Reserves
How Much is Enough?

Finding the Right Amount for
your Community

California Municipal League, December 2018
A Reserve is a Hedge Against Risk

*But how much is enough?*
A Complete Definition of Risk*

The **probability** and **magnitude** of a loss, disaster, or other undesirable event

*Definitions on this and previous slide from Doug Hubbard in *The Failure of Risk Management*

Why We Need Probabilities

“Without numbers, there are no odds and no **probabilities**; without odds and **probabilities**, the only way to deal with risk is to appeal to the gods and the fates. Without numbers, risk is wholly a matter of gut.”

-Peter Bernstein, *Against the Gods: The Remarkable Story of Risk*
Why Not Go With the Gut?

What will the next color be?

Cognitive Biases

- **Overconfidence bias.** We are overconfident in our predictions and underestimate uncertainty. Research shows we usually underestimate uncertainty by around 50%.

- **Availability bias.** Details that are more easily recalled are overweighed when assessing risk.
  - Example: Flood insurance

- **Confirmation bias.** Random patterns will be taken as evidence if they match an expectation.
Beware the “Flaw of Averages”*

- Averages condense down a range of possibilities into a “convenient” single number
- This obscures the variation you are subject to
- Variation is a source of uncertainty
- Understanding uncertainty is key to understanding risk


The Normal Distribution

Average 5’ 9”

4’ 5”

6’ 9”

Height
Normal Distribution in Cities

The “Tails” of a distribution are often of great interest in risk analysis.

Snowpocalypse

High Winds
Asymmetrical Distribution

Earthquakes

Tremors

Earthquakes

“The Big One”

“Subway” Uncertainty*

*Terminology from Spyros Mikridakis, et al. Dance with Chance
“Meteorite” Uncertainty

Earthquakes

Tremors
Reserves
Debt
Earthquakes
Insurance
“The Big One”

Cumulative Probability Chart

Floods

$527,000 is 90% likely to cover damages from a given flood
Risks aren’t Additive

<table>
<thead>
<tr>
<th>Likelihood of covering the extreme event</th>
<th>Hazardous Materials</th>
<th>Wildfires</th>
<th>Total (New Distribution of Total Risk)</th>
<th>Total (Simple Sum of Individual Risks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>90%</td>
<td>$3.1 million</td>
<td>$2.5 million</td>
<td>$4.7 million</td>
<td>$5.6 million</td>
</tr>
<tr>
<td>95%</td>
<td>$3.5 million</td>
<td>$2.8 million</td>
<td>$5.2 million</td>
<td>$6.3 million</td>
</tr>
<tr>
<td>99%</td>
<td>$4.1 million</td>
<td>$3.2 million</td>
<td>$6.1 million</td>
<td>$7.3 million</td>
</tr>
</tbody>
</table>

Probability of Extreme Events over Various Time Horizons

Poisson Distribution

<table>
<thead>
<tr>
<th>Number of Extreme Events that Occur</th>
<th>Time Horizon</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 year</td>
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<tr>
<td>0</td>
<td>81.9%</td>
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<tr>
<td>1</td>
<td>16.4%</td>
</tr>
<tr>
<td>2</td>
<td>1.6%</td>
</tr>
<tr>
<td>3</td>
<td>0.1%</td>
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<tr>
<td>4</td>
<td>0.0%</td>
</tr>
<tr>
<td>5</td>
<td>0.0%</td>
</tr>
</tbody>
</table>
The Method

Triple-A Approach to Uncertainty

- Accept
  - Uncertainty is inevitable
- Assess
  - Find potential impact, using reference cases – historical or analogues
- Augment
  - Uncertainty will usually be underestimated!
Probability Management

- Open-source standard for probabilistic analysis
- Works in 100% native Microsoft Excel
  - Free set of tools gives you shortcuts
- Makes “Monte Carlo” analysis more accessible than ever before

Monte Carlo Analysis

- Computerized equivalent of developing your own custom set of dice to represent the likelihood of an undesirable event, and then rolling them thousands of times to see what happens
Assess Sales Taxes
Assess Monthly Revenues

Augment Expectations for Risk

- Blue line is 12-month moving average
- Red line is actual monthly
- Great Recession revenue downturn = 12-24 months
- 2001 Dot Bomb revenue downturn = 16 months

- 70% Confidence, Reserve of 8.0%
- 90% Confidence, Reserve of 12.0%
The Model