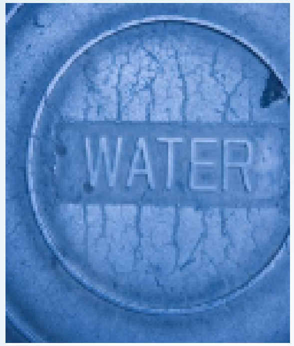
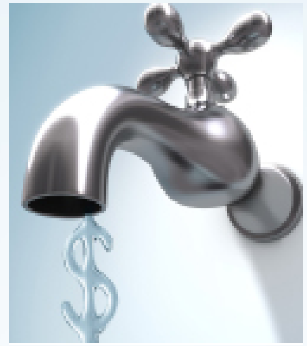
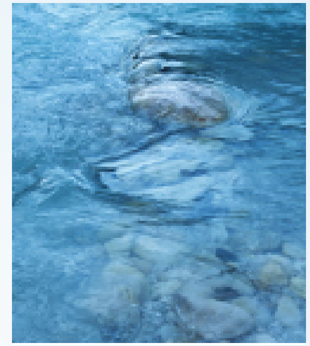
This presentation premiered at WaterSmart Innovations

watersmartinnovations.com







Building Better Water Rates for an Uncertain World: Probability Management for Laypeople

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FINANCING SUSTAINABLE WATER
Rates. Revenue. Resources.

Alliance for Water Efficiency

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The Heart of the Problem

- Water rates have traditionally been focused solely on historical cost-recovery
- When system costs change quickly, and perhaps unpredictably, historical rates do not reflect today's cost consequences
- Rates do not then give customers correct information to make consumptive decisions

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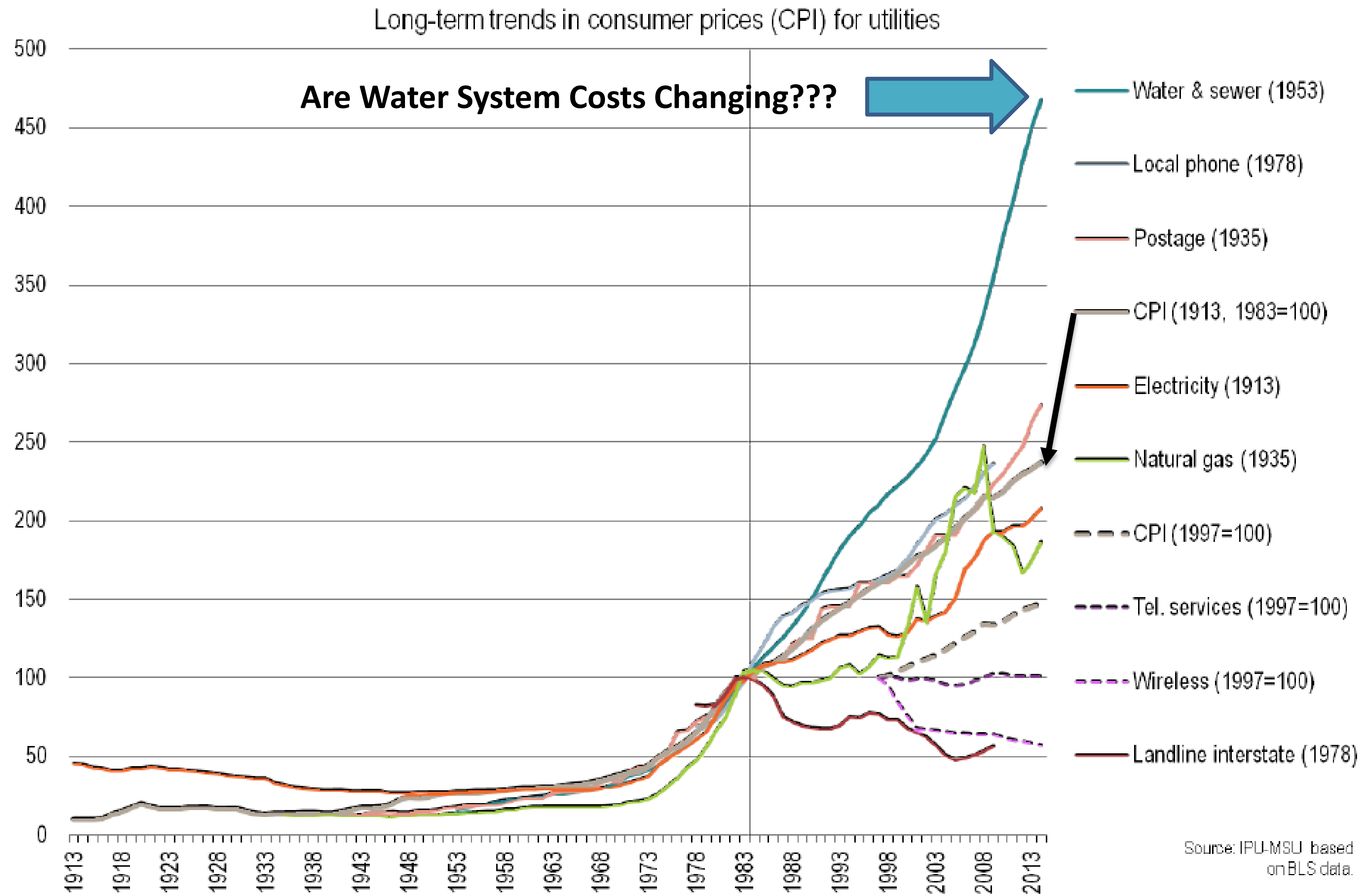


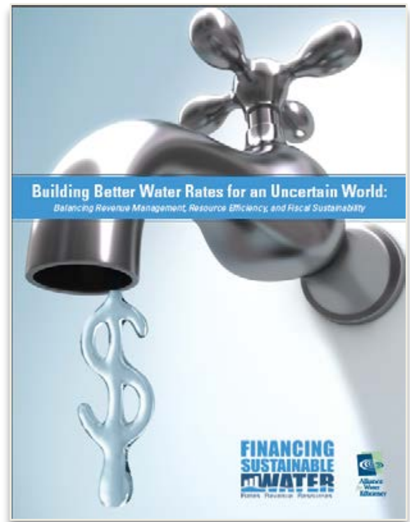
Exhibit 1. Long-term trends in the Consumer Price Index (CPI) for utilities (1913-2014). The index is set to 100 for 1982-1984 except for telephone and wireless services, where the index is set to 100 for 1997. Year (*) indicates start of series.

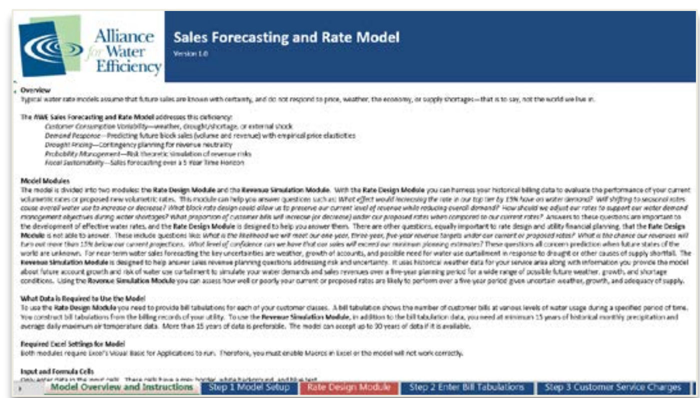
Conservation is Part of the Solution

- It is a long-term cost reducer to the utility
- Revenue loss is often due to other drivers
- Every gallon saved is water that does not have to be pumped, treated and delivered
- Conservation is an investment and short-term effects must be planned for
- Reduced utility costs generally mean reduced customer rates in the long-term due to avoided infrastructure capacity increases

Financing Sustainable Water

- **Building Better Rates in an Uncertain World:** A Handbook to explain key concepts, provide case studies and implementation advice
- **AWE Sales Forecasting and Rate Model:** An innovative, user-friendly tool to model scenarios, solve for flaws, and incorporate uncertainty into rate making
- **FinancingSustainableWater.org:** Web-based resources to convene the latest research and information in one location





AWE Handbook

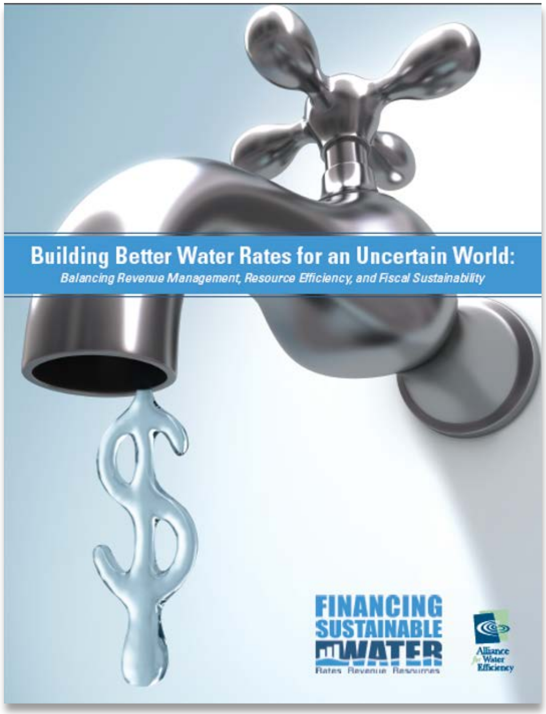
Building Better Water Rates for an Uncertain World

