of the average NEP the company would be eligible for an experience adjustment.

[13] A research paper on the subject is under development by the CAS Risk-Based Capital Dependencies Working Party.

Acknowledgment

The authors acknowledge the help of CAS staff, especially David Core, Karen Sonnet, and Cheri Widowski.

Appendix A

Exhibit A-1: Alternative filtering – 90% of Industry Targeted

Figures in '000						
Line	Line Letter	% of Industry Reserves	Reserve Threshold		% of Industry Premium	Premium Threshold
(1) H/F	A	90.00%	9,434		90.00%	30,562
(2) PPA	B	90.10%	51,414		90.00%	60,000
(3) CA	C	90.00%	16,519		89.90%	11,942
(4) WC	D	90.10%	100,771		89.90%	34,257
(5) CMP	E	90.00%	21,830		90.00%	18,026
(6) MM Occurrence	F1	90.00%	37,497		90.00%	8,046
(7) MM CM	F2	90.00%	34,978		90.10%	14,060
(8) SL	G	90.00%	11,419		90.00%	12,655
(9) OL	H	90.10%	65,884		90.00%	22,183
(11) Spec Prop	I	90.10%	10,381		90.10%	12,778
(12) Auto Phys Damage	J	90.10%	13,315		90.10%	37,487
(10) Fidelity & Surety	K	90.00%	13,040		90.00%	7,932
(13) Other	L	90.00%	15,936		90.10%	26,473
(15) International	M	90.00%	4,950		90.00%	4,849
(16) Reins Property & Financial	N&P	90.00%	28,712		90.00%	23,964
(17) Reinsurance Liab	O	90.00%	130,409		90.00%	53,534
(18) Products Liability	R	90.10%	23,719		90.00%	4,202
(14) Fin & Mort*	S	***	***		***	***
(19) Warranty	T	***	***		***	***

*** Not enough data

Note: The uniform 90% rule is illustrative. In practice we recommend research to consider whether the targeted premium/reserve standard is appropriate for each line and to address concerns arising from the elimination of data points rather than companies.

Appendix B: Graphs of reserve run-off ratios vs. carried reserves

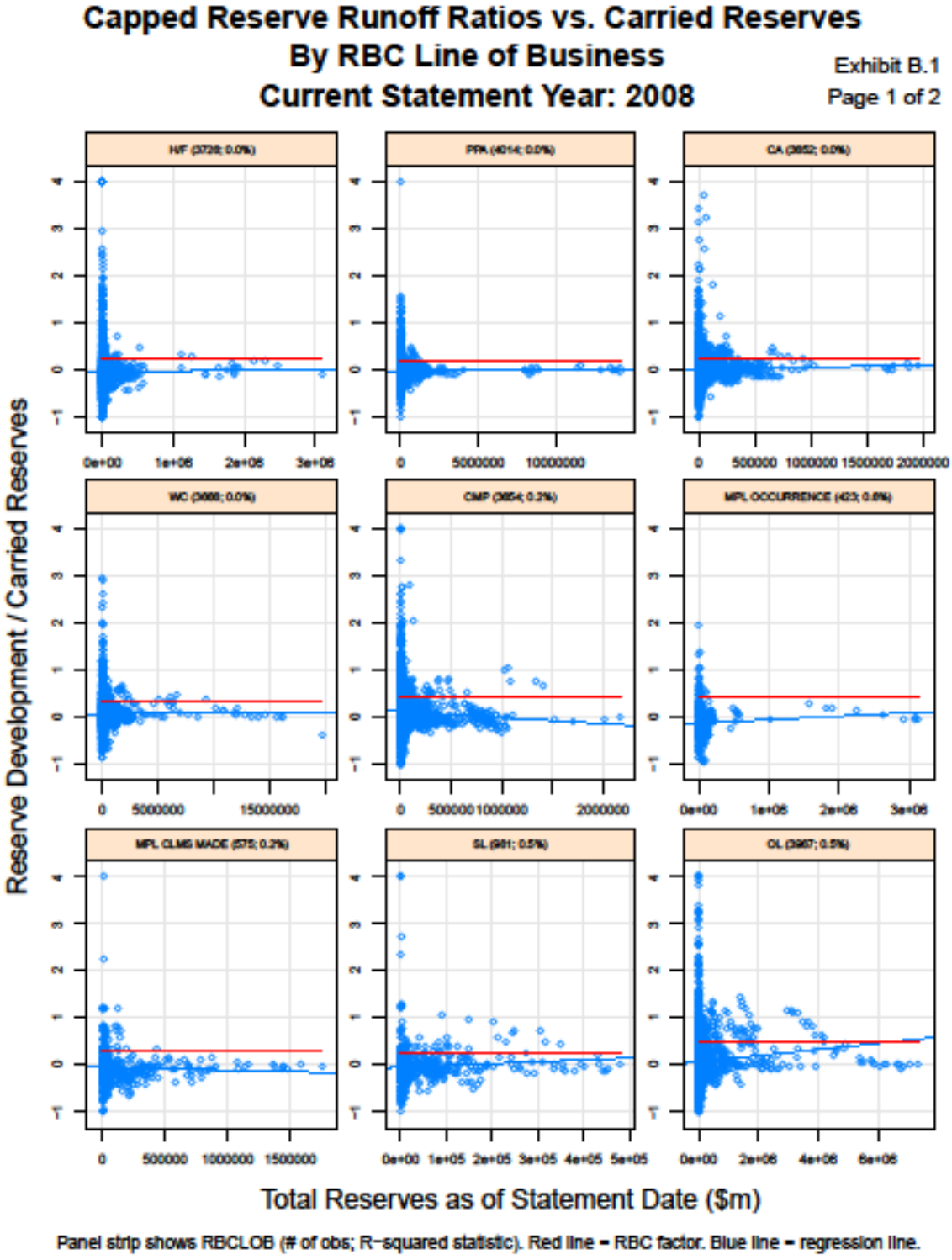
The RBC reserve charge is determined by a statistic (the 87.5th percentile) from the reserve run-off ratio (RRR) data discussed above.[14] In Exhibit B we display RRR data by RBC line of business on the y-axis and the carried reserves (the denominators of the RRRs) on the x-axis.

We also show a superimposed regression line. For most RBC lines of business (RBCLOBs), the regression line is horizontal and goes through the origin. These characteristics imply that industry carried reserves in that RBCLOB are unbiased, and that conclusion does not depend on the size of a company's booked reserves. Notable exceptions include APD, which is over-reserved on average (most of the observations are above the x-axis), and Reinsurance Liability and Products Liability, which appear under-reserved on average (most of the observations are below the x-axis).

With limited exceptions, reserve run-off ratio volatility appears to decrease as companies' carried reserves increase. This is not unexpected; the carried reserve amount forms the denominator of the RRR, implying that smaller carried reserves will lead to higher ratios. However, this result is contrary to what would be desirable in an RBC factor-based approach. Changes that could address this inconsistency include:

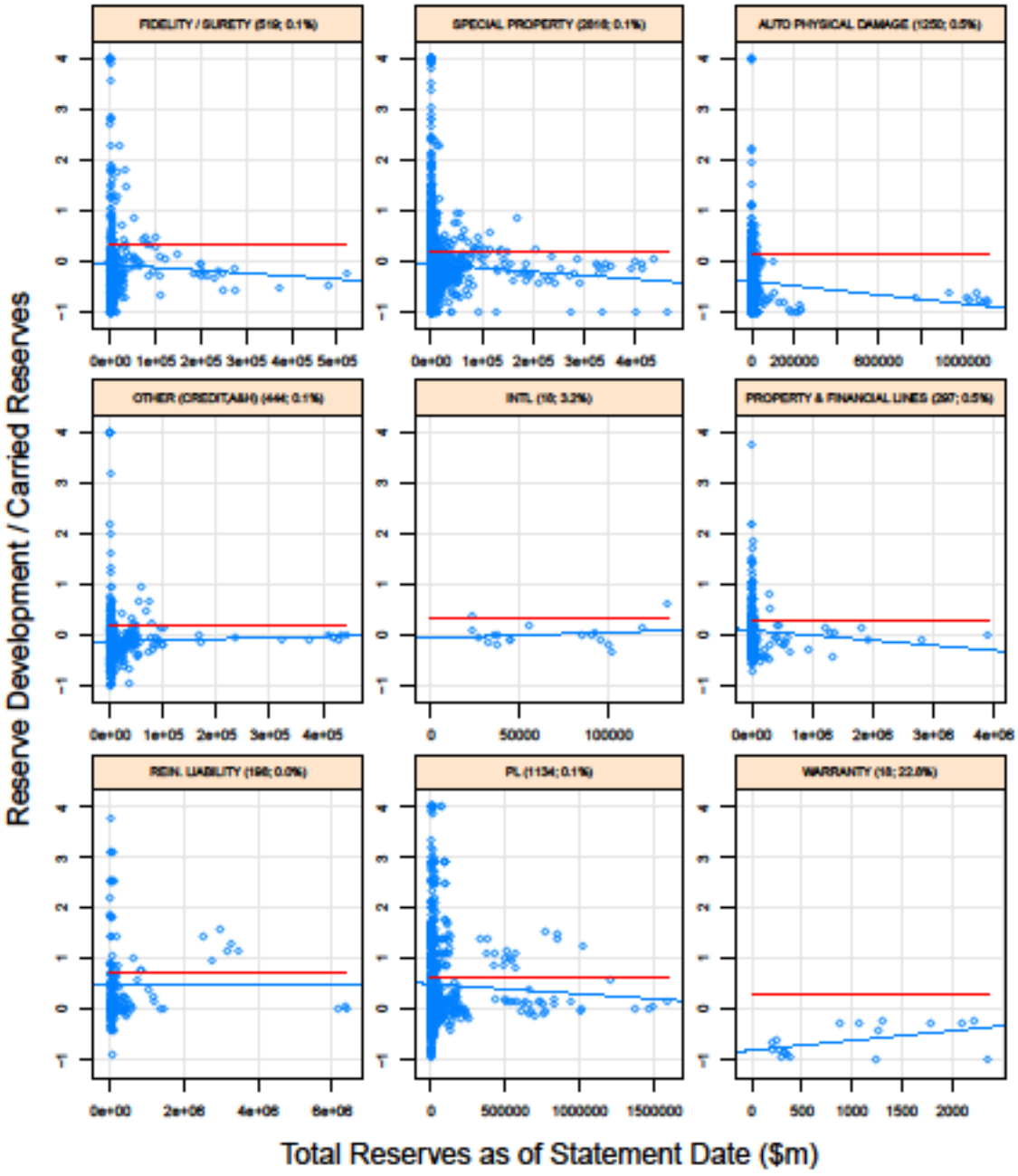
- Change the functional relationship between volatility and carried reserves to be something other than a simple factor (e.g., change the factor based on the size of the carried reserve).
- Use a base other than or in addition to carried reserves (e.g., premium) could be investigated as a potential predictor of reserve development volatility.

[14] The data utilized was compiled using unaudited database queries and varies somewhat from that found in the NAIC's spreadsheets. We do not expect the differences to have significant impact on the results below.