Balancing Revenue Management, Resource Efficiency, and Fiscal Sustainability

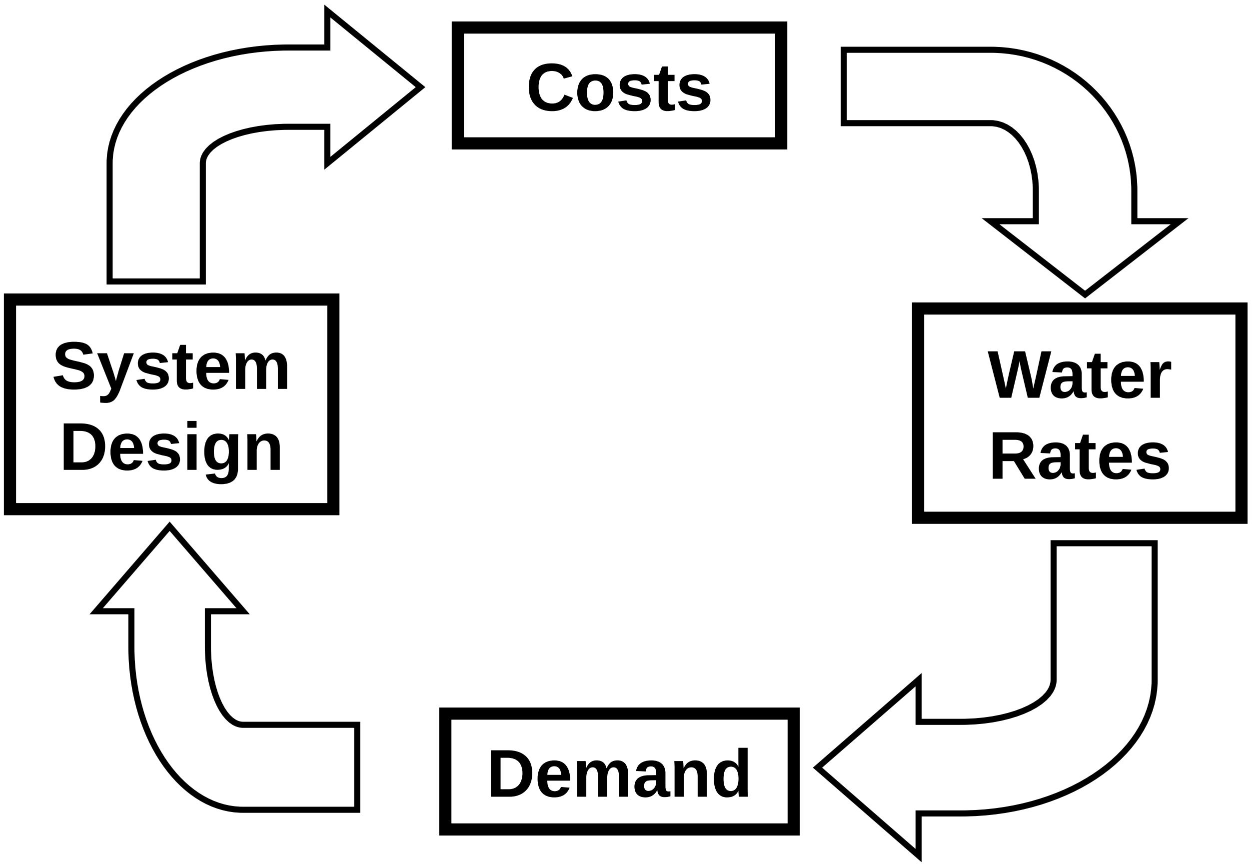
SECTION I: Introduction
SECTION II: Today's Imperative for Utility Financial Management
SECTION III: The Role of Ratemaking
SECTION IV: Building a Better (Efficiency-Oriented) Rate Structure
SECTION V: Financial Policies & Planning for Improved Fiscal Health
SECTION VI: Implementing an Efficiency-Oriented Rate Structure

Appendices

- Appendix A – Costing Methods
- Appendix B – Demand and Revenue Modeling
- Appendix C – AWE Sales Forecasting and Rate Model User Guide



Flow of Economic Logic



How Do Utilities Address This?

- **Ends** of Water Utilities: Water Services
  - *Reliable Delivery of Quality Water*
  - *Handling of Waste water, Storm water, Watershed management*
- By what financial **means** do utilities achieve these ends?
  - *Cost Recovery (Short term)*
  - *Resource Efficiency (Short and Long term)*
  - *Fiscal Sustainability (Long term)*

Why a New Rate Model?

Typical water rate models assume that future sales are known with certainty, and do not respond to price, weather, the economy, or supply shortages—that is to say, not the world we live in.

- The **AWE Sales Forecasting and Rate Model** addresses this deficiency:
  - *Customer Consumption Variability*—weather, drought/shortage, or external shock
  - *Demand Response*—Predicting future block sales (volume and revenue) with empirical price elasticity's
  - *Drought Pricing*—Contingency planning for revenue neutrality
  - *Probability Management*—Risk theoretic simulation of revenue risks using SIPmath®
  - *Fiscal Sustainability*—Sales forecasting over a 5 Year Time Horizon
  - *Affordability*—Can customers afford water service?


Alliance for Water Efficiency
Sales Forecasting and Rate Model
Version 1.0

Overview
Typical water rate models assume that future sales are known with certainty, and do not respond to price, weather, the econo

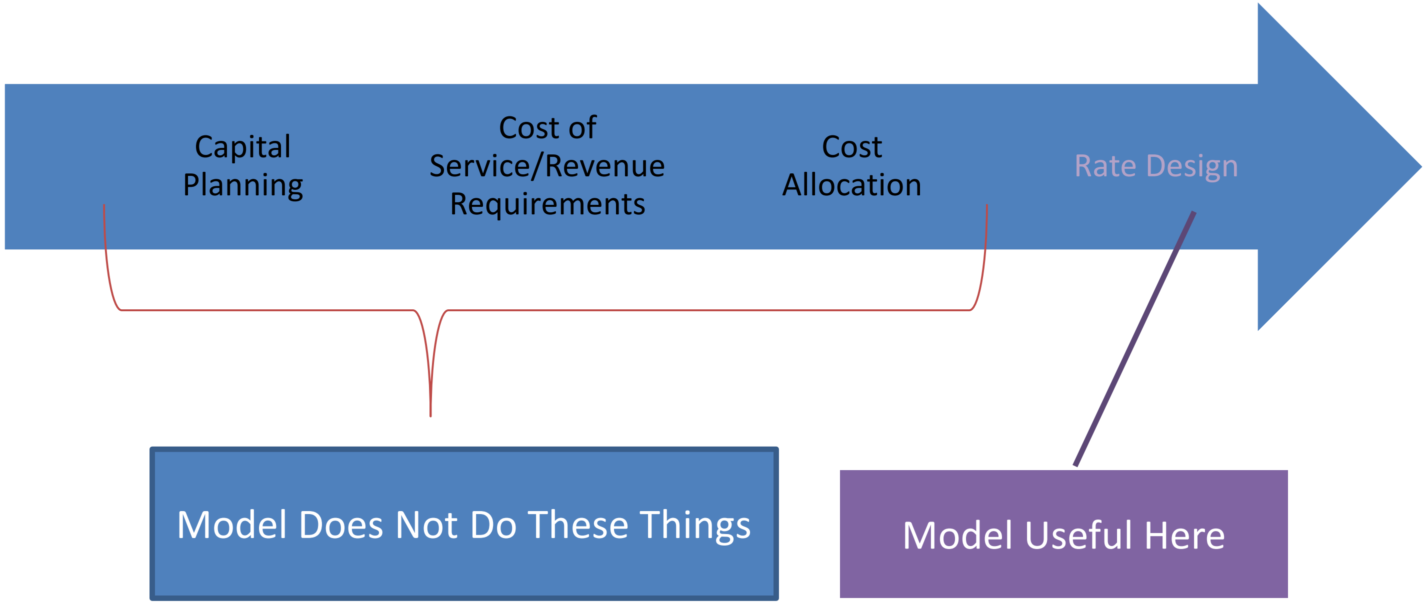
The **AWE Sales Forecasting and Rate Model** addresses this deficiency:
Customer Consumption Variability—weather, drought/shortage, or external shock
Demand Response—Predicting future block sales (volume and revenue) with empirical price elasticities
Drought Pricing—Contingency planning for revenue neutrality
Probability Management—Risk theoretic simulation of revenue risks
Fiscal Sustainability—Sales forecasting over a 5 Year Time Horizon

Model Modules
The model is divided into two modules: the **Rate Design Module** and the **Revenue Simulation Module**. With the **Rate Design**
volumetric rates or proposed new volumetric rates. This module can help you answer questions such as: *What effect would in*
cause overall water use to increase or decrease? What block rate design could allow us to preserve our current level of revenue
management objectives during water shortages? What proportion of customer bills will increase (or decrease) under our propo
the development of effective water rates, and the **Rate Design Module** is designed to help you answer them. There are other
Module is not able to answer. These include questions like: *What is the likelihood we will meet our one-year, three-year, five-y*
turn out more than 15% below our current projections. What level of confidence can we have that our sales will exceed our mi
world are unknown. For near-term water sales forecasting the key uncertainties are weather, growth of accounts, and possibl
Revenue Simulation Module is designed to help answer sales revenue planning questions addressing risk and uncertainty. It u
about future account growth and risk of water use curtailment to simulate your water demands and sales revenues over a five
conditions. Using the **Revenue Simulation Module** you can assess how well or poorly your current or proposed rates are likely

What Data is Required to Use the Model
To use the **Rate Design Module** you need to provide bill tabulations for each of your customer classes. A bill tabulation shows
You construct bill tabulations from the billing records of your utility. To use the **Revenue Simulation Module**, in addition to th

Model Overview and Instructions	Step 1 Model Setup	Rate Design Module	Step 2 Enter Bill Tabulations	Step 3 Custom

WHERE MODEL FITS INTO RATE SETTING PROCESS



What Rate Designs Can Be Modeled?

- Rate Designs
  - Uniform
  - Seasonal
  - Block
  - Seasonal Block
- Up to 5 blocks
- Can vary rates and blocks by customer class
- Up to six customer classes

What Data is Needed to Use It?

- Bill Tabulations from Billing System Data
  - By Class
  - By Season (Off-Peak, Peak)
- Follows AWWA M1 Bill Tabulation Methodology
- Allocating Bills to Seasons
  - Easy when bills are rendered monthly
  - Bit harder when bills are rendered bi-monthly or quarterly

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Bill Tabulation Screenshot

Step 2: Enter Customer Class Bill Tabulations

On this worksheet, you enter bill tabulations for your Bill Tabulation Year for the customer classes you set up in Step 1. A bill tabulation shows the number of
bills may not fall neatly into the seasons you defined in Step 1,creating a seasonal bill tabulation is more challenging than creating an annual bill tabulation. It
which this read date corresponds). It will always be the case that consumption will span the two seasons for some bills. In these cases, you will need to have
are in the first season, then assign it to the first season). The User Guide provides additional guidance and examples for preparing your bill tabulations. In add
using your meter read data.

Go back to Rate Design Module Worksheet

Usage Bin (Thou. Gal.)		Customer Class: Single Family				Customer Class: Multi Family			
		Off Peak Season		Peak Season		Off Peak Season		Peak Season	
		Oct - Apr		May - Sep		Oct - Apr		May - Sep	
From	To	Bills in Bin	Total Use of Bills in Bin (Thou. Gal.)	Bills in Bin	Total Use of Bills in Bin (Thou. Gal.)	Bills in Bin	Total Use of Bills in Bin (Thou. Gal.)	Bills in Bin	Total Use of Bills in Bin (Thou. Gal.)
0	0	1,854	0	700	0	36	0	17	0
1	1	1,781	1,781	601	601	11	11	4	4
2	2	2,073	4,146	631	1,262	12	24	3	6
3	3	3,122	9,366	787	2,361	8	24	5	15
4	4	4,084	16,336	917	3,668	22	88	4	16
5	5	4,974	24,870	1,122	5,610	22	110	9	45
6	6	5,751	34,506	1,150	6,900	20	120	7	42
7	7	6,548	45,836	1,322	9,254	29	203	10	70
8	8	7,080	56,640	1,354	10,832	41	328	6	48
9	9	7,883	70,947	1,385	12,465	49	441	10	90
10	10	8,173	81,730	1,531	15,310	54	540	9	90
11	11	8,333	91,663	1,554	17,094	55	605	10	110
12	12	8,439	101,268	1,588	19,056	45	540	15	180
13	13	8,309	108,017	1,565	20,345	66	858	18	234
14	14	8,377	117,278	1,552	21,728	80	1,120	21	294
15	15	8,082	121,230	1,611	24,165	81	1,215	17	255

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Rate Design Table

Block #	Block Switch Point	Rate for Block
Block 1	10	$2.50
Block 2	20	$3.00
Block 3		$3.75
Block 4		$3.75
Block 5		$3.75

Rate for first 10 units

Rate for next 10 units

Rate for units in excess of 20

Copy rate in last block to unused blocks

Rate Design Screenshot

Rate Design Tables

Rate Performance Indicators

2. Specify rates for each Customer Class in the tables below.

Use the tables below to specify the Current and Proposed rates for each Customer Class. You can specify ock, seasonal, and seasonal block rates.

Uniform and Uniform Seasonal Designs: Enter the same rate for all five blocks. If you want the uniform ra by season, set a different uniform rate for each season.

Block and Seasonal Block Designs: Enter the blocks and rates for each block level. You can specify up to 5 b If you want fewer blocks than 5 -- say 3 -- then enter the same rate and block information for Block 4 and Block 5 that you did for Block 3. If you want seasonal block rates, you can fy different blocks and/or rates for each season.

Mixed Designs: You can vary the rate design by Customer Class and season. For example, you can specify a ck rate for the single family residential class and uniform rates for all other classes. Or you can specify a uniform rate for one season and a block rate for the other.

Save/Load Rates button

Save/Load Rates

Single Family

	Off Peak Season				Peak Season			
	Current Rates		Proposed Rates		Current Rates		Proposed Rates	
	Block (CCF)	Rate ($/CCF)	Block (CCF)	Rate ($/CCF)	Block (CCF)	Rate ($/CCF)	Block (CCF)	Rate ($/CCF)
Block 1	5	$3.00	5	$2.50	5	$3.00	5	$3.75
Block 2	10	$3.00	10	$2.50	10	$3.00	10	$3.75
Block 3	15	$3.00	15	$2.50	15	$3.00	15	$3.75
Block 4	15	$3.00	15	$2.50	15	$3.00	15	$3.75
Block 5	15	$3.00	15	$2.50	15	$3.00	15	$3.75

Rate Performance by Customer Class

Annual Sales Volume

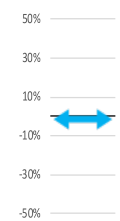
	Current	Proposed	% Change
CCF	9,069,061	8,913,705	-1.7%

Annual Revenue (Thou. $)

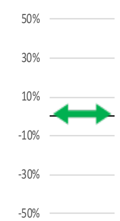
	Current	Proposed	% Change
Service	$12,263	$12,263	0.0%
Volume	$27,207	$27,744	2.0%
Total	$39,470	$40,007	1.4%

Impact of Proposed Rates Relative to Current Rates

Annual Sales Volume (% Change)



Annual Service & Volume Revenue (% Change)



Bill Impacts Screenshot

Avg and median bill impacts

Affordability Indicator

Bill Impact Histograms

3. Bill impacts of Proposed rates

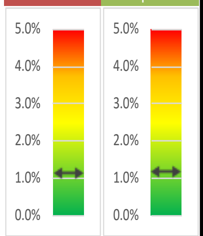
Under your Proposed rates, the volume charge may go up for some customers and down or stay the same for others. The Bill Impacts Table shows the percentage of bills that will go down, stay the same, or go up -- and by how much. Charts showing the distribution of bill impacts for each customer class are provided on the Bill Impacts worksheet.

% Change in Average and Median Annual Water Service Cost by Customer Class

	Average Annual Water Service Cost			Median Annual Water Service Cost		
Customer Class	Current	Proposed	% Change	Current	Proposed	% Change
Single Family	$777	$804	3.4%	$650	$672	3.3%
Multi Family	$4,254	$4,294	0.9%	$1,930	$1,942	0.6%
CII	$3,323	$3,382	1.8%	$1,481	$1,504	1.5%
Landscape	$5,599	$6,007	7.3%	$2,503	$2,720	8.7%
Not in use						
Not in use						

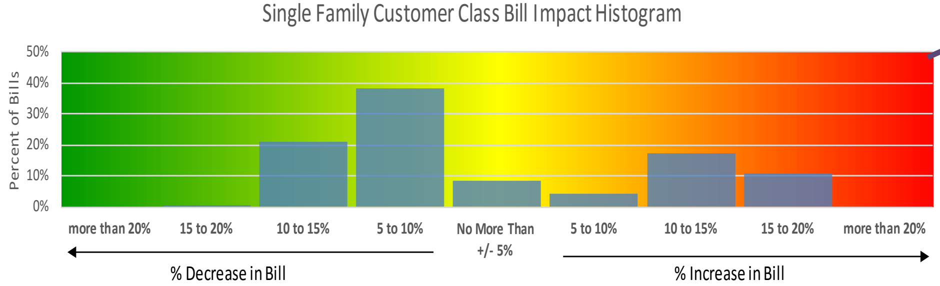
Affordability Index

Affordability index equals the median annual water cost for the primary residential customer class divided by median household income.



Bill Impacts Table

	% of bills decreasing by				No More Than	% of bills increasing by			
Customer Class	more than 20%	15 to 20%	10 to 15%	5 to 10%	+/- 5%	5 to 10%	10 to 15%	15 to 20%	more than 20%
Single Family	0%	0%	21%	38%	9%	4%	17%	11%	0%
Multi Family	0%	1%	38%	25%	4%	4%	18%	12%	0%
CII	0%	0%	25%	20%	28%	7%	9%	10%	0%
Landscape	0%	0%	26%	12%	33%	2%	6%	20%	0%
Not in use									
Not in use									



Drought Rates

- Evaluate rate performance under water use curtailment
- Up to 4 drought stages can be specified
- Curtailment levels can vary by customer class
- User can design rates “by hand”, OR
- Use built-in calculator to find revenue-neutral rates by drought stage

Specifying Curtailment Levels

Requested curtailment level by stage

1. Specify Curtailment Levels for Drought/Shortage Stages

1. Enter the Customer Class curtailment levels for each stage. If you have fewer than 4 stag… e last curtailment level in the unused stages. Stage 0 is the default No Shortage condition. Do not modify the settings for this stage.
2. For each stage, enter the expected compliance rate. The compliance rate can vary by sta… xample, stages with voluntary curtailment may have lower compliance than stages where curtailment is mandatory and enforced. The expected curtailment level f… e is the product of the stage's curtailment level and the expected compliance rate.

	Drought/Shortage Stage Customer Class Curtailment L…s Table					Expected Curtailment				
Customer Class	**Stage 0**	**Stage 1**	**Stage 2**	**Stage 3**	**Stage 4**	**Stage 0**	**Stage 1**	**Stage 2**	**Stage 3**	**Stage 4**
Single Family	0%	10%	15%	20%	25%	0%	8%	12%	17%	21%
Multi Family	0%	10%	15%	20%	25%	0%	8%	12%	17%	21%
CII	0%	0%	10%	20%	25%	0%	0%	8%	17%	21%
Landscape	0%	0%	10%	20%	25%	0%	0%	8%	17%	21%
Not in use	0%					0%	0%	0%	0%	0%
Not in use	0%					0%	0%	0%	0%	0%
Enter Expected Compliance %	100%	80%	80%	85%	85%					

Expected compliance rate

Expected curtailment

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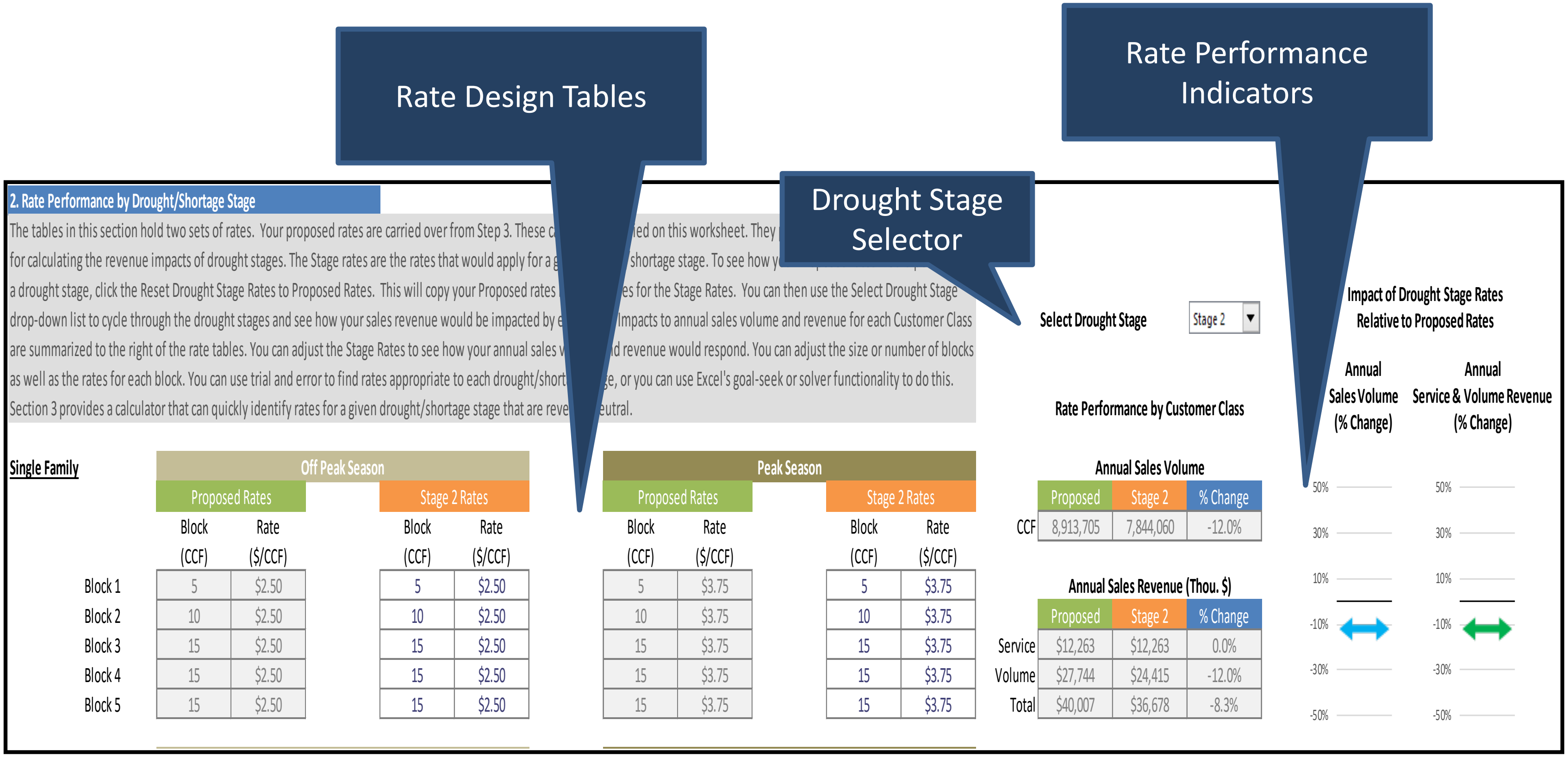
Designing Drought Rates