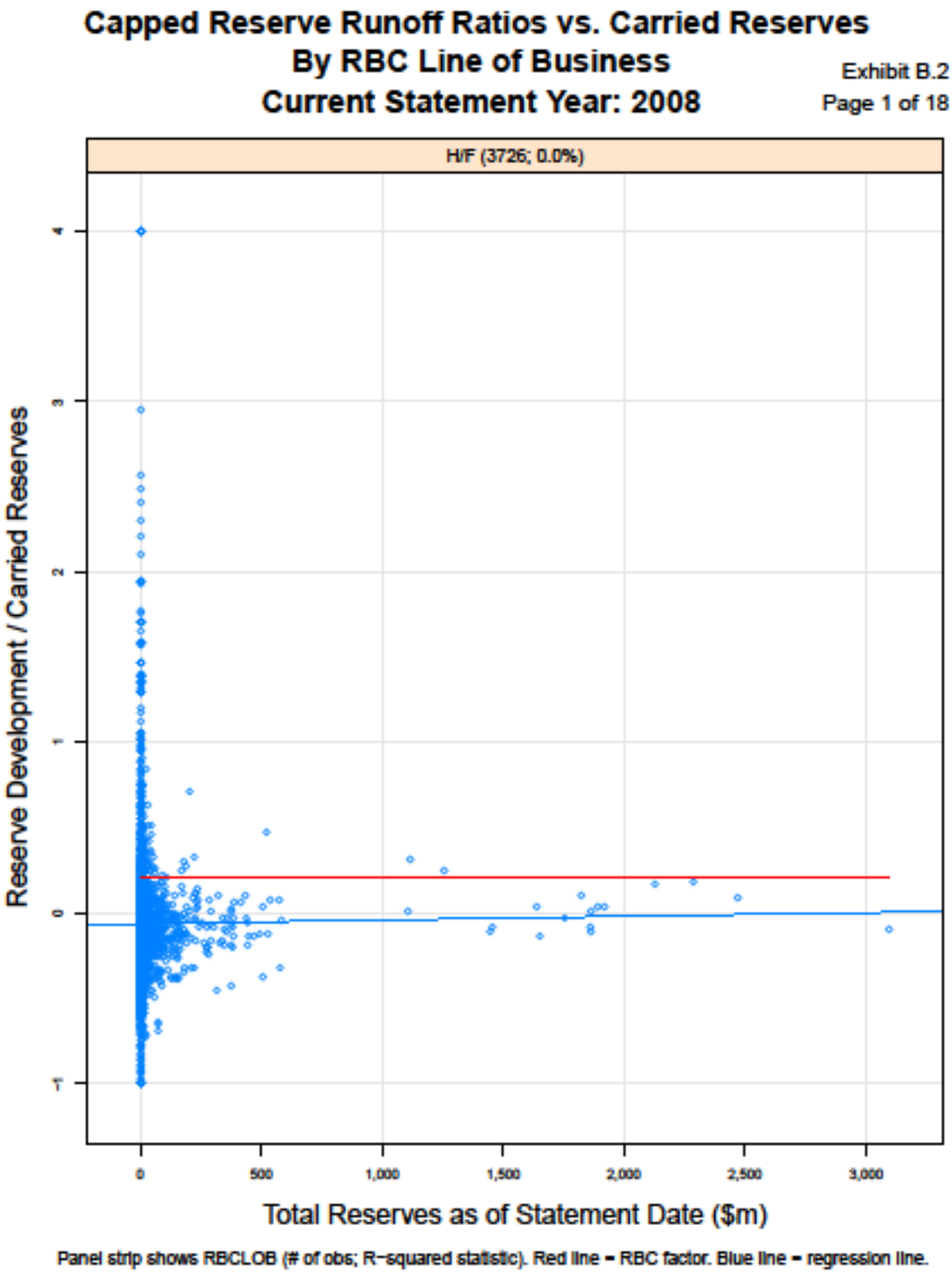

Capped Reserve Runoff Ratios vs. Carried Reserves
By RBC Line of Business
Current Statement Year: 2008
Exhibit B.1
Page 1 of 2
Reserve Development / Carried Reserves
Total Reserves as of Statement Date ($m)
Panel strip shows RBCLOB (# of obs; R-squared statistic). Red line = RBC factor. Blue line = regression line.

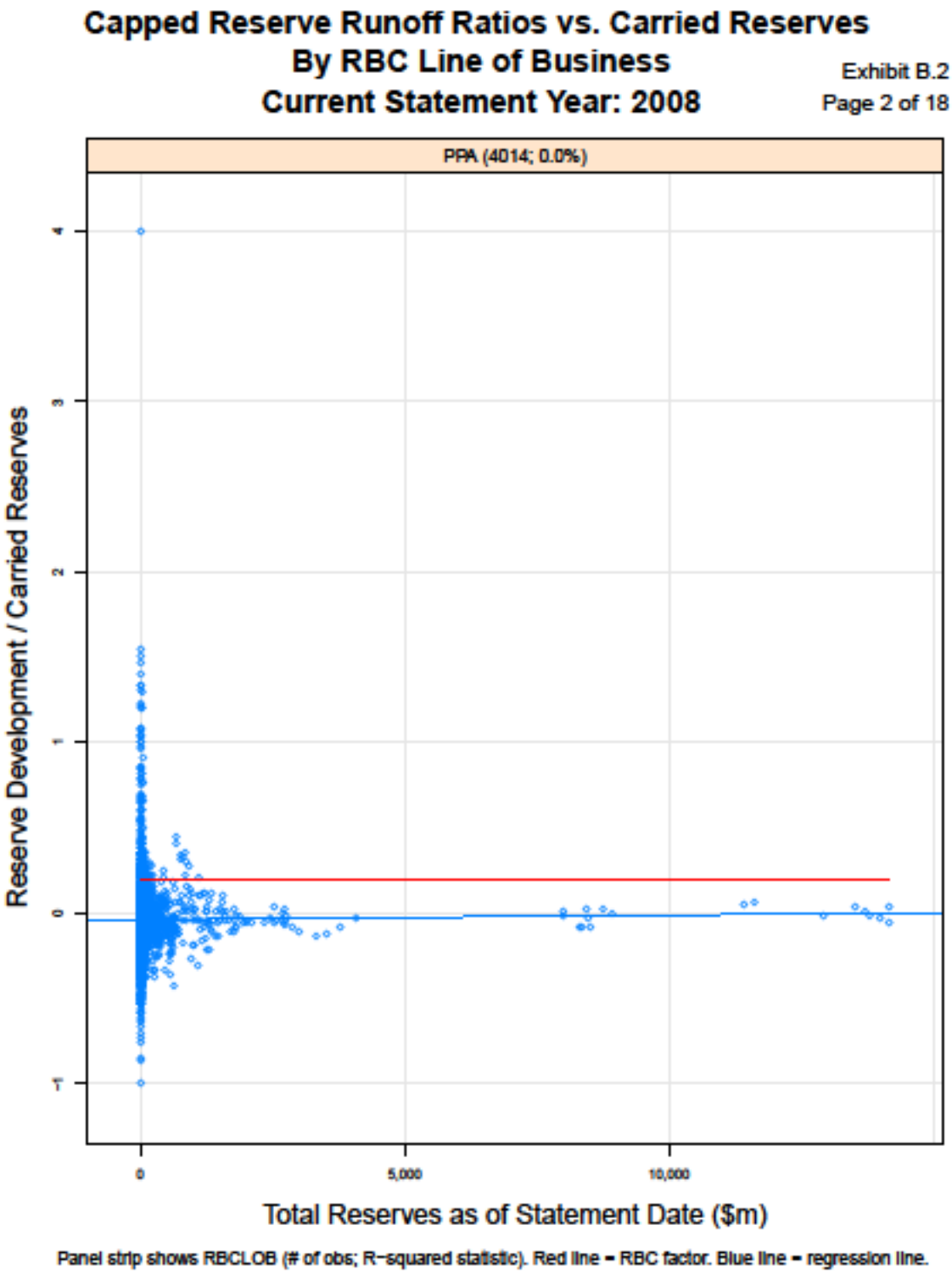
Capped Reserve Runoff Ratios vs. Carried Reserves
By RBC Line of Business
Current Statement Year: 2008