2. Rate Performance by Drought/Shortage Stage

The tables in this section hold two sets of rates. Your proposed rates are carried over from Step 3. These c ed on this worksheet. They for calculating the revenue impacts of drought stages. The Stage rates are the rates that would apply for a g shortage stage. To see how y a drought stage, click the Reset Drought Stage Rates to Proposed Rates. This will copy your Proposed rates es for the Stage Rates. You can then use the Select Drought Stage drop-down list to cycle through the drought stages and see how your sales revenue would be impacted by e Impacts to annual sales volume and revenue for each Customer Class are summarized to the right of the rate tables. You can adjust the Stage Rates to see how your annual sales v d revenue would respond. You can adjust the size or number of blocks as well as the rates for each block. You can use trial and error to find rates appropriate to each drought/short e, or you can use Excel's goal-seek or solver functionality to do this. Section 3 provides a calculator that can quickly identify rates for a given drought/shortage stage that are reve eutral.

Single Family

	Off Peak Season				Peak Season			
	Proposed Rates		Stage 2 Rates		Proposed Rates		Stage 2 Rates	
	Block (CCF)	Rate ($/CCF)	Block (CCF)	Rate ($/CCF)	Block (CCF)	Rate ($/CCF)	Block (CCF)	Rate ($/CCF)
Block 1	5	$2.50	5	$2.50	5	$3.75	5	$3.75
Block 2	10	$2.50	10	$2.50	10	$3.75	10	$3.75
Block 3	15	$2.50	15	$2.50	15	$3.75	15	$3.75
Block 4	15	$2.50	15	$2.50	15	$3.75	15	$3.75
Block 5	15	$2.50	15	$2.50	15	$3.75	15	$3.75

Rate Performance by Customer Class

Annual Sales Volume

	Proposed	Stage 2	% Change
CCF	8,913,705	7,844,060	-12.0%

Annual Sales Revenue (Thou. $)

	Proposed	Stage 2	% Change
Service	$12,263	$12,263	0.0%
Volume	$27,744	$24,415	-12.0%
Total	$40,007	$36,678	-8.3%

Drought Rate Calculator

3. Calculate Revenue Neutral Rates by Drought Stage

The revenue neutral rates calculator will quickly find a set of rates for a given drought/shortage stage that will generate the same revenue as your Proposed rates under a no shortage condition. There are four steps to using the calculator:

1. Choose the drought/shortage stage you want to calculate rates for.
2. Choose the method for calculating the rates. There are two choices. The first choice is to adjust your Proposed rates so that each customer class generates the same revenue it would have generated under your Proposed rates assuming no use curtailment. This may result in significant differences across classes in the amount by which rates are adjusted. The second choice is to adjust your Proposed rates so that all classes when grouped together are revenue neutral. Rates across classes will be adjusted by the same proportionate amount. Revenue neutrality may not hold for individual classes, but overall revenue will be neutral to the Proposed rates assuming no use curtailment.
3. Complete the Leave or Adjust Rate in Block table below. Choose Leave if you want the rate in the block to be the same as it is for your Proposed rates. Choose Adjust if you want the calculator to adjust this rate. For example, if you only want to adjust the upper block rates, choose Leave for lower blocks and Adjust for upper blocks. If you have fewer than 5 blocks, set the unused blocks to the same setting used for your last block.
4. Make desired adjustments to the block widths for the Stage Rates in the Stage Rates tables above.
5. Click the Find Revenue Neutral Rates button.

Note: The calculator will overwrite the rates that are in the Stage Rates tables above. If you want to preserve these rates, save them as a rate scenario by clicking the Save/Load Rates button before using the calculator.

Choose Drought Stage to Evaluate: Stage 2

Choose Method for Calculating Revenue Neutral Rates: 1. Scale rates so that each customer class is revenue neutral

Find Revenue Neutral Rates

Reset Drought Stage Rates to Proposed Rates

Save/Load Rates

Leave or Adjust Rate in Block?

Class	Block 1	Block 2	Block 3	Block 4	Block 5
Single Family	Leave	Adjust	Adjust	Adjust	Adjust
Multi Family	Leave	Adjust	Adjust	Adjust	Adjust
CII	Leave	Adjust	Adjust	Adjust	Adjust
Landscape	Leave	Adjust	Adjust	Adjust	Adjust
Not in use	Leave	Leave	Leave	Leave	Leave
Not in use	Leave	Leave	Leave	Leave	Leave

Limitations of the Rate Design Module

Plans based on average assumptions are wrong on average --
Sam Savage, The Flaw of Averages

- Results only as good as the **bill tabulation** data
- Can only evaluate how rates will perform **ON AVERAGE**
- Does not provide insight into VARIABILITY of performance
- That's where the **Revenue Simulation Module** steps in

Revenue Simulation Module

Questions the Simulation Module Can Address

- *What is the likelihood we will meet our one-year, three-year, five-year revenue targets under our current or proposed rates?*
- *What is the chance our revenues will turn out more than 15% below our current projections?*
- *What level of confidence can we have that our sales will exceed our minimum planning estimates?*

What is Net Revenue Volatility?

- Empirical view of Volatility: Definition in Finance
  - One year change
- Big *Scary* Question: How does sales variation affect **Net Revenues** (Revenues minus Costs)
- Typically the more revenues collected on variable/commodity charges the more potential for revenue volatility (up and down)
  - Exception: Seasonal Rates (Peak season demand can be less variable)

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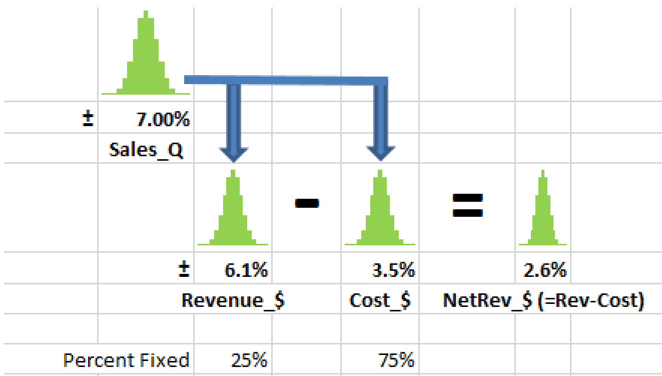
Short Term: The Shape of Uncertainty and Revenue Risk

Annual Sales Volatility,
standard deviation of ≈ 7 %



$$Revenue = Fixed\ Revenue + Variable\ Revenue$$

or

$$Revenue = Fixed\ Revenue + Volumetric\ Rate * Sales\ Volume$$

-

$$Cost = Fixed\ Cost + Variable\ Cost$$

$$Cost = Fixed\ Cost + Unit\ Cost_i * SupplyVolume_i$$

=

Net Revenue = Revenue – Costs
±2.6%

Monte Carlo Simulation Results

Short Term Uncertainty looks manageable; **Don't** Celebrate **Yet.**

ProbabilityManagement.org

Sam Savage on
Curing the *Flaw of Averages*

Probability

Management

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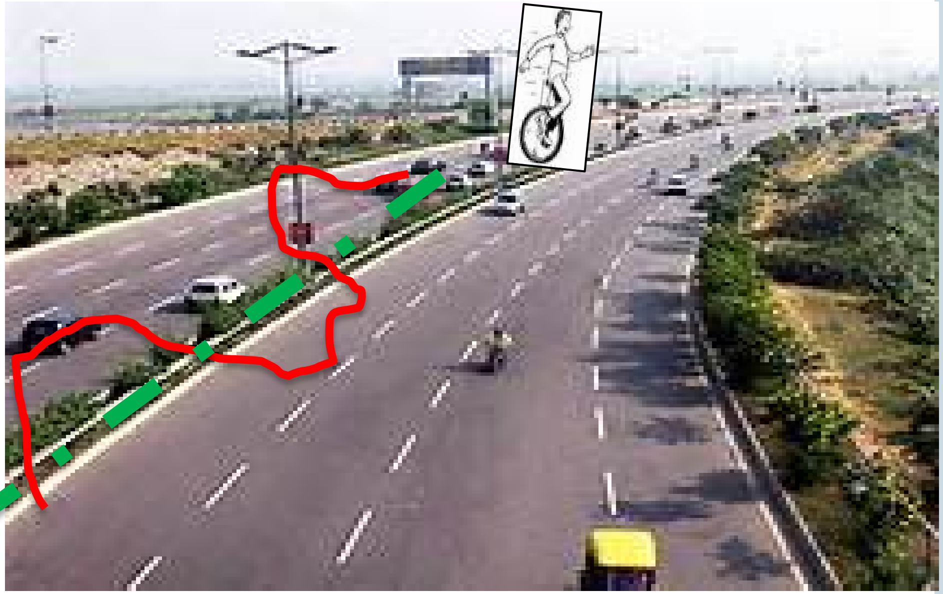
Average Outcome vs. Likely Outcomes

Flaw of Averages

- **Fact 1** – Planning for the future is rife with uncertainties.
- **Fact 2** - Most people are not happy with Fact 1 and prefer to think of the future in terms of average outcomes.
- **Fact 3** - The "flaw of averages" states that plans based on average assumptions are, on average, wrong.

-adapted from Savage (2012) Flaw of Averages

www.probabilitymanagment.org



The cyclist is safe on the average path

On average, the cyclist is dead.