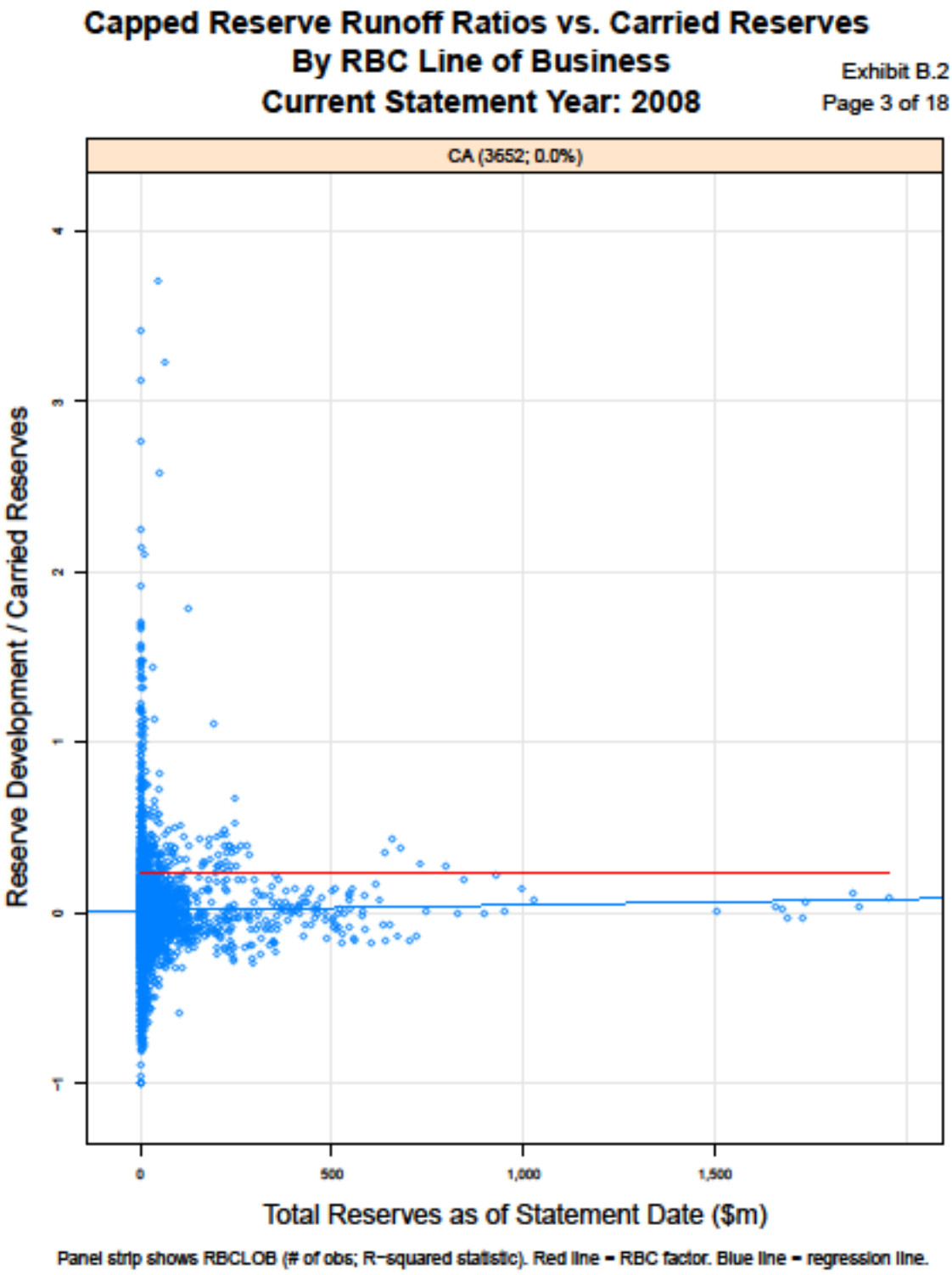
Exhibit B.1
Page 2 of 2

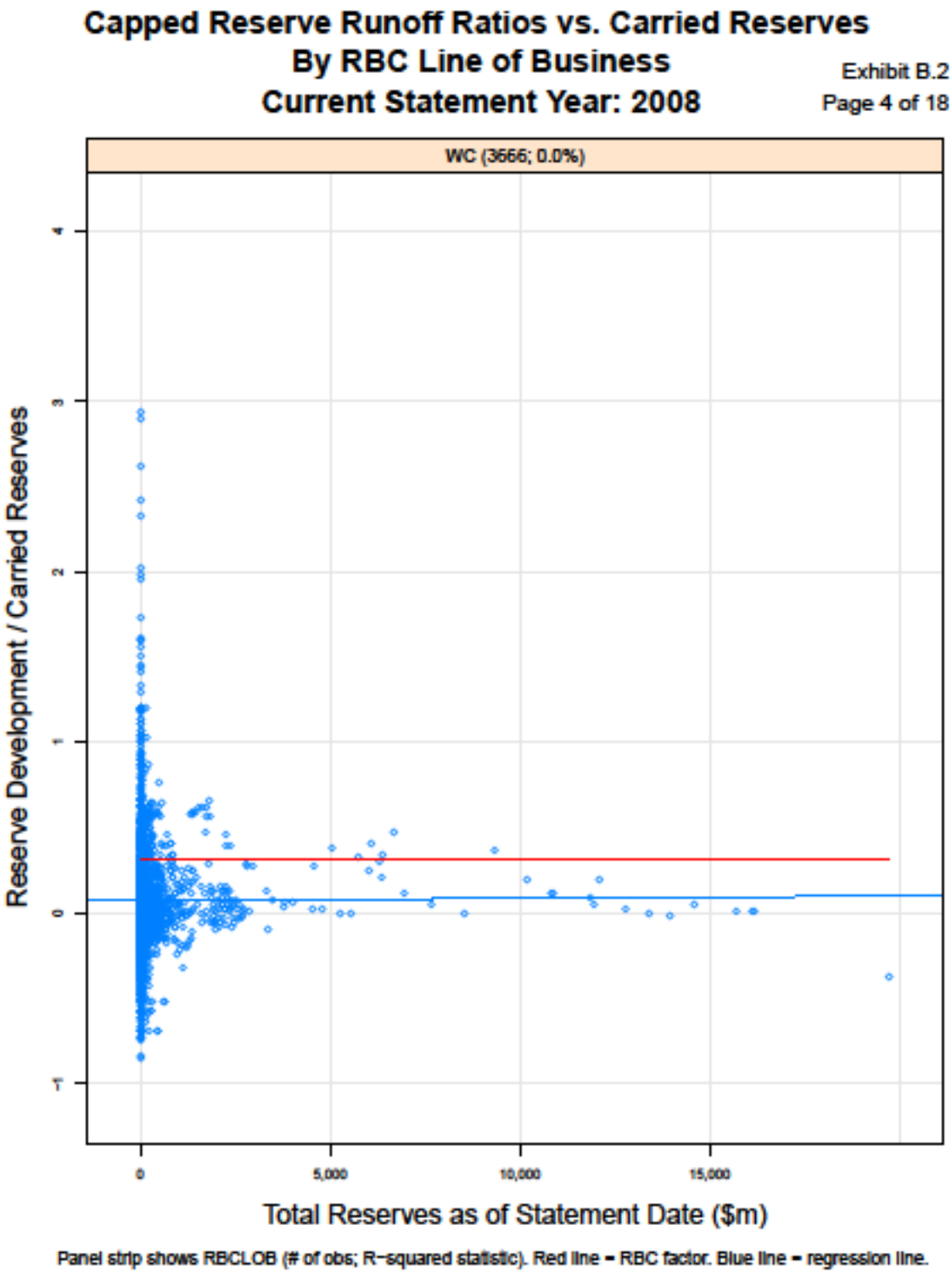


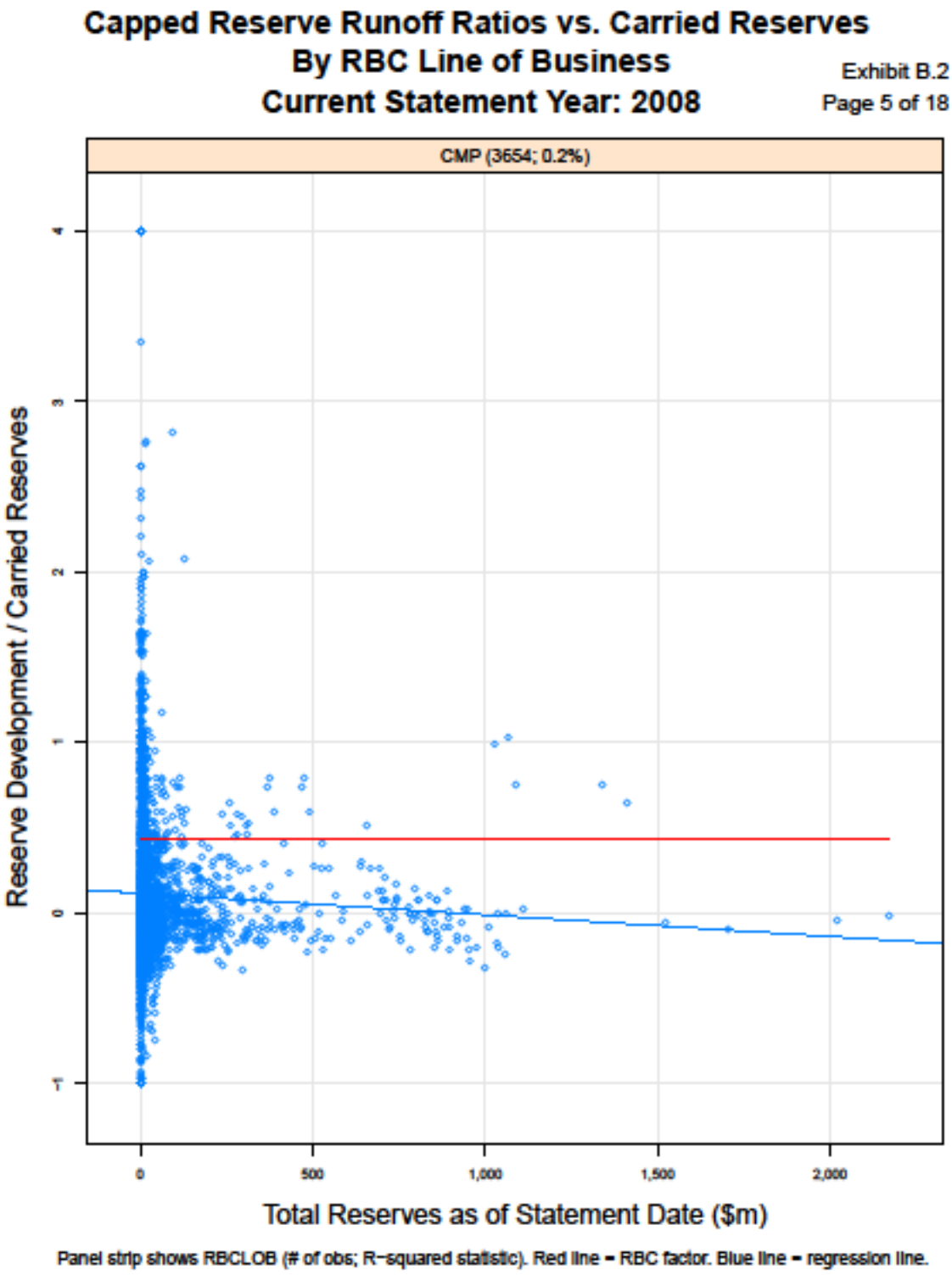
Panel strip shows RBCLOB (# of obs; R-squared statistic). Red line = RBC factor. Blue line = regression line.

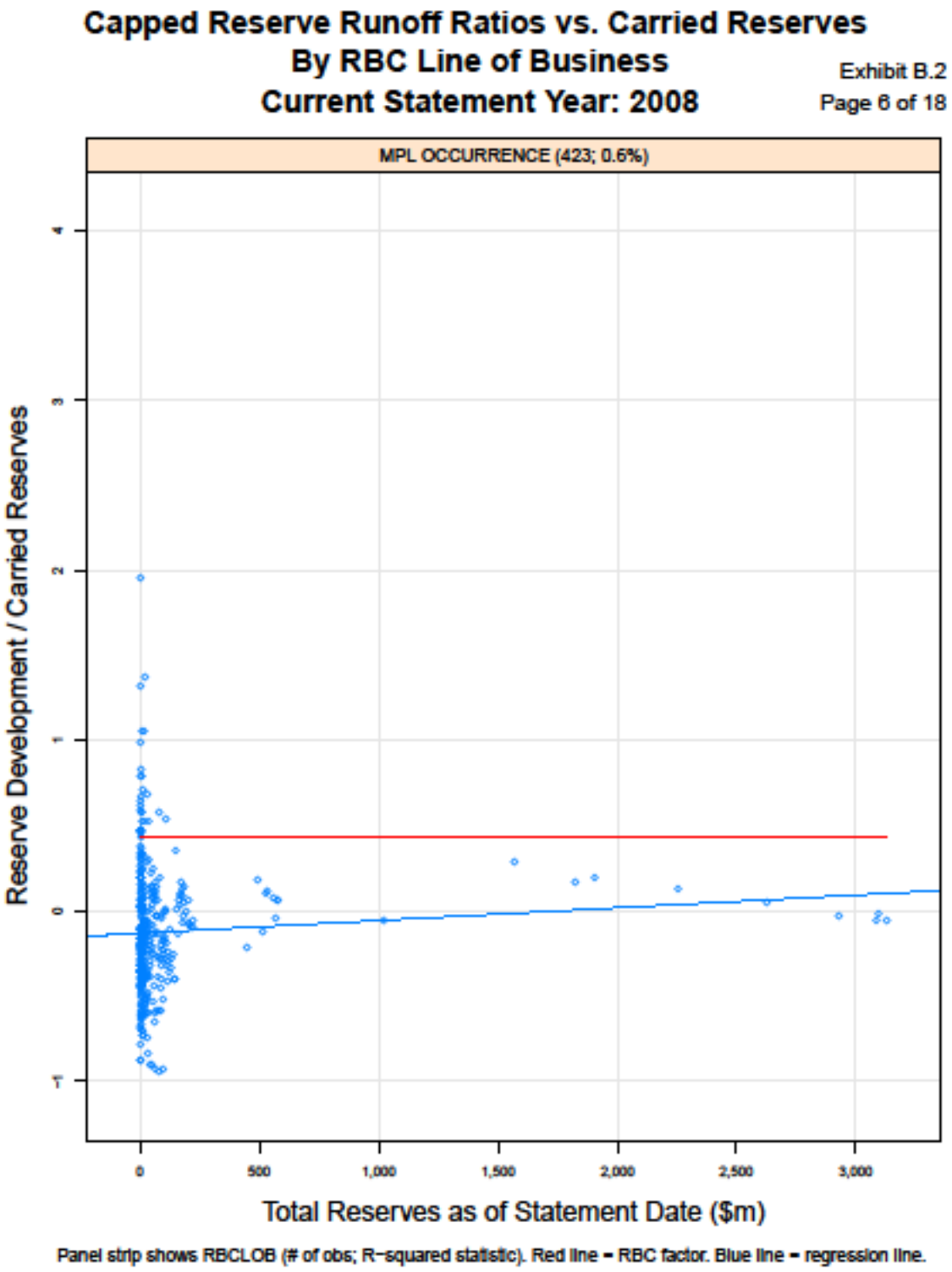

Capped Reserve Runoff Ratios vs. Carried Reserves
By RBC Line of Business
Current Statement Year: 2008
Exhibit B.2
Page 1 of 18
H/F (3726; 0.0%)
Reserve Development / Carried Reserves
4
3
2
1
0
-1
0
500
1,000
1,500
2,000
2,500
3,000
Total Reserves as of Statement Date ($m)
Panel strip shows RBCLOB (# of obs; R-squared statistic). Red line = RBC factor. Blue line = regression line.

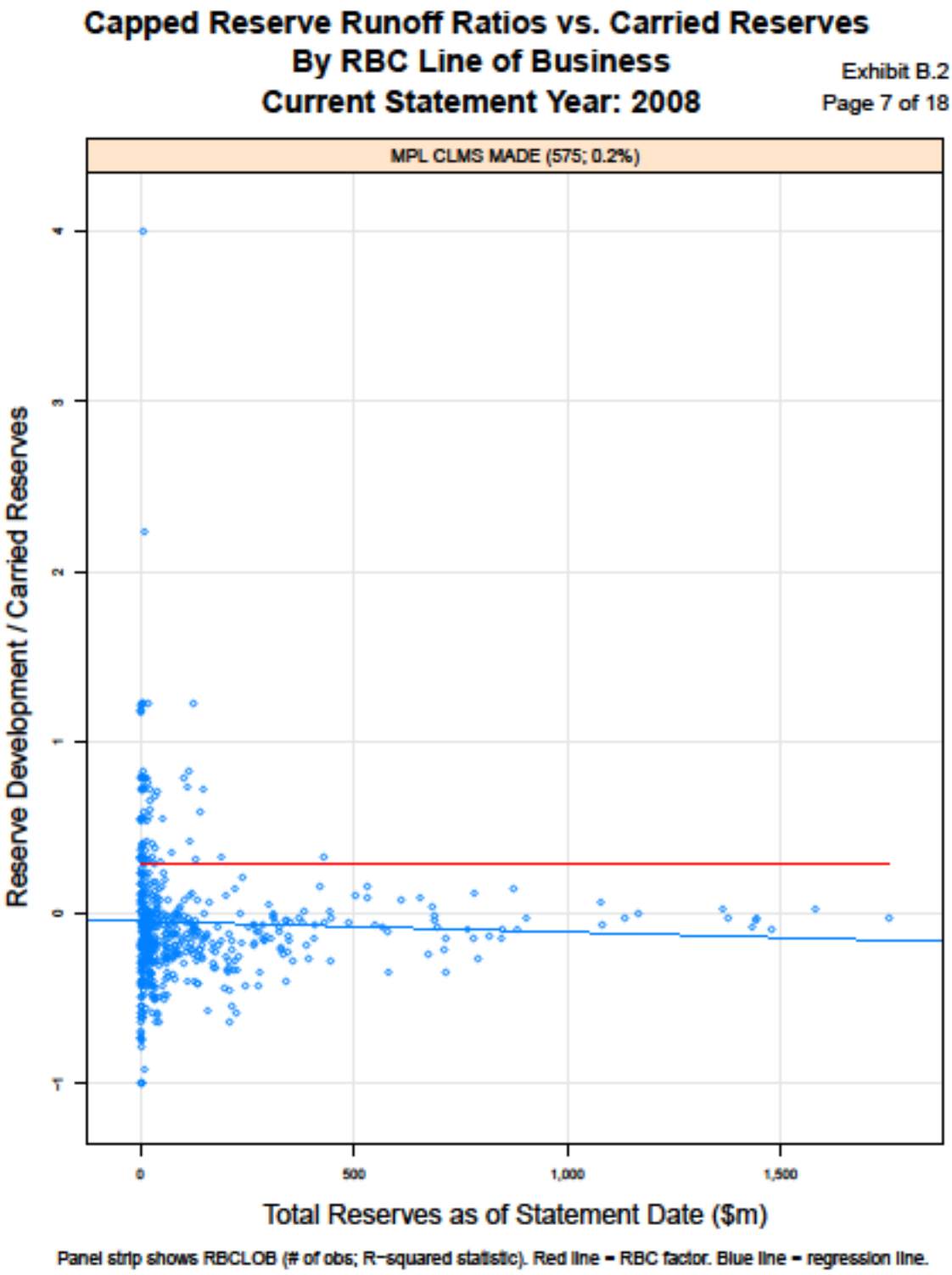

Capped Reserve Runoff Ratios vs. Carried Reserves
By RBC Line of Business
Current Statement Year: 2008
Exhibit B.2
Page 2 of 18
PPA (4014; 0.0%)
Reserve Development / Carried Reserves
4
3
2
1
0
-1
0
5,000
10,000
Total Reserves as of Statement Date ($m)
Panel strip shows RBCLOB (# of obs; R-squared statistic). Red line = RBC factor. Blue line = regression line.