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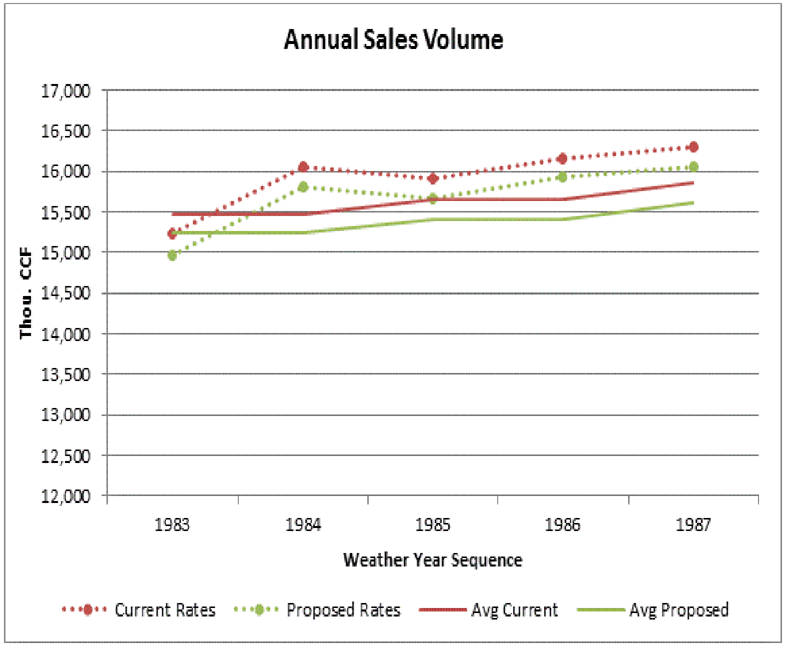
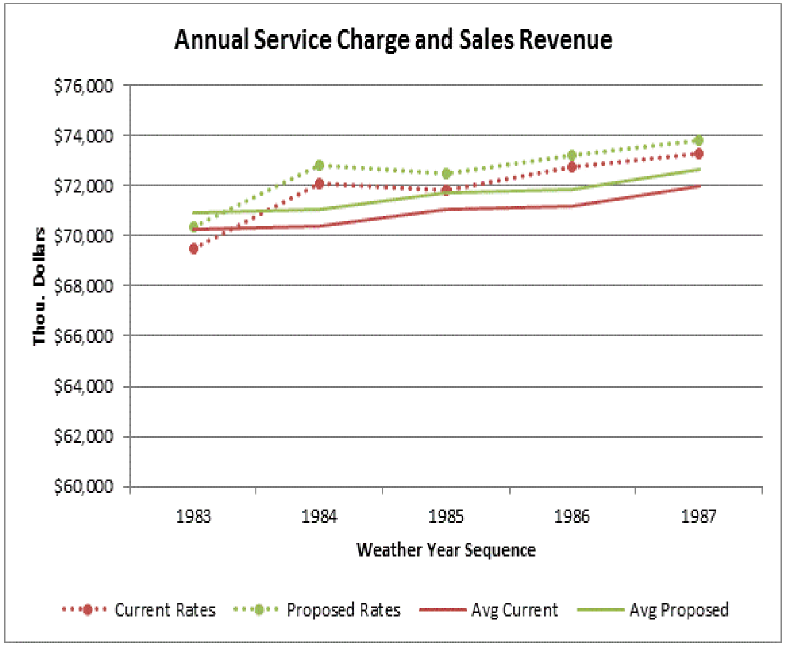
Do Water Sales stay on the average path? Then why do water sales forecasts?





Answer: They don't have to.

AWE Sales Forecasting and Rate Model: Open Source Drought Rates

http://www.financingsustainablewater.org/tools/awe-sales-forecasting-and-rate-model

FINANCING SUSTAINABLE WATER
Rates. Revenue. Resources.

Alliance for Water Efficiency

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Towards an Alternative Decision-Making Framework

- **Information** can reduce uncertainty. Information that cannot effect a decision has no strategic value.
- **Interactive simulation** is a strategy for explicitly displaying the effects of a decision on uncertain outcomes.
- **Diversification**—spreading risk over a variety of outcomes—helps minimize the likelihood of extreme outcomes.

SIPs and SLURPs of Water

- Interactive simulation and visualization better communicate decision uncertainties
- SIP – Stochastic Information Packets
  - *In the SIPmath™ 2.0 Standard, uncertainties are communicated as data arrays called SIPs (Stochastic Information Packets). Thus random draws from uncertain possibilities are stored as a column of realizations.*
- SLURP – Stochastic Library Unit Relations Preserved
  - *A **coherent** set of SIPs that preserve statistical relationships between uncertainties is known as a Stochastic Library Unit with Relationships Preserved (SLURP).*

Stochastic Information Packets (SIPs)

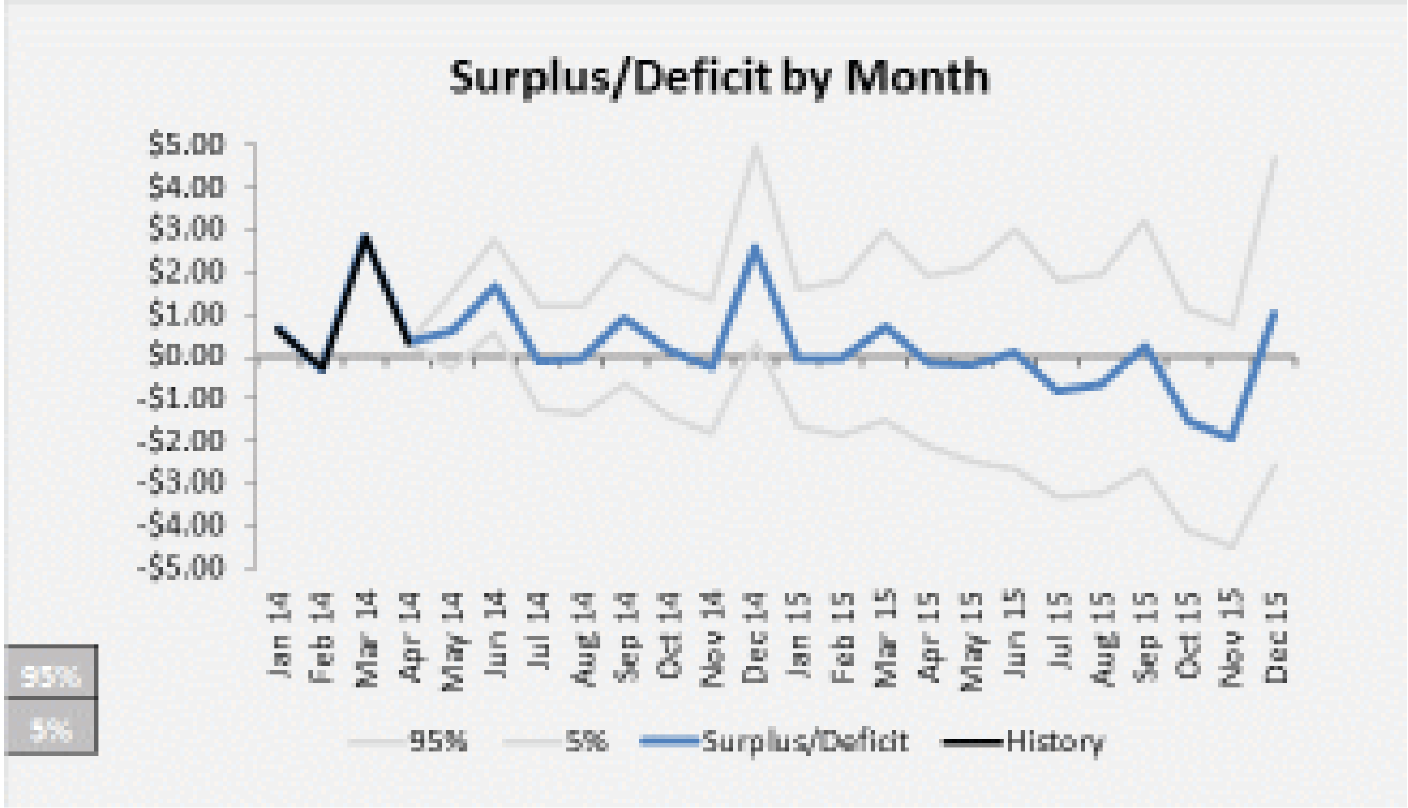
- SIPs advance the modeling of uncertainty.

- SIPs are:
- Actionable
- Additive
- Auditable

SIPmath™ 2.0 Standard

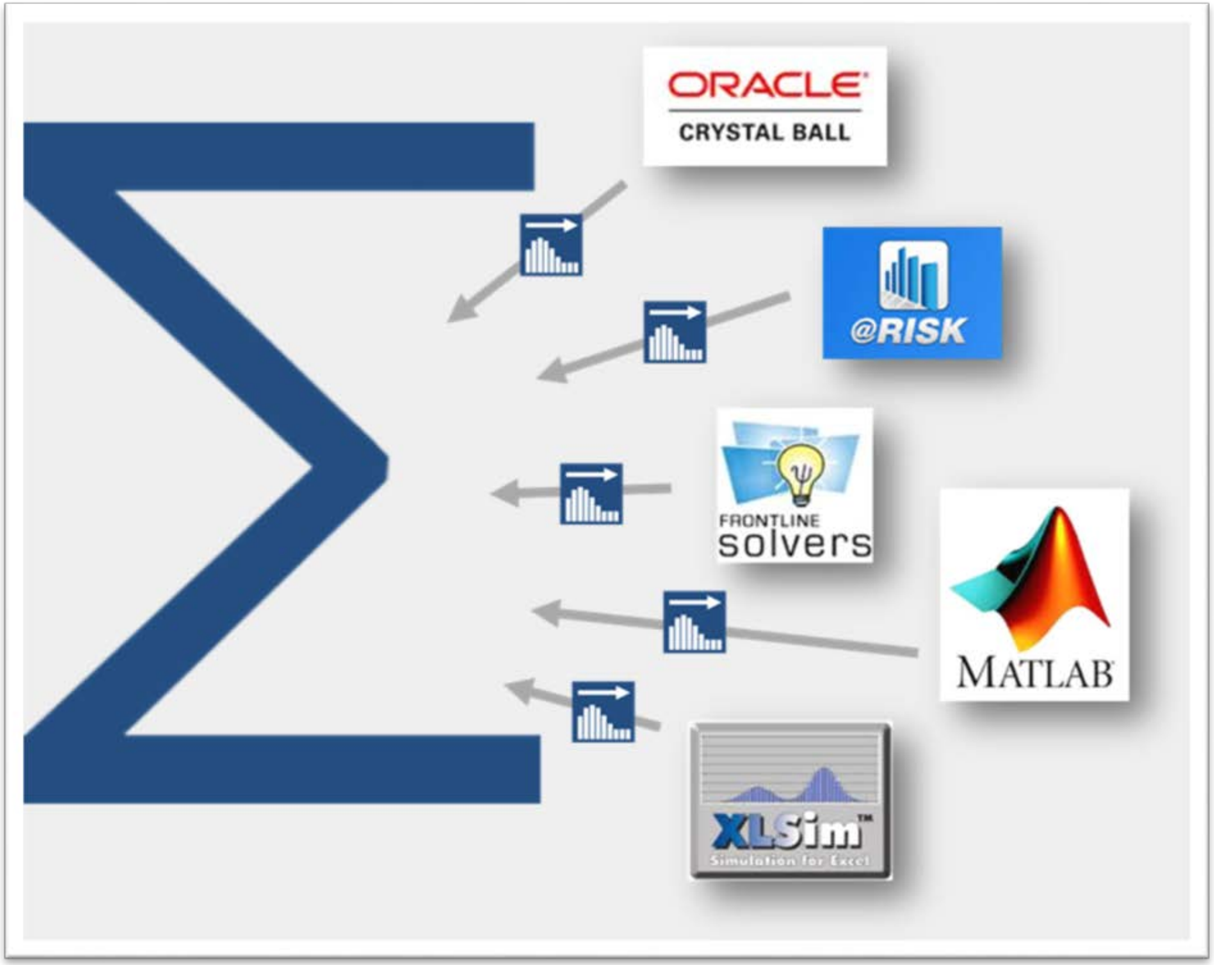
SIPMath™ is Actionable

Sips can be used directly in calculations of uncertainty.
Cells in Excel can refer to SIPs instead of a single number.
No macros or add-ins need remain in the spreadsheet.



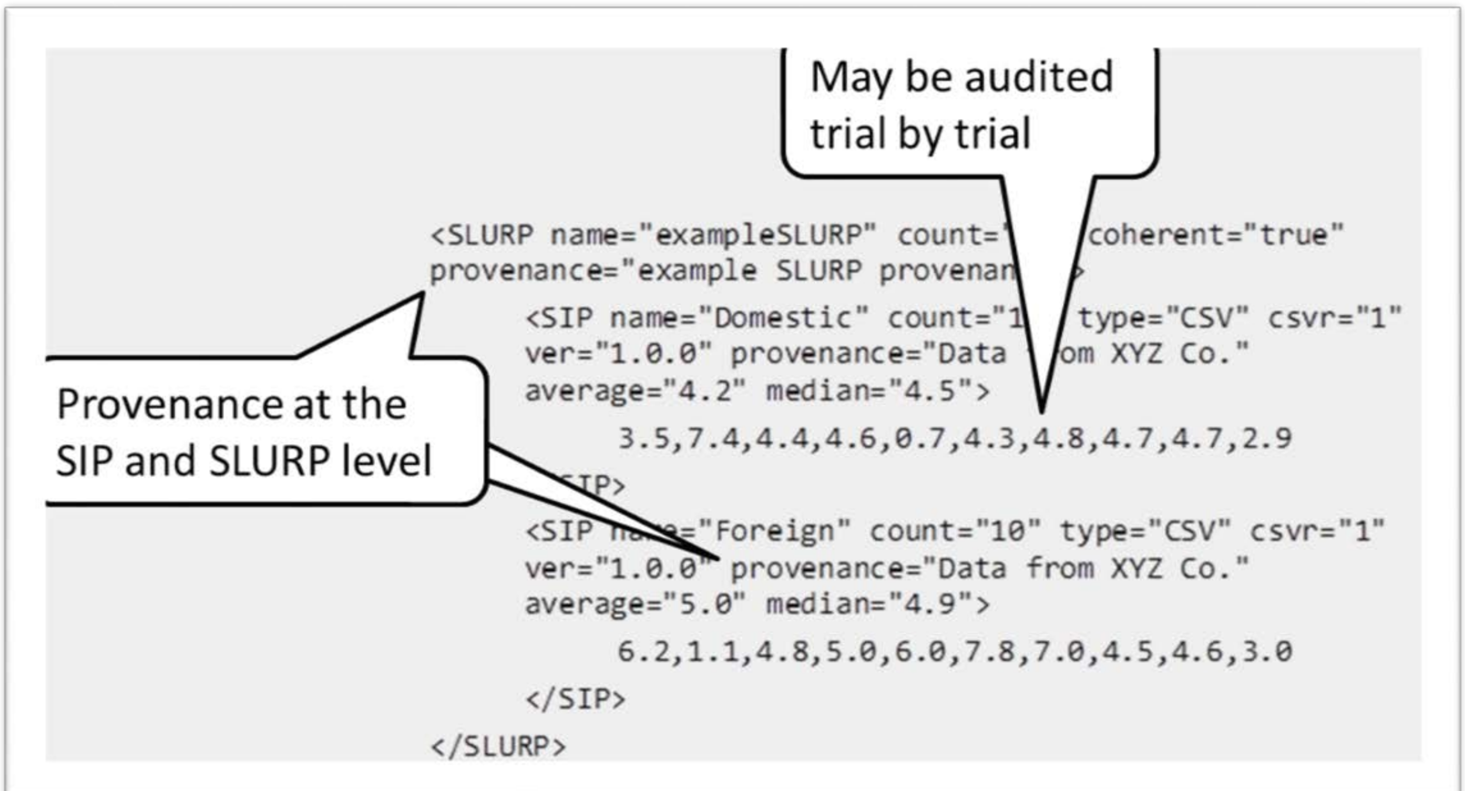
SIPMath™ is Additive

Uncertainties can be summed, enabling enterprise risk management



SIPMath™ is Auditable

The SIPMath™ standard requires provenance.
Saved SIPs can be replicated using same seed=auditability.



How Does Probability Management Work in The AWE Rate Model?

- The model focuses on three variables that are key to short-run revenue performance:
  - Weather (historical or synthetic)
  - Growth (projected)
  - Supply disruption/use curtailment (correlated to weather)
- Two rate designs are simultaneously evaluated:
  - Current rate (reference condition)
  - Proposed rate
- Simulation enacted with SIPmath®

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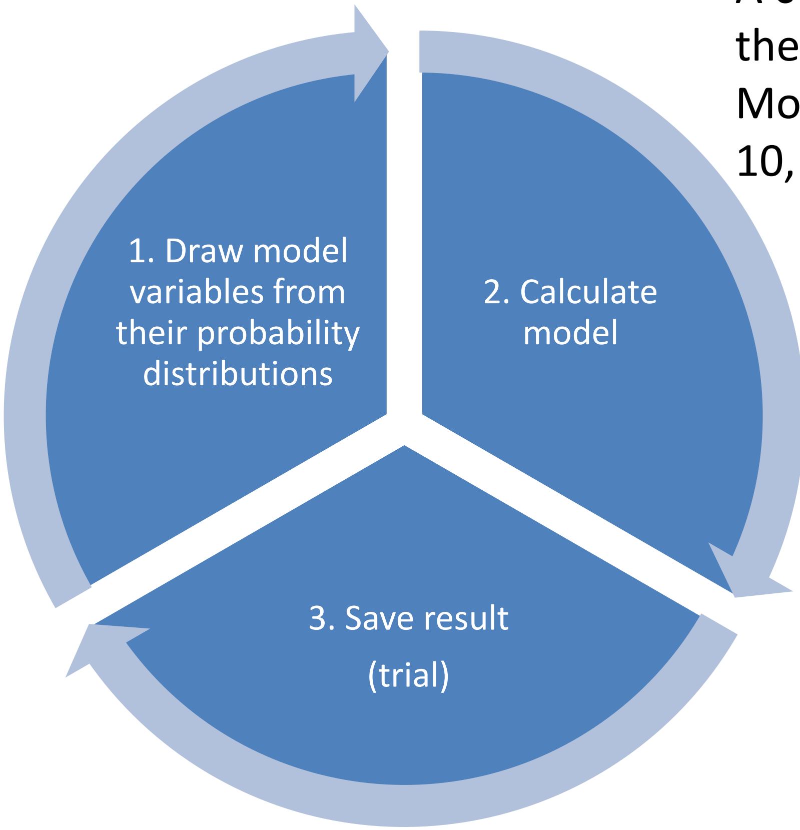
Simulation Process

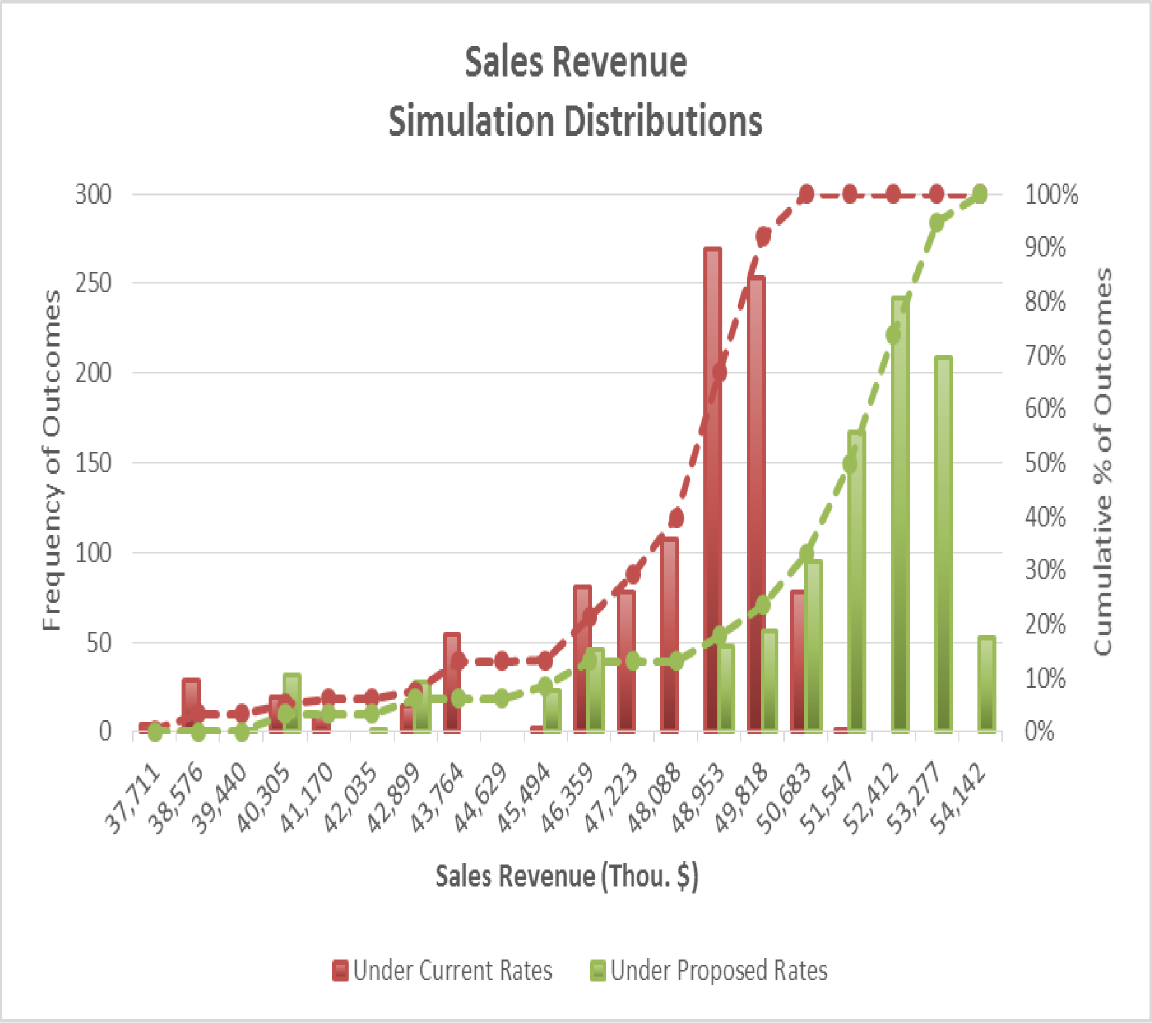


A cycle constitutes 1 trial. In the Revenue Simulation Module, User can simulate 10, 100, 500, or 1000 trials.