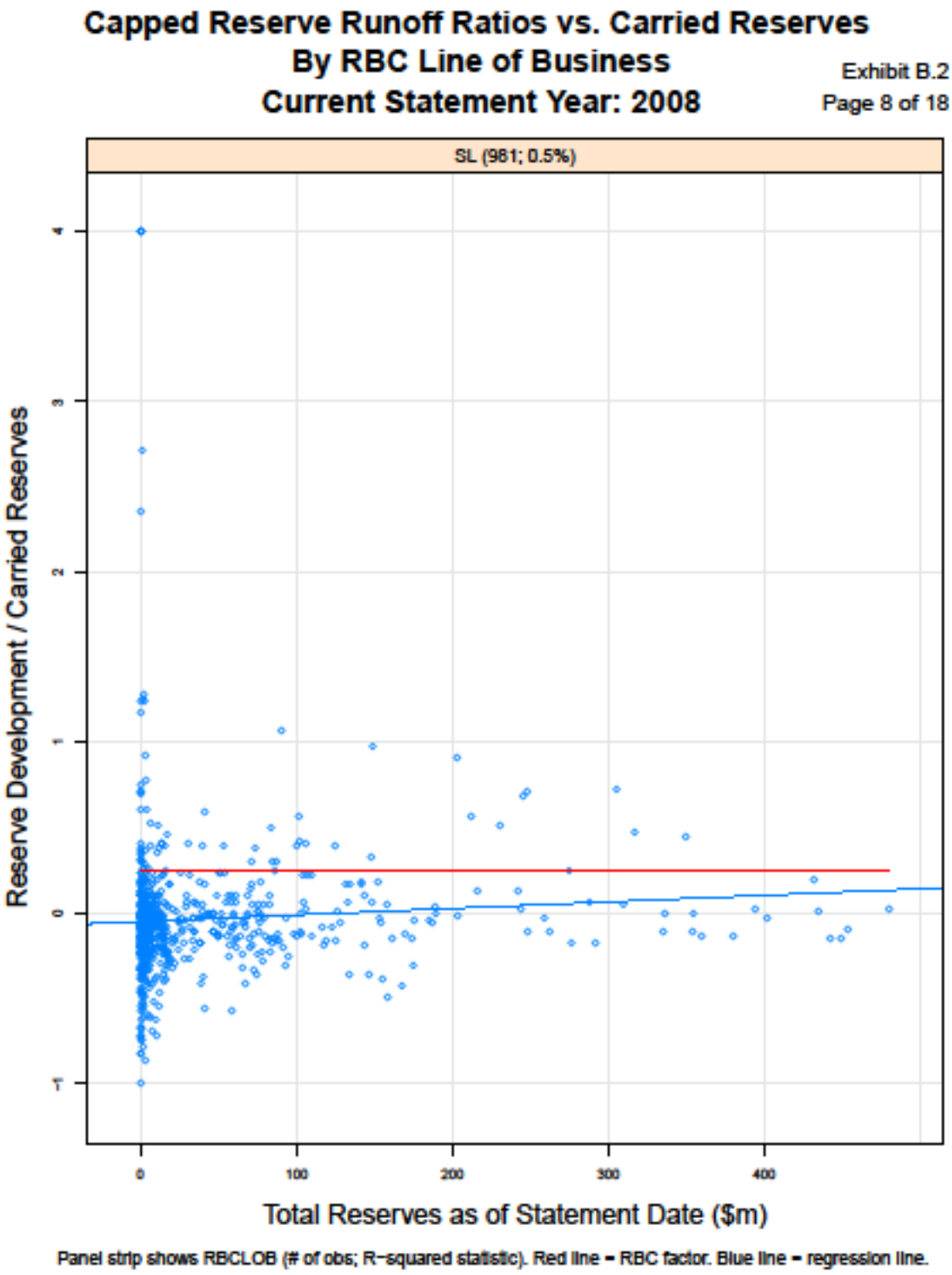

Capped Reserve Runoff Ratios vs. Carried Reserves
By RBC Line of Business
Current Statement Year: 2008
Exhibit B.2
Page 3 of 18
CA (3652; 0.0%)
Reserve Development / Carried Reserves
4
3
2
1
0
-1
0
500
1,000
1,500
Total Reserves as of Statement Date ($m)
Panel strip shows RBCLOB (# of obs; R-squared statistic). Red line = RBC factor. Blue line = regression line.

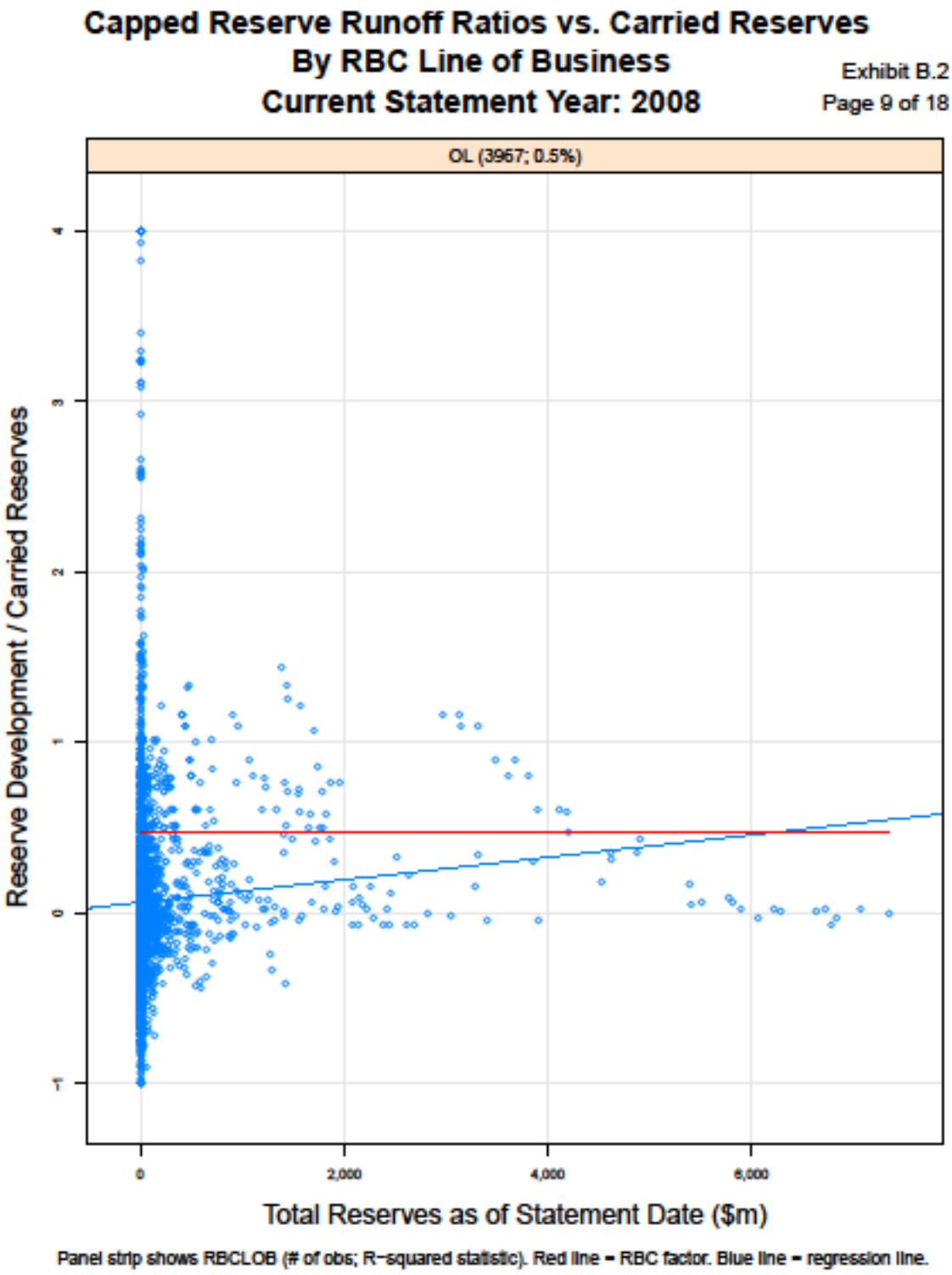

Capped Reserve Runoff Ratios vs. Carried Reserves
By RBC Line of Business
Current Statement Year: 2008
Exhibit B.2
Page 4 of 18
WC (3666; 0.0%)
Reserve Development / Carried Reserves
4
3
2
1
0
-1
0
5,000
10,000
15,000
Total Reserves as of Statement Date ($m)
Panel strip shows RBCLOB (# of obs; R-squared statistic). Red line = RBC factor. Blue line = regression line.

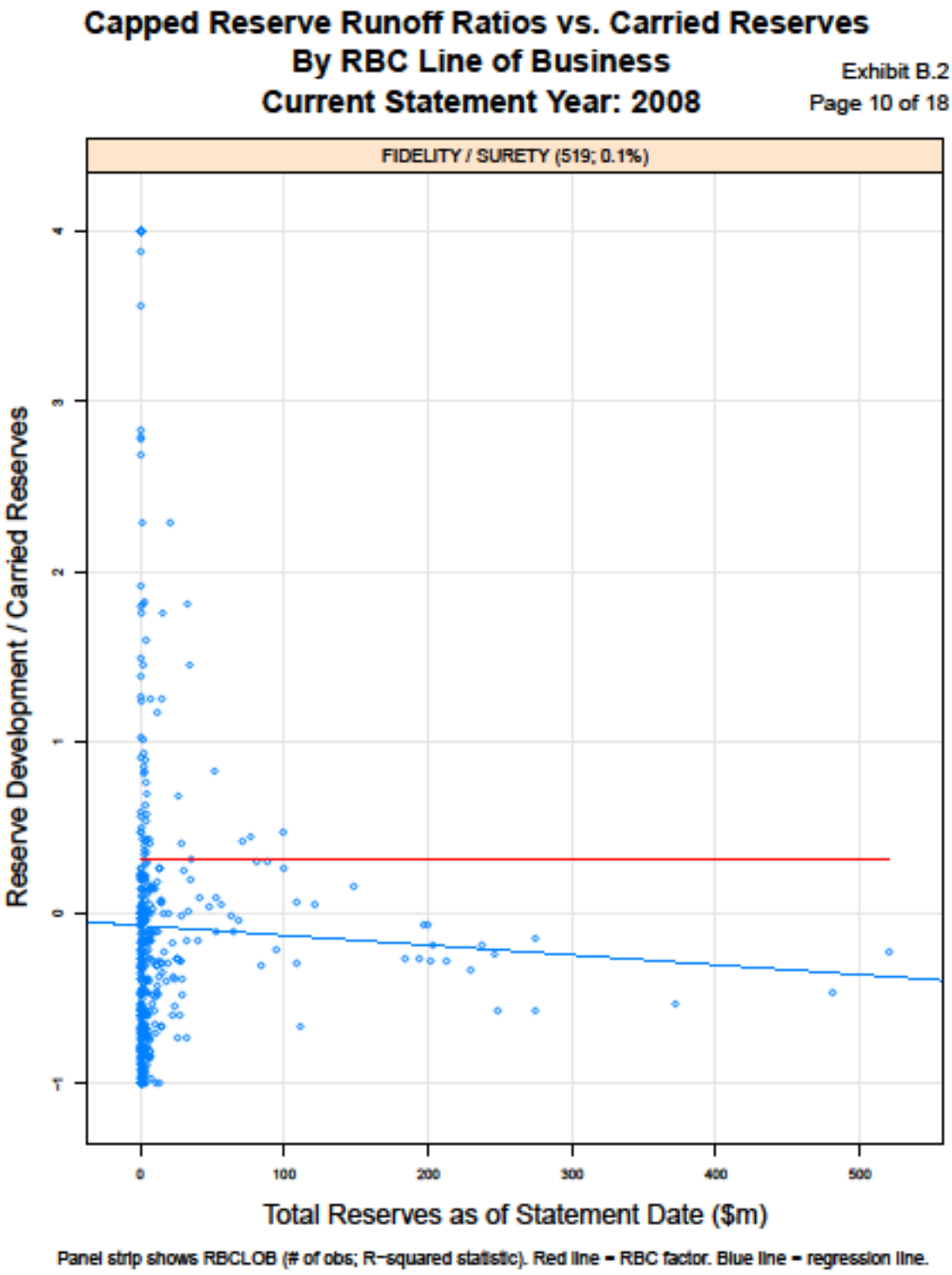

Capped Reserve Runoff Ratios vs. Carried Reserves
By RBC Line of Business
Current Statement Year: 2008
Exhibit B.2
Page 5 of 18
CMP (3654; 0.2%)
Reserve Development / Carried Reserves
4
3
2
1
0
-1
0
500
1,000
1,500
2,000
Total Reserves as of Statement Date ($m)
Panel strip shows RBCLOB (# of obs; R-squared statistic). Red line = RBC factor. Blue line = regression line.

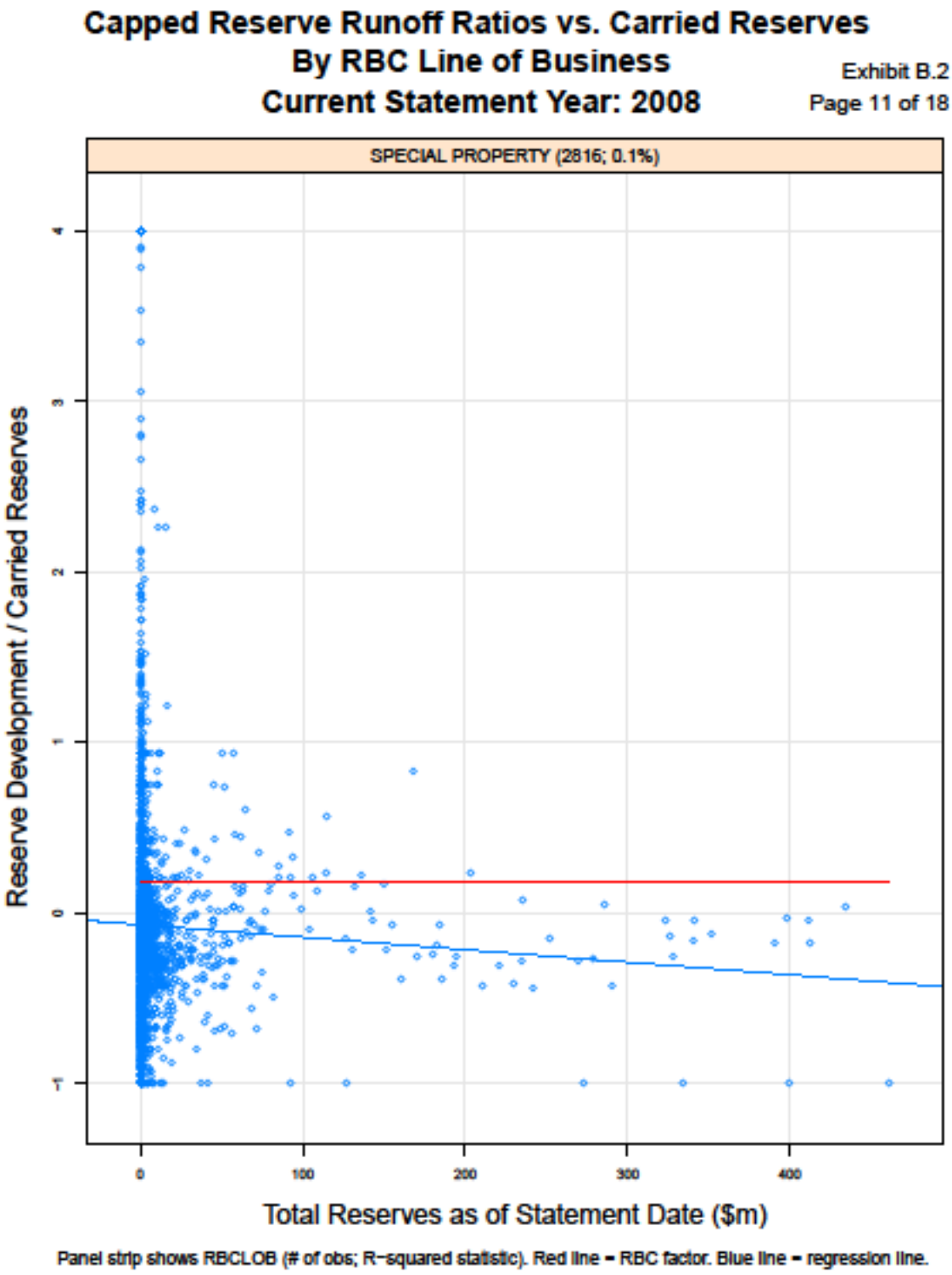

Capped Reserve Runoff Ratios vs. Carried Reserves
By RBC Line of Business
Current Statement Year: 2008
Exhibit B.2
Page 6 of 18
MPL OCCURRENCE (423; 0.6%)
Reserve Development / Carried Reserves
4
3
2
1
0
-1
0
500
1,000
1,500
2,000
2,500
3,000
Total Reserves as of Statement Date ($m)
Panel strip shows RBCLOB (# of obs; R-squared statistic). Red line = RBC factor. Blue line = regression line.

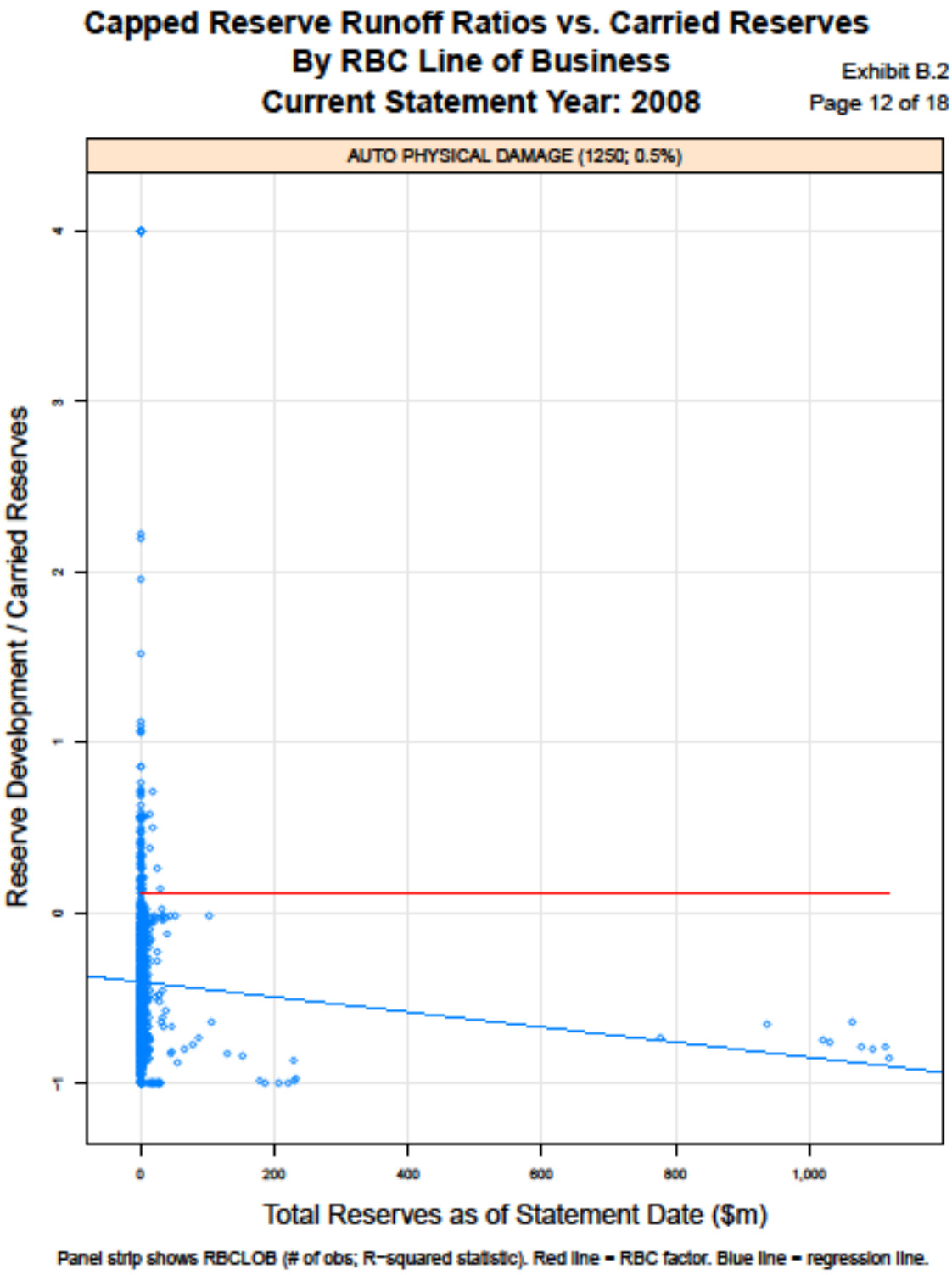

Capped Reserve Runoff Ratios vs. Carried Reserves
By RBC Line of Business
Current Statement Year: 2008
Exhibit B.2
Page 7 of 18
MPL CLMS MADE (575; 0.2%)
Reserve Development / Carried Reserves
4
3
2
1
0
-1
0
500
1,000
1,500
Total Reserves as of Statement Date ($m)
Panel strip shows RBCLOB (# of obs; R-squared statistic). Red line = RBC factor. Blue line = regression line.

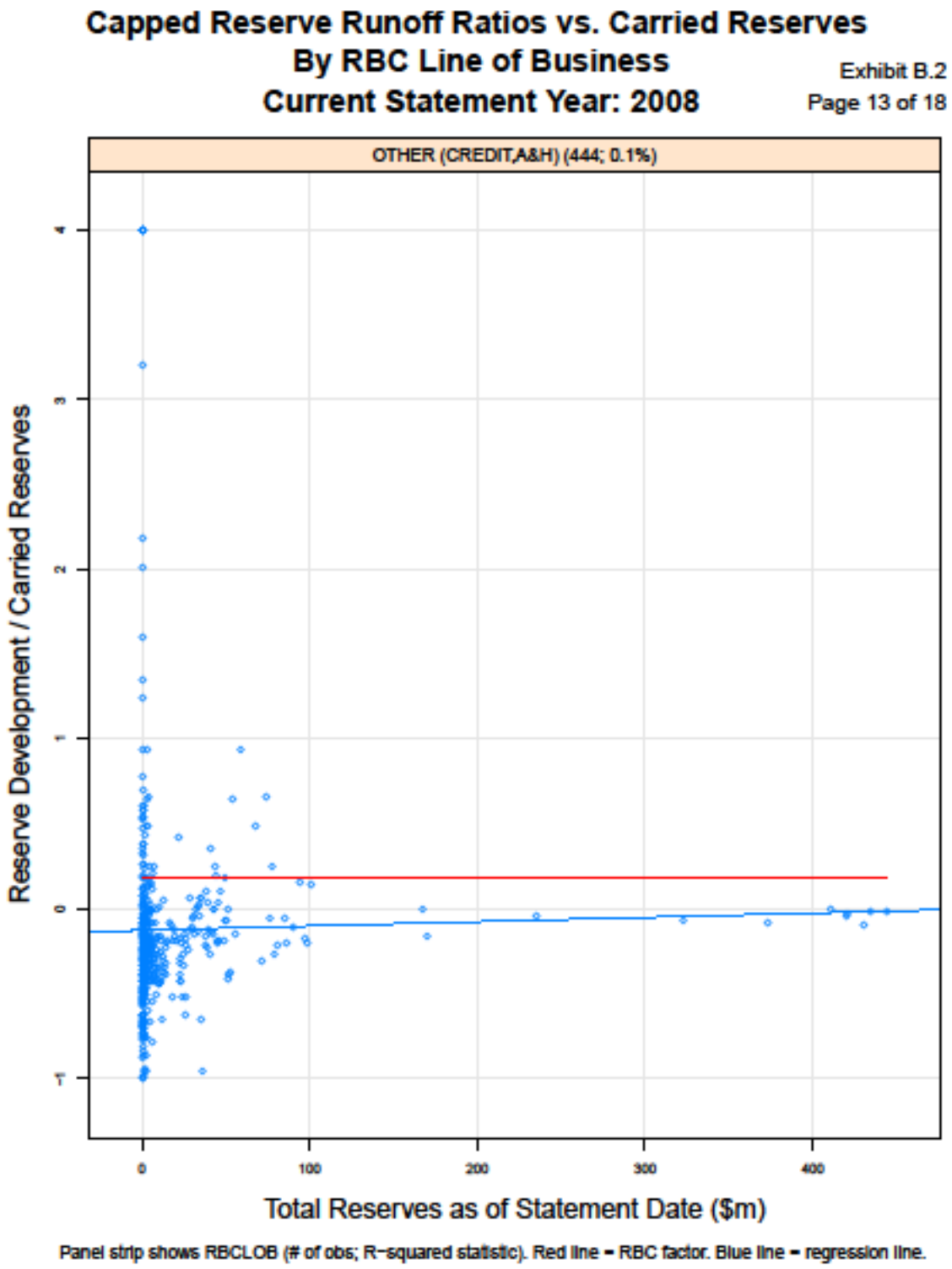

Capped Reserve Runoff Ratios vs. Carried Reserves
By RBC Line of Business
Current Statement Year: 2008
Exhibit B.2
Page 8 of 18
SL (981; 0.5%)
Reserve Development / Carried Reserves
4
3
2
1
0
-1
0
100
200
300
400
Total Reserves as of Statement Date ($m)
Panel strip shows RBCLOB (# of obs; R-squared statistic). Red line = RBC factor. Blue line = regression line.