Why Simulate?

- Alternatives to simulation are:
  - Ignore uncertainty (a common strategy)
  - Construct scenarios (also common)
  - Both are problematic
- Simulation offers:
  - More complete enumeration of possible outcomes
  - Likelihood of particular outcomes

Simulation of Sales Revenue Distribution



Additional Data Needed for Module

- Weather
  - Monthly Precipitation and Temperature data for Service Area
    - *Historical (up to 90 years), OR*
    - *Synthetic (for example, to simulate impact of climate change)*
  - Easy to get historical weather data for service areas – Guidebook recommends several sources for weather data
- Customer Class Account Growth
  - User specifies Low, Medium, High Account Growth Rates, by Class

Weather Data Screenshot: Two SIPs make a SLURP

Can enter up to 90 yrs. Need at least 15. More is better than less.

Can modify historical weather for future climate change if desired.

Step 6: Enter Weather Data to be Used

On this worksheet you enter historical mor ... ow your demands may vary in respons

You can enter up to a maximum of 90 years ... ears. It also must be complete across

It is not required that you provide data for ... rate rows of the tables. To get reliabl

Consult the user guide for information on weather data sources.

Go back to Revenue Simulation Module Worksheet

Go forward to Step 7: ... heet

1. Set most recent year in your weather data

Enter the most recent year for which you are providing weather data.

Most recent year: 2012

2. Enter Monthly Precipitation Totals (in)

Enter total monthly precipitation in inches for each year of weather data you have for your service area.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	2.91	1.18	4.17	2.56	0.00	0.04	0.00	0.00	0.00	0.87	4.09	5.83
2011	1.18	4.06	6.26	0.28	0.79	1.93	0.00	0.00	0.00	0.91	1.22	0.08
2010	5.71	2.80	1.93	3.82	1.06	0.00	0.00	0.00	0.00	0.83	1.85	5.71
2009	1.02	6.34	2.36	1.22	0.71	0.00	0.00	0.00	0.16	3.74	0.59	2.40
2008	7.13	1.85	0.12	0.08	0.00	0.00	0.00	0.00	0.00	0.04	2.36	1.81
2007	0.43	3.70	0.24	0.59	0.28	0.00	0.00	0.00	0.12	1.22	0.75	2.40
2006	2.24	1.97	6.26	4.25	1.02	0.00	0.00	0.00	0.00	0.12	1.42	2.95
2005	4.33	3.31	2.60	1.46	1.26	0.28	0.00	0.00	0.00	0.12	0.94	10.04
2004	2.48	5.04	0.91	0.08	0.08	0.00	0.00	0.00	0.08	2.64	2.17	3.90
2003	1.14	0.98	1.46	3.58	0.51	0.00	0.00	0.00	0.00	0.00	1.65	5.94
2002	0.75	1.54	1.89	0.16	1.18	0.00	0.00	0.00	0.00	0.00	2.40	8.66
2001	1.89	5.51	1.10	1.14	0.00	0.12	0.00	0.00	0.12	0.28	3.58	7.01
2000	5.79	8.11	2.01	0.79	1.14	0.08	0.00	0.00	0.04	1.34	0.75	0.39
1999	2.76	5.12	2.48	1.69	0.08	0.00	0.00	0.00	0.00	0.31	2.05	0.51
1998	8.03	12.20	2.09	1.26	2.64	0.00	0.00	0.00	0.16	0.79	3.07	0.67
1997	8.19	0.20	0.24	0.24	0.28	0.20	0.00	0.47	0.00	0.79	5.47	2.56
1996	5.28	5.94	2.44	1.81	1.77	0.00	0.00	0.00	0.00	0.91	2.72	6.89
1995	9.84	0.20	8.62	1.06	1.22	1.18	0.00	0.00	0.00	0.00	0.00	6.77
1994	1.77	3.94	0.20	0.87	1.61	0.00	0.00	0.00	0.00	0.67	5.91	2.48
1993	8.46	4.25	2.13	0.59	0.55	0.39	0.00	0.00	0.00	0.31	2.52	2.36
1992	1.38	5.94	3.11	0.31	0.00	0.28	0.00	0.00	0.00	1.38	0.16	6.02

3. Enter Monthly Average Maximum Air Temperature (degrees F)

Enter the monthly average daily maximum air temperature in degrees Fahrenheit for each year of we...er data you have for your service area. Be sure you are entering average daily **maximum** air temperature and not average daily air temperature.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	61.0	63.0	63.0	70.6	78.6	82.9	85.9	87.3	83.4	75.7	65.8	56.9
2011	56.2	60.5	62.7	69.0	72.4	79.2	84.3	84.5	86.4	76.5	62.8	60.0
2010	55.1	60.8	65.3	66.1	72.5	82.6	84.1	83.3	85.2	74.9	64.7	57.2
2009	60.4	59.1	65.4	70.6	78.6	80.4	86.6	87.1	88.0	73.3	65.7	54.6
2008	53.7	60.8	66.5	71.6	77.7	85.3	86.7	88.5	85.1	78.1	66.9	54.7
2007	58.2	60.8	70.5	72.2	77.7	83.9	86.1	87.0	80.8	72.9	67.4	55.9
2006	58.5	63.2	59.3	66.0	77.8	84.9	91.8	83.9	83.0	74.0	64.2	57.9
2005	52.7	61.3	67.0	68.8	74.9	78.7	89.7	87.2	80.1	75.6	67.8	58.8
2004	55.1	59.7	74.0	75.0	77.9	83.2	85.9	87.0	86.7	73.1	62.2	56.8
2003	59.2	61.5	67.6	64.9	76.6	83.3	91.1	86.3	86.6	81.5	61.7	56.6
2002	55.0	63.0	64.6	69.5	76.1	84.0	87.5	86.1	86.1	76.2	66.9	58.1
2001	57.0	59.2	69.1	67.9	85.9	87.2	84.0	86.4	82.1	78.7	65.9	55.7
2000	58.8	60.0	66.5	72.9	76.9	84.5	82.5	86.1	84.3	73.1	61.0	59.3
1999	55.3	58.5	60.8	69.1	73.0	80.7	83.2	83.3	82.8	79.3	66.4	61.2
1998	56.3	57.6	64.9	67.5	67.3	76.5	85.4	88.9	82.6	73.8	62.3	55.3
1997	56.0	63.4	69.9	73.1	82.6	83.0	86.5	84.6	86.1	75.2	65.5	56.5
1996	57.9	62.1	67.1	72.9	77.5	84.3	89.5	88.9	82.1	75.5	65.1	59.0
1995	57.1	61.3	62.2	68.3	71.7	79.9	86.2	87.7	83.8	79.2	71.2	59.9
1994	58.2	58.4	68.4	70.9	74.1	83.4	84.4	87.0	82.4	75.3	58.0	53.0
1993	54.8	58.7	67.2	69.9	75.8	84.6	85.7	86.6	84.1	76.8	65.3	55.0
1992	52.8	63.7	65.7	74.8	81.9	80.8	85.7	88.8	84.9	79.1	66.6	54.2

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Calculation of Weather Effects

- Based on **CUWCC GPCD Weather Normalization Methodology and Empirical Model**
- Accounts for
  - Seasonal Shape of Demand
  - Relative Importance of (weather sensitive) Outdoor Use
- Monthly effects formed into weighted-average seasonal effect
- Weighting accounts for:
  - Monthly contribution to total seasonal use
  - Strength of monthly weather effect on total seasonal use
- Weather effect coefficients can be modified by user

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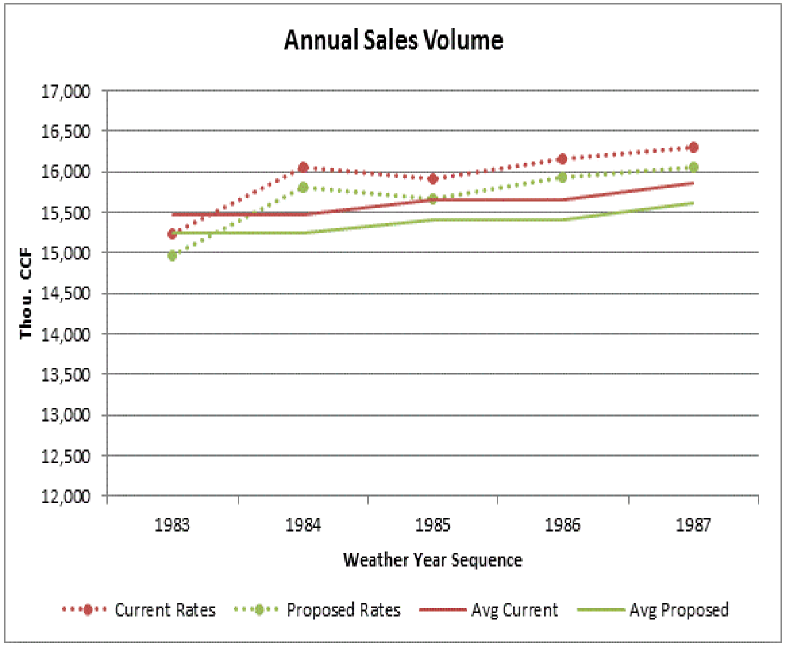
Uncertain Account Growth

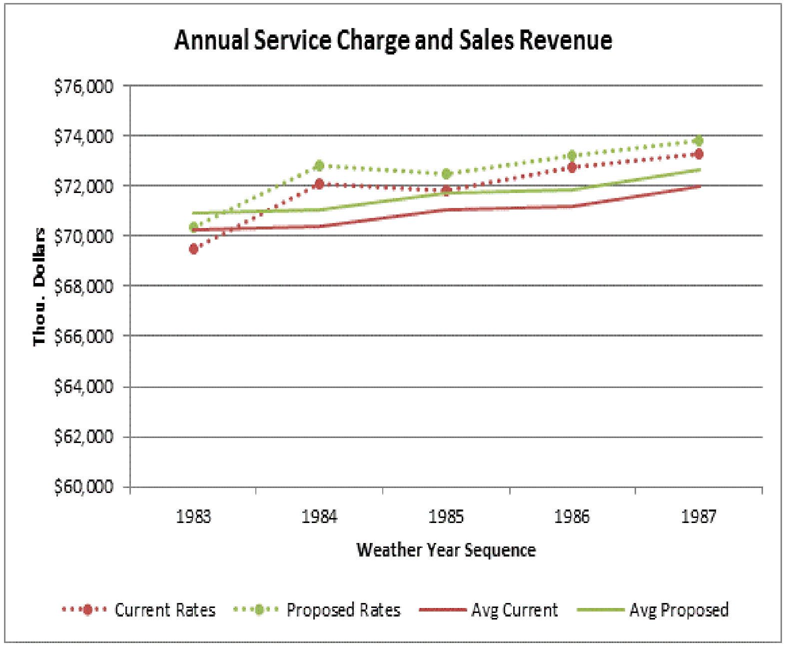
- Can simulate with or without growth uncertainty
  - No Growth
  - Certain Growth
  - Uncertain Growth
- If Uncertain Growth, then Low, Medium, High Growth Rates transformed into probability distribution
  - Normal
  - Triangular
  - Uniform
- User specifies which distribution to use

Water Use Curtailments

- Three Choices
  - Exclude from simulation
  - Associate with historical weather (preferred method)
  - Specify likelihood

Are Future Sales and Revenue Uncertain?