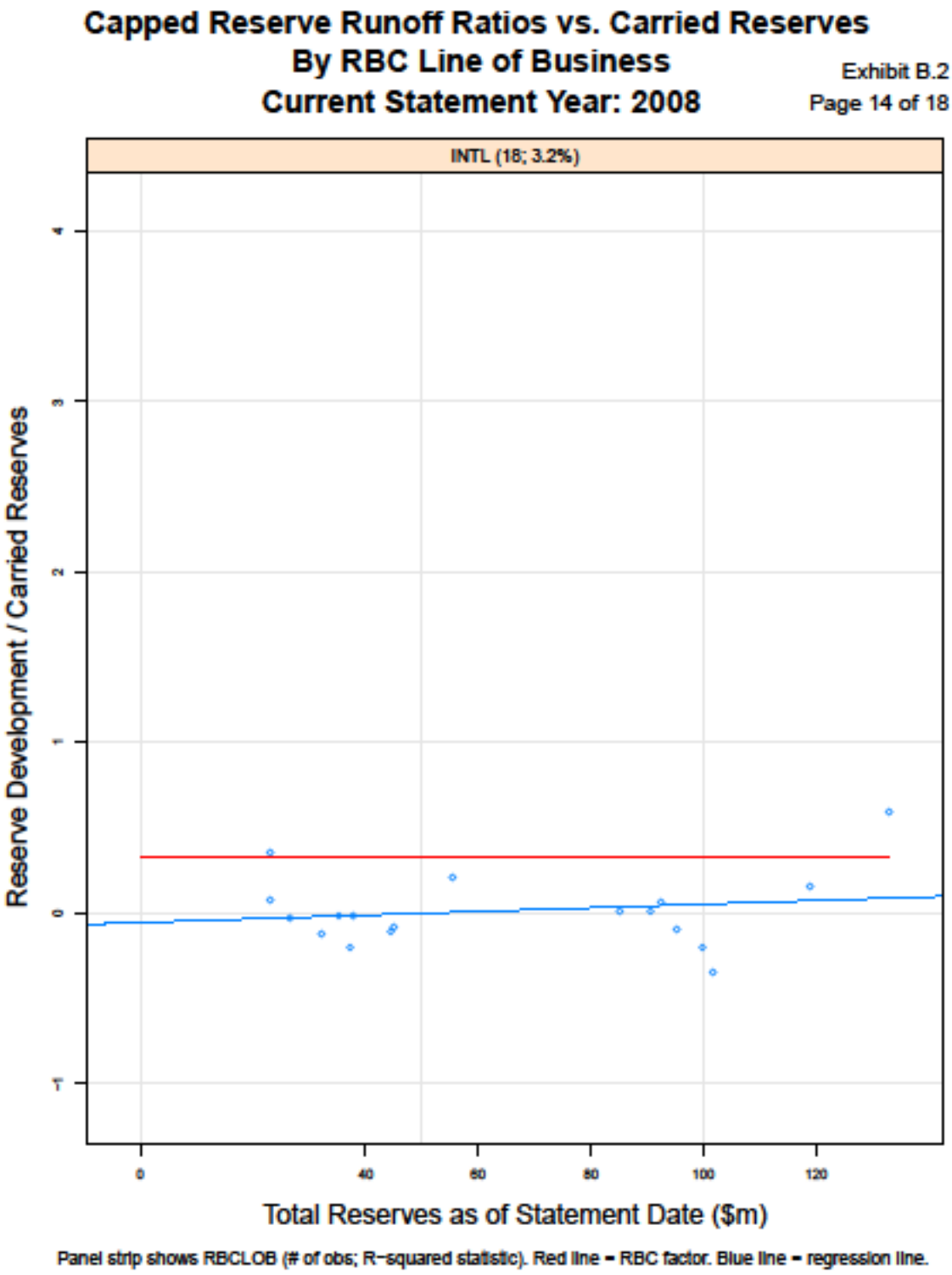

Capped Reserve Runoff Ratios vs. Carried Reserves
By RBC Line of Business
Current Statement Year: 2008
Exhibit B.2
Page 9 of 18
OL (3967; 0.5%)
Reserve Development / Carried Reserves
4
3
2
1
0
-1
0
2,000
4,000
6,000
Total Reserves as of Statement Date ($m)
Panel strip shows RBCLOB (# of obs; R-squared statistic). Red line = RBC factor. Blue line = regression line.

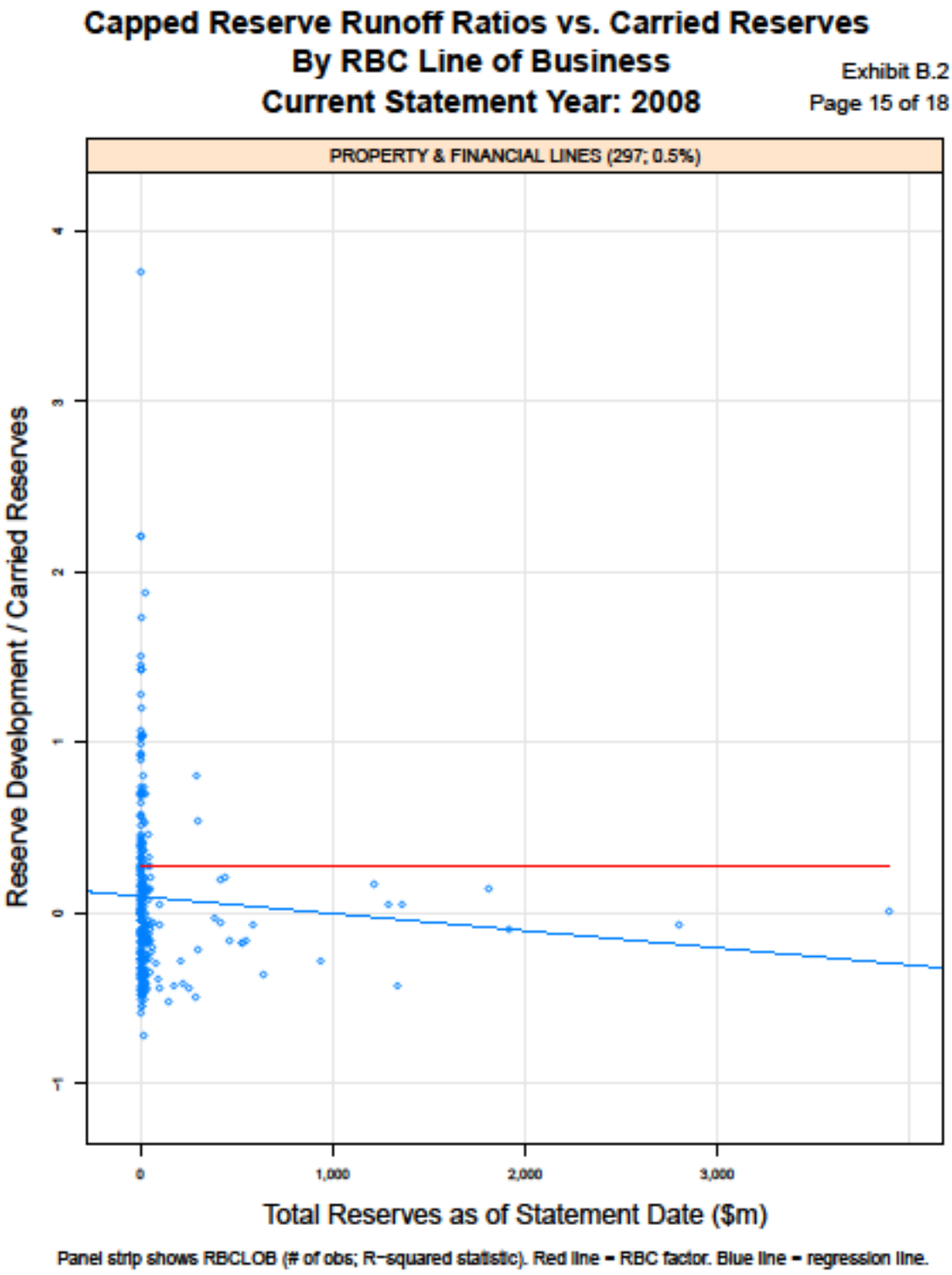

Capped Reserve Runoff Ratios vs. Carried Reserves
By RBC Line of Business
Current Statement Year: 2008
Exhibit B.2
Page 10 of 18
FIDELITY / SURETY (519; 0.1%)
Reserve Development / Carried Reserves
4
3
2
1
0
-1
0
100
200
300
400
500
Total Reserves as of Statement Date ($m)
Panel strip shows RBCLOB (# of obs; R-squared statistic). Red line = RBC factor. Blue line = regression line.

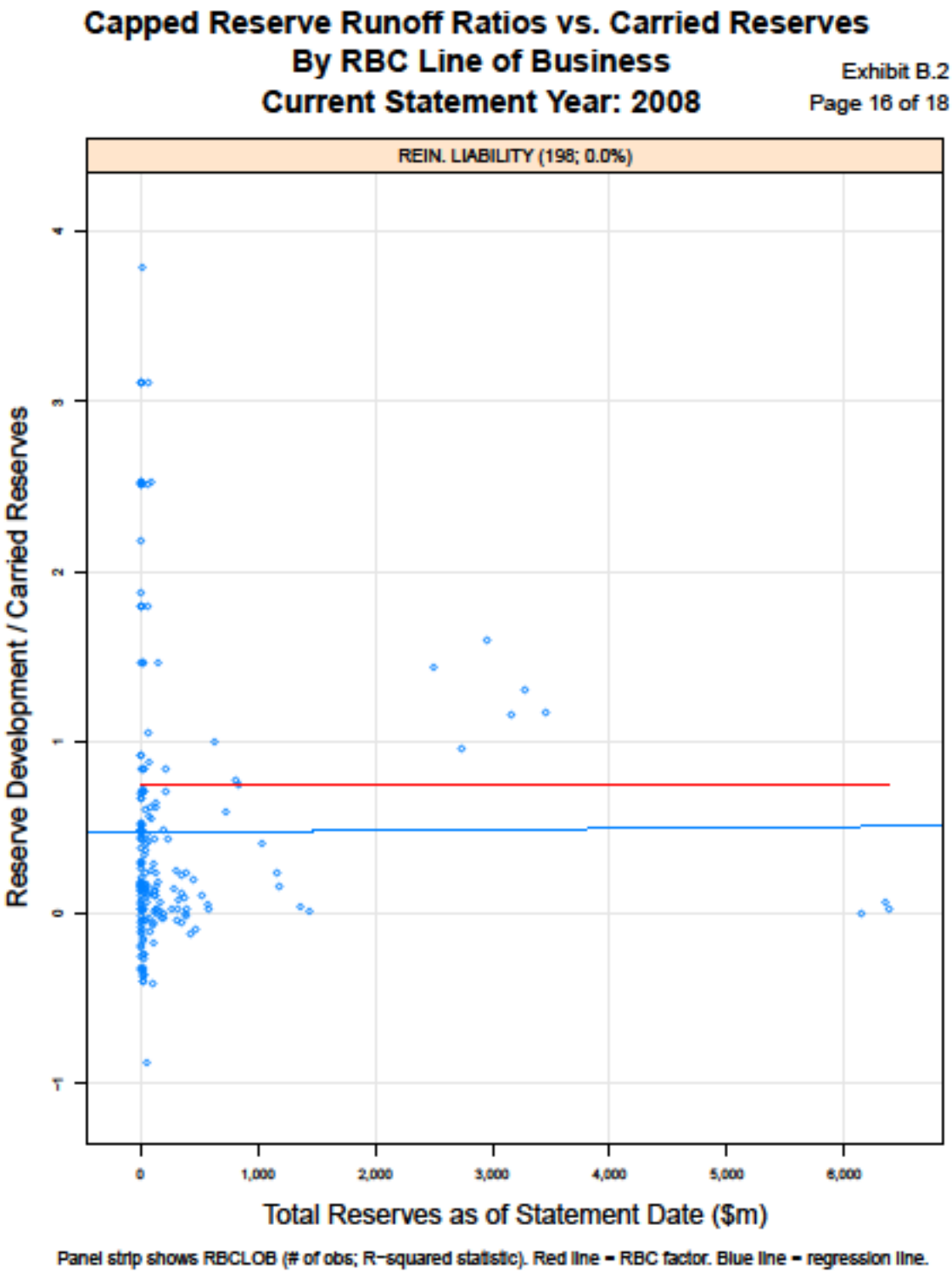

Capped Reserve Runoff Ratios vs. Carried Reserves
By RBC Line of Business
Current Statement Year: 2008
Exhibit B.2
Page 11 of 18
SPECIAL PROPERTY (2816; 0.1%)
Reserve Development / Carried Reserves
4
3
2
1
0
-1
0
100
200
300
400
Total Reserves as of Statement Date ($m)
Panel strip shows RBCLOB (# of obs; R-squared statistic). Red line = RBC factor. Blue line = regression line.

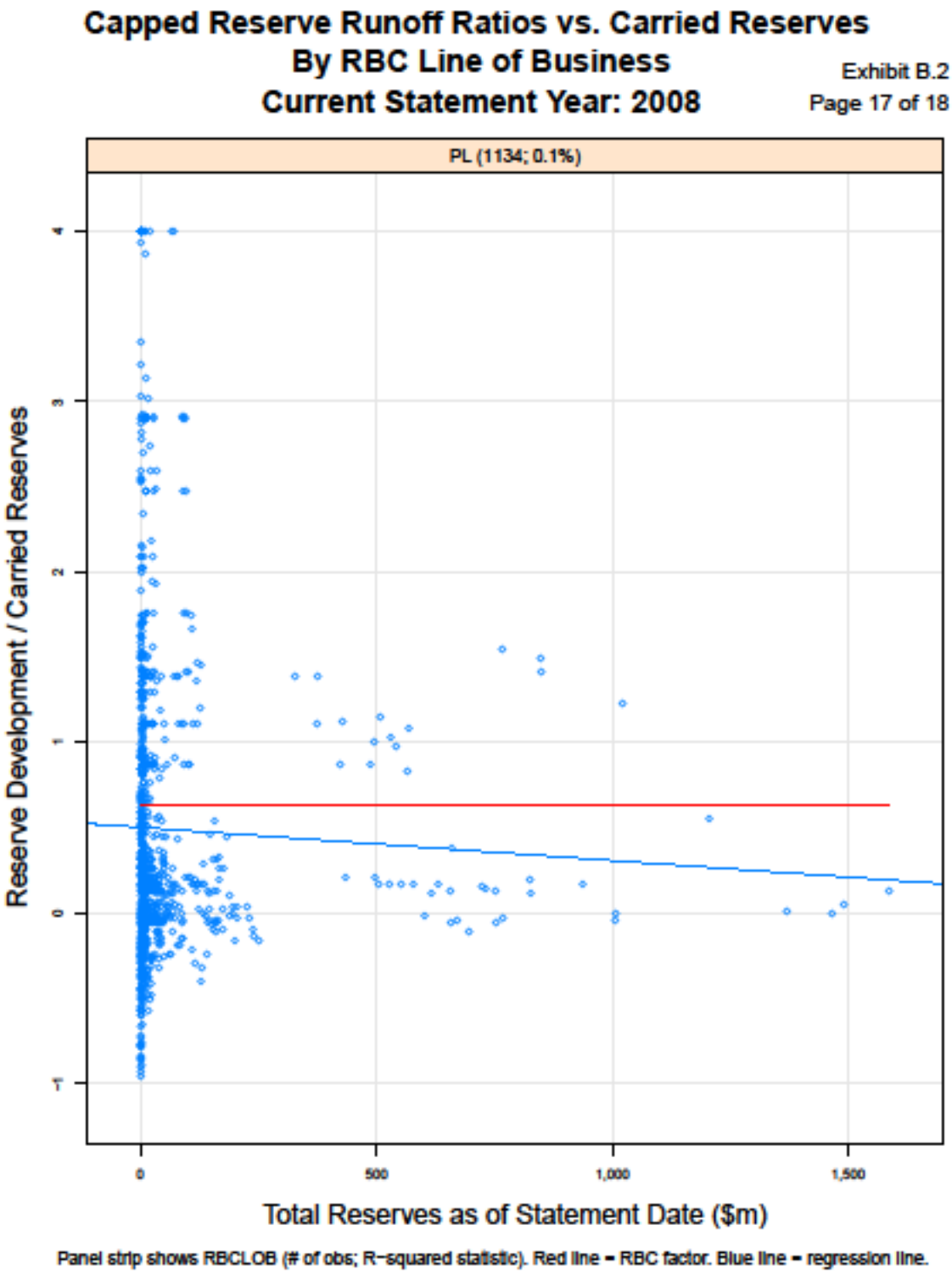

Capped Reserve Runoff Ratios vs. Carried Reserves
By RBC Line of Business
Current Statement Year: 2008
Exhibit B.2
Page 12 of 18
AUTO PHYSICAL DAMAGE (1250; 0.5%)
Reserve Development / Carried Reserves
4
3
2
1
0
-1
0
200
400
600
800
1,000
Total Reserves as of Statement Date ($m)
Panel strip shows RBCLOB (# of obs; R-squared statistic). Red line = RBC factor. Blue line = regression line.

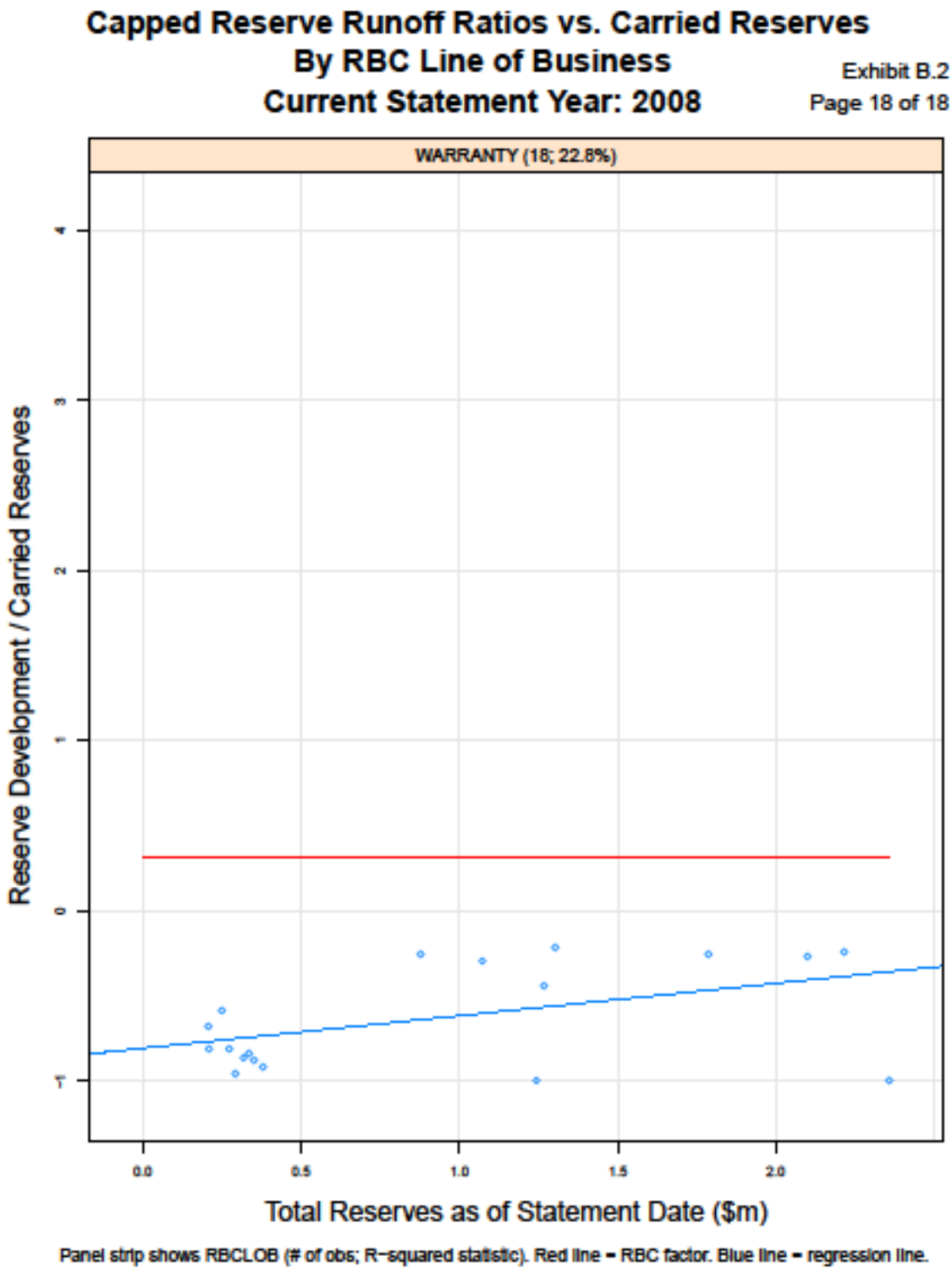

Capped Reserve Runoff Ratios vs. Carried Reserves
By RBC Line of Business
Current Statement Year: 2008
Exhibit B.2
Page 13 of 18
OTHER (CREDIT,A&H) (444; 0.1%)
Reserve Development / Carried Reserves
4
3
2
1
0
-1
0
100
200
300
400
Total Reserves as of Statement Date ($m)
Panel strip shows RBCLOB (# of obs; R-squared statistic). Red line = RBC factor. Blue line = regression line.


Capped Reserve Runoff Ratios vs. Carried Reserves
By RBC Line of Business
Current Statement Year: 2008
Exhibit B.2
Page 14 of 18
INTL (18; 3.2%)
Reserve Development / Carried Reserves
4
3
2
1
0
-1
0
40
60
80
100
120
Total Reserves as of Statement Date ($m)
Panel strip shows RBCLOB (# of obs; R-squared statistic). Red line = RBC factor. Blue line = regression line.


Capped Reserve Runoff Ratios vs. Carried Reserves
By RBC Line of Business
Current Statement Year: 2008
Exhibit B.2
Page 15 of 18
PROPERTY & FINANCIAL LINES (297; 0.5%)
Reserve Development / Carried Reserves
4
3
2
1
0
-1
0
1,000
2,000
3,000
Total Reserves as of Statement Date ($m)
Panel strip shows RBCLOB (# of obs; R-squared statistic). Red line = RBC factor. Blue line = regression line.


Capped Reserve Runoff Ratios vs. Carried Reserves
By RBC Line of Business
Current Statement Year: 2008
Exhibit B.2
Page 16 of 18
REIN. LIABILITY (198; 0.0%)
Reserve Development / Carried Reserves
4
3
2
1
0
-1
0
1,000
2,000
3,000
4,000
5,000
6,000
Total Reserves as of Statement Date ($m)
Panel strip shows RBCLOB (# of obs; R-squared statistic). Red line = RBC factor. Blue line = regression line.


Capped Reserve Runoff Ratios vs. Carried Reserves
By RBC Line of Business
Current Statement Year: 2008
Exhibit B.2
Page 17 of 18
PL (1134; 0.1%)
Reserve Development / Carried Reserves
4
3
2
1
0
-1
0
500
1,000
1,500
Total Reserves as of Statement Date ($m)
Panel strip shows RBCLOB (# of obs; R-squared statistic). Red line = RBC factor. Blue line = regression line.


Capped Reserve Runoff Ratios vs. Carried Reserves
By RBC Line of Business
Current Statement Year: 2008
Exhibit B.2
Page 18 of 18
WARRANTY (18; 22.8%)
Reserve Development / Carried Reserves
4
3
2
1
0
-1
0.0
0.5
1.0
1.5
2.0
Total Reserves as of Statement Date ($m)
Panel strip shows RBCLOB (# of obs; R-squared statistic). Red line = RBC factor. Blue line = regression line.

Appendix C: Confidence intervals for the RBC reserve charge

In their 2007 report,[15] the American Academy of Actuaries recommended limiting the swing in charges by RBCLOB to 35% of the prior charge. For 2010, the NAIC limited the swing to 5%. Given the limited volume of filtered data and the variability of the reserve run-off ratios, we investigated how likely it is for an RBCLOB charge to exceed the swing limit from one calibration cycle to the next.

In Exhibit C-1 we show estimates of 90% confidence intervals around the 87.5th percentiles by using the 2008 RBC data in the context of a binomial distribution. To find a confidence interval [CR, CL] for the 87.5% quantile[16] (call it "$Q_{.875}$") we start by forming the order statistics $Y_1, \ldots, Y_n$ of the data, which are just the reserve run-off ratios sorted in ascending order. The probability that the k^{th} order statistic Y_k falls below the 87.5 percentile $Q_{.875}$ is the probability that exactly k observations are less than or equal to $Q_{.875}$ and n-k observations are greater than $Q_{.875}$. This probability follows a binomial distribution (where "success" means that a value fall below $Q_{.875}$ and we want the probability of k successes in n trials): $P(Y_k <= Q_{.875})$=pbinom(k, n, .875)=$\binom{n}{k}.875^k(1-.875)^{n-k}$.

A 90% confidence interval for $Q_{.875}$ is found by searching for integers l and r such that

$$P(Y_l \le Q_{.875} < Y_r) = \sum_{x=l}^{r} \binom{n}{x} .875^x (1-.875)^{n-x}$$

is as close to 90% as possible (in most cases it is not possible to achieve the desired confidence level exactly in problems of this type). Then CL=Y_l and CR= Y_r.

We find that volatility in the Current Calibration Method is highly likely: five of the 19 RBCLOBs (ignoring APD) will reach a 35% swing in 90% of calculations of this type. Virtually all RBCLOBs will exceed a swing of 5% in 90% of calculations of this type.

Exhibit C-2 illustrates how the error margin swing decreases for those RBCLOBs with greater numbers of observations. Auto Physical Damage's result is an anomaly of the line's reserving practices. International's data point (18 observations, 200%) is not shown. This graph illustrates how swings in RBC factors can possibly be tempered by utilizing more data.

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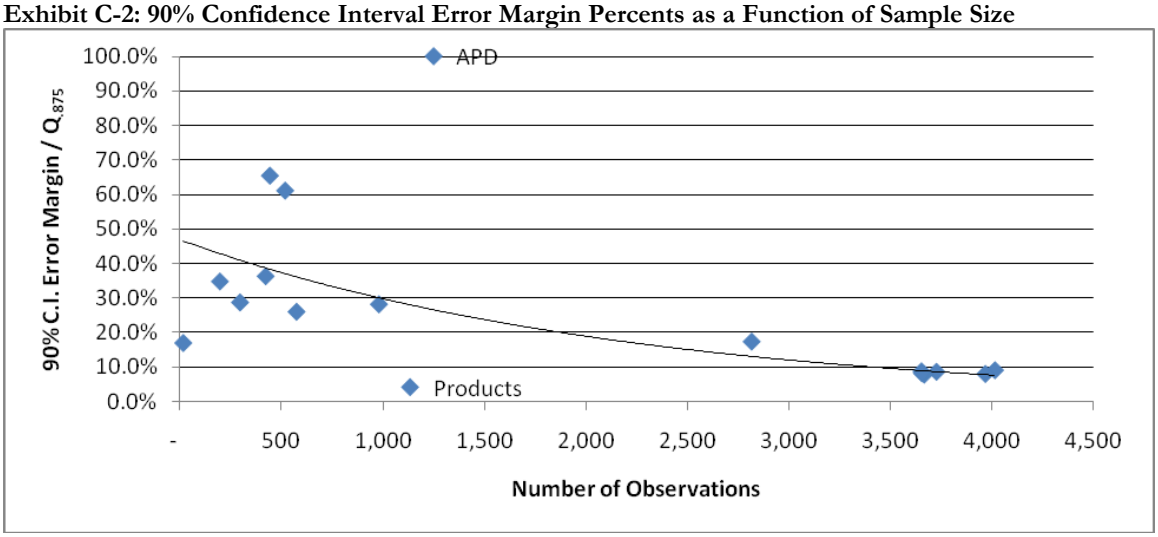
[15] *An Update to P/C Risk-Based Capital Underwriting Factors*, p. 3.

[16] Derivations of distributions of order statistics can be found in statistics texts and online at http://en.wikipedia.org/wiki/Order_statistic#The_joint_distribution_of_the_order_statistics_of_an_absolutely_continuous_distribution. The equi-tailed calculation utilized here follows the R code outlined at http://tolstoy.newcastle.edu.au/R/e2/help/07/02/9857.html. Another helpful online source is http://turing.une.edu.au/~stat354/notes/node72.html. Reserve runoff ratio data probably violate the classic "i.i.d." assumptions underlying the theory; as a result, confidence intervals may be overstated. The data utilized was compiled using unaudited database queries and varies somewhat from that found in the NAIC's spreadsheets. We do not expect the differences to have significant impact on the results.

Exhibit C-1: 87.5 percentiles and Related 90% Confidence Intervals

RBCLOB	Conf Int lower bound	87.5% quantile ($Q_{.875}$)	Conf Int upper bound	C.I. "Error Margin" (E)	E as a percent of $Q_{.875}$	Number of Obs
H/F	0.148	0.161	0.175	0.014	8.50%	3,726
PPA	0.109	0.117	0.128	0.011	9.00%	4,014
CA	0.215	0.222	0.241	0.019	8.60%	3,652
WC	0.323	0.338	0.364	0.026	7.70%	3,666
CMP	0.455	0.476	0.514	0.038	8.10%	3,654
MPL OCCURRENCE	0.164	0.218	0.296	0.079	36.20%	423
MPL CLMS MADE	0.230	0.310	0.330	0.080	25.90%	575
SL	0.118	0.164	0.186	0.046	28.10%	981
OL	0.512	0.534	0.576	0.042	7.90%	3,967
FIDELITY / SURETY	0.306	0.432	0.696	0.264	61.00%	519
SPECIAL PROPERTY	0.326	0.354	0.415	0.061	17.20%	2,816
AUTO PHYSICAL DAMAGE	-0.033	-0.020	-	0.020	100.00%	1,250
OTHER (CREDIT,A&H)	0.082	0.150	0.249	0.098	65.40%	444
FINANCIAL/MORT GUARANTEE	no data					
INTL	0.062	0.200	0.596	0.396	198.30%	18
PROPERTY & FINANCIAL LINES	0.461	0.646	0.739	0.185	28.60%	297
REIN. LIABILITY	0.887	1.357	1.800	0.471	34.70%	198
PL	1.382	1.382	1.438	0.056	4.10%	1,134
WARRANTY	-0.297	-0.254	-0.222	0.043	16.80%	18

Exhibit C-2: 90% Confidence Interval Error Margin Percents as a Function of Sample Size



Appendix D: RBC Action Levels

Authorized Control Level (ACL) RBC = .5 x Total RBC After Covariance[17]

RBC % = ACL RBC / company's Total Adjusted Capital

A company's RBC % determines which of four action levels (if any) take place, summarized in the following table:

Level	Abbrev	RBC %	Regulator Action	Company Action
Company Action Level	CAL	200% of ACL	No action required	Company must submit a plan to improve its capital position
Regulatory Action Level	RAL	150% of ACL	Insurance commissioner is allowed to order corrective actions	Company must submit a plan to improve its capital position; additional actions dependent on commissioner action
Authorized Control Level	ACL	100% of ACL	Insurance commissioner is authorized to take action to protect policyholders and creditors of the company, including rehabilitation or liquidation	Depends on commissioner action
Mandatory Control Level	MCL	70% of ACL	Insurance commissioner must rehabilitate or liquidate the company	

[17] The information in this appendix is based on *Risk-Based Capital Forecasting & Instructions: Property/Casualty*, 2010. 43. See also "Risk Based Capital General Overview,", NAIC, 7/15/2009.

Appendix E: Pro Forma Underwriting RBC Factors

The pro forma underwriting RBC factor is the factor of industry-wide net written premium that indicates the overall combined reserve and premium risk-based capital amount for each line of business. Refer to Exhibit 8 and its footnotes for its method of calculation.

For example, the 2010 Current Homeowners/Farmowners factor of 0.176, also found in Exhibit 8 column (9), is calculated according to following formula:

$$\frac{\sqrt{(0.127 \cdot 22.3)^2 + (0.169 \cdot 59.0)^2}}{59.0}$$

where the current reserve charge (0.127), premium charge (0.169), industry reserves (22.3) and industry net written premium (59.0) come from Exhibit 8. The pro forma factors under alternative approaches are calculated according to the same formula, with the same Exhibit 8 reserve and premium amounts, but using alternative reserve charges from Exhibit 7 and alternative premium charges from Exhibit E.1 below. For example, the 1.396 factor for MM Occurrence in Exhibit E column (10) is

$$\frac{\sqrt{(0.225 \cdot 10{,}884{,}369)^2 + (0.711 \cdot 2{,}036{,}894)^2}}{2{,}036{,}894}$$

where the 0.225 reserve factor under the one-year horizon is from Exhibit 7 column (9), the 0.711 premium factor under the run-off horizon is from Exhibit E.1 column (7), and the reserve and premium dollars are shown here in thousands to reproduce the Exhibit E value to three decimal places.

For the all-lines-combined factor there was no adjustment for diversification by line of business.[18] Neither the line of business nor the overall average factors include provision for growth, loss-sensitive business, or individual company experience. These values do not reflect asset risk or reinsurance or other credit risk, all beyond the scope of the URWP's charge.

Using the alternative factors in Exhibits 7 and E.1, alternative industry-wide premium to reserve risk relativities can be calculated. For example, assuming the 95th percentile is calculated from a Normal distribution fit to the reserve run-off ratios under a one-year horizon (Exhibit 7 column (9)) and from a Normal distribution fit to loss ratios under a run-off horizon (Exhibit E.1 column (7)), the industry-wide premium charge to reserve charge would be as follows, using the factors from the exhibits' "Average" rows and using industry-wide premium and reserve dollars from Exhibit 8:

$$1.204 = \frac{0.253 \cdot 429.5}{0.161 \cdot 560.8}.$$

[18] If the industry were a single company, the credit for diversification would be approximately 23%.

This is significantly different from the current relativity calculated from Exhibit 8:

$$0.588 = \frac{66.4}{112.9}.$$

Exhibit E: Pro Forma Underwriting RBC Factors

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Filter		2010 Cur	2010 Indi-cated	Alt	Alt	Alt	Alt	Alt	Alt	Alt
Safety Level				87.5	87.5	87.5	87.5	95	95	95
Empirical/Curve Fit				Emp	Norm	Log Norm	Emp	Emp	Norm	Log Norm
Risk Horizon				Runoff	Runoff	Runoff	Rsrv: One Yr, Prem: Runoff	Rsrv: One Yr, Prem: Runoff	Rsrv: One Yr, Prem: Runoff	Rsrv: One Yr, Prem: Runoff
(1) H/F	A	0.176	0.159	0.152	0.238	0.234	0.150	0.296	0.356	0.407
(2) PPA	B	0.197	0.146	0.126	0.181	0.183	0.126	0.184	0.194	0.208
(3) CA	C	0.237	0.205	0.207	0.393	0.390	0.130	0.315	0.320	0.365
(4) WC	D	0.357	0.387	0.325	0.356	0.358	0.199	0.288	0.276	0.303
(5) CMP	E	0.376	0.370	0.280	0.425	0.416	0.084	0.232	0.267	0.315
(6) MM Occurrence	F1	1.438	0.638	1.259	1.634	1.560	0.604	1.409	1.396	1.610
(7) MM CM	F2	0.424	0.555	0.460	0.695	0.660	0.374	0.689	0.683	0.788
(8) SL	G	0.169	0.097	0.139	0.288	0.276	0.090	0.292	0.386	0.458
(9) OL	H	0.908	0.953	1.504	1.614	1.552	0.183	0.390	0.570	0.668
(11) Spec Prop	I	0.184	0.124	0.137	0.227	0.208	0.099	0.333	0.351	0.424
(12) Auto Phys Dam	J	0.094	0.066	0.052	0.070	0.068	0.050	0.100	0.125	0.142
(10) Fidelity & Surety	K	0.209	0.242	0.654	0.914	0.759	0.289	0.730	0.890	1.026
(13) Other	L	0.121	0.119	0.153	0.317	0.281	0.153	0.328	0.494	0.583
(15) International	M	0.424	0.424	0.370	0.658	0.600	0.344	1.034	0.882	1.022
(16) Reins Property & Financial	N&P	0.515	0.963	0.564	0.705	0.620	0.545	1.125	0.896	1.026
(17) Reins Liability	O	2.725	5.473	3.117	3.349	3.240	0.508	1.301	1.638	1.887
(18) Products Liability	R	2.298	6.176	5.385	5.832	5.404	0.624	2.579	2.406	2.773
(14) Fin & Mort*	S	0.585	0.585	0.585	0.585	0.585	0.585	0.585	0.585	0.585
(19) Warranty	T	0.077	0.162	0.098	0.202	0.113	0.062	0.494	0.377	0.445
Average		0.305	0.359	0.352	0.443	0.425	0.138	0.297	0.328	0.377

See notes to Exhibit 2.

Exhibit E.1: Alternative Premium Charges

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Filter		**2010 Current**	**Indicated**	**Alt**	**Alt**	**Alt**	**Alt**
Safety Level				**87.5**	**95**	**95**	**95**
Empirical/Curve Fit				**Empirical**	**Empirical**	**Normal**	**Log Normal**
Time Horizon				**Runoff**	**Runoff**	**Runoff**	**Runoff**
(1) H/F	A	0.169	0.152	0.149	0.290	0.348	0.398
(2) PPA	B	0.171	0.138	0.118	0.178	0.176	0.187
(3) CA	C	0.154	0.099	0.106	0.264	0.250	0.289
(4) WC	D	0.142	0.125	0.111	0.236	0.221	0.254
(5) CMP	E	0.100	0.069	0.055	0.197	0.195	0.236
(6) MM Occurrence	F1	0.672	0.572	0.541	0.819	0.711	0.811
(7) MM CM	F2	0.178	0.392	0.352	0.589	0.558	0.640
(8) SL	G	0.087	0.075	0.066	0.210	0.210	0.262
(9) OL	H	0.125	0.093	0.094	0.305	0.283	0.346
(11) Spec Prop	I	0.168	0.050	0.067	0.285	0.272	0.330
(12) Auto Phys Dam	J	0.094	0.065	0.050	0.097	0.120	0.135
(10) Fidelity & Surety	K	0.073	0.160	0.050	0.489	0.363	0.429
(13) Other	L	0.121	0.119	0.153	0.328	0.494	0.583
(15) International	M	0.333	0.333	0.270	0.909	0.628	0.728
(16) Reins Property & Financial	N&P	0.480	0.823	0.536	1.068	0.828	0.946
(17) Reins Liability	O	0.446	0.601	0.424	0.827	0.660	0.758
(18) Products Liability	R	0.215	0.272	0.110	0.458	0.403	0.488
(14) Fin & Mort*	S	0.585	0.585	0.585	0.585	0.585	0.585
(19) Warranty	T	0.073	0.160	0.050	0.489	0.363	0.429
Average		0.155	0.135	0.116	0.256	0.253	0.291

5. REFERENCES

[1] American Academy of Actuaries, "An Update to P/C Risk-Based Capital Underwriting Factors: September 2007 Report to the National Association of Insurance Commissioners P/C Risk-Based Capital Working Group," September 2007.
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[8] United States Treasury Department, http://www.treasury.gov/resource-center/data-chart-center/Pages/index.aspx.
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Abbreviations and notations
ACL, authorized control level
APD, automobile physical damage
AY, accident year
DCC, direct and cost-containment
IFRS, international financial reporting standards
IIO, investment income offset
NAIC, National Association of Insurance Commissioners
RBC, risk-based capital
RBCLOB, risk-based capital line of business
RRR, reserve run-off ratio
URWP, Underwriting Risk Working Party