Drought Pricing

- Shortages are when, not if.
- Imposing curtailments on customers affects revenues
- This can be planned for, communicated, and effectively implemented.

Drought Rates Missing from Most Local Drought Plans in California

Posted February 24, 2014 in Living Sustainably, U.S. Law and Policy

Print this page

Tags: AWWA, California, climatechange, consumer, drought, waterbills, waterconservation, waterrates

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Today they're short of water. Tomorrow they'll be short of cash. As water supplies dwindle in the face of the driest year in California's history, most of the state's urban water utilities face 2014 financially flatfooted.

CalTrans Highway Sign 2014 -- photo: Eric Beteille, pedestrianphotographer.com

Drought

- Let’s talk probability and evidence
- What is the probability of a more than one decade-long drought? …Where? When?
  - In the Southwest US
  - Within a 50 year period,
    - *1950 to 2000?*
    - *Or better 2050-2099?*

Odds and “P” Value

1 in 100 ≡ P01

1 in 10 ≡ 10 in 100 ≡ P10

1 in 5 ≡ 20 in 100 ≡ P20

Answer - P80

[I'm not making this up.]

This will be on the test…new vocabulary

- Megadrought
- Semi-permanent drought

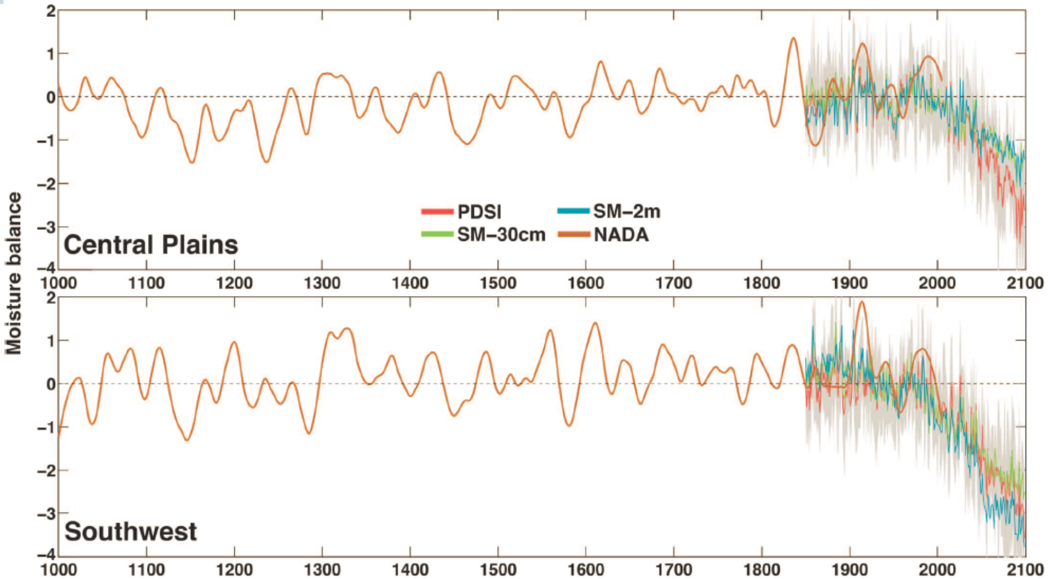


Fig. 1. Top: Multimodel mean summer (JJA) PDSI and standardized soil moisture (SM-30cm and SM-2m) over North America for 2050–2099 from 17 CMIP5 model projections using the RCP 8.5 emissions (125°W–105°W, 32°N–41°N). Bottom: Regional average time series of the summer season moisture balance metrics from the NADA and CMIP5 models. The observational NADA PDSI series (brown) is smoothed using a 50-year

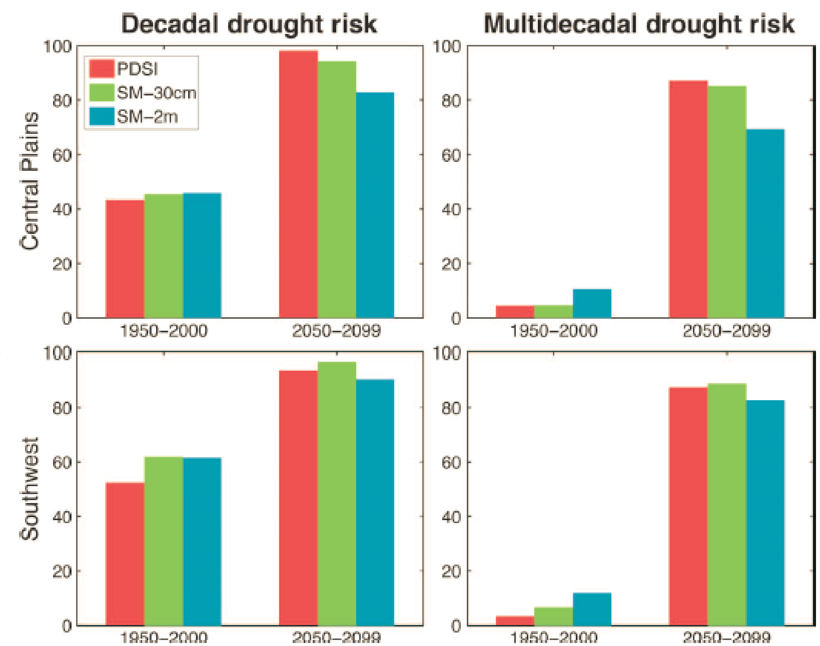


Fig. 5. Risk (percent chance of occurrence) of decadal (11-year) and multidecadal (35-year)

Citation: B. I. Cook, T. R. Ault, J. E. Smerdon, Unprecedented 21st century drought risk in the American Southwest and Central Plains. *Sci. Adv.* **1**, e1400082 (2015).

advances.sciencemag.org/content/advances/1/1/e1400082.full.pdf

Associate Drought Stage with Historical Weather

Preferred Method

3. Enter Monthly Average Maximum Air Temperature (degrees F)

Enter the monthly average daily maximum air temperature in degrees Fahrenheit for each year of weather data you have for your service area. Be sure you are entering average daily **maximum** air temperature and not average daily air temperature.

4. Enter Drought Shortage Stage

(Optional) For each hydrologic year you can select what drought/shortage stage would have applied given your current system supplies and customer demands. You can then have the model use this information when it simulates water sales. This is explained further in Step 5 Setup Simulation.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Stage	Index
2012	61.0	63.0	63.0	70.6	78.6	82.9	85.9	87.3	83.4	75.7	65.8	56.9	Stage 0	0
2011	56.2	60.5	62.7	69.0	72.4	79.2	84.3	84.5	86.4	76.5	62.8	60.0	Stage 0	0
2010	55.1	60.8	65.3	66.1	72.5	82.6	84.1	83.3	85.2	74.9	64.7	57.2	Stage 0	0
2009	60.4	59.1	65.4	70.6	78.6	80.4	86.6	87.1	88.0	73.3	65.7	54.6	Stage 2	2
2008	53.7	60.8	66.5	71.6	77.7	85.3	86.7	88.5	85.1	78.1	66.9	54.7	Stage 0	0
2007	58.2	60.8	70.5	72.2	77.7	83.9	86.1	87.0	80.8	72.9	67.4	55.9	Stage 0	0
2006	58.5	63.2	59.3	66.0	77.8	84.9	91.8	83.9	83.0	74.0	64.2	57.9	Stage 0	0
2005	52.7	61.3	67.0	68.8	74.9	78.7	89.7	87.2	80.1	75.6	67.8	58.8	Stage 0	0
2004	55.1	59.7	74.0	75.0	77.9	83.2	85.9	87.0	86.7	73.1	62.2	56.8	Stage 0	0
2003	59.2	61.5	67.6	64.9	76.6	83.3	91.1	86.3	86.6	81.5	61.7	56.6	Stage 0	0
2002	55.0	63.0	64.6	69.5	76.1	84.0	87.5	86.1	86.1	76.2	66.9	58.1	Stage 0	0
2001	57.0	59.2	69.1	67.9	85.9	87.2	84.0	86.4	82.1	78.7	65.9	55.7	Stage 1	1
2000	58.8	60.0	66.5	72.9	76.9	84.5	82.5	86.1	84.3	73.1	61.0	59.3	Stage 0	0
1999	55.3	58.5	60.8	69.1	73.0	80.7	83.2	83.3	82.8	79.3	66.4	61.2	Stage 0	0
1998	56.3	57.6	64.9	67.5	67.3	76.5	85.4	88.9	82.6	73.8	62.3	55.3	Stage 0	0
1997	56.0	63.4	69.9	73.1	82.6	83.0	86.5	84.6	86.1	75.2	65.5	56.5	Stage 0	0
1996	57.9	62.1	67.1	72.9	77.5	84.3	89.5	88.9	82.1	75.5	65.1	59.0	Stage 0	0
1995	57.1	61.3	62.2	68.3	71.7	79.9	86.2	87.7	83.8	79.2	71.2	59.9	Stage 0	0
1994	58.2	58.4	68.4	70.9	74.1	83.4	84.4	87.0	82.4	75.3	58.0	53.0	Stage 0	0
1993	54.8	58.7	67.2	69.9	75.8	84.6	85.7	86.6	84.1	76.8	65.3	55.0	Stage 0	0
1992	52.8	63.7	65.7	74.8	81.9	80.8	85.7	88.8	84.9	79.1	66.6	54.2	Stage 0	0
1991	57.8	65.3	59.6	68.5	72.7	77.9	85.1	82.0	84.4	80.6	67.6	57.1	Stage 4	4
1990	57.0	57.8	65.4	73.3	74.6	81.8	85.8	84.7	83.3	79.2	65.9	53.9	Stage 3	3
1989	55.6	56.8	63.4	73.5	75.6	80.5	86.4	83.1	79.0	74.5	67.2	57.0	Stage 2	2
1988	56.2	66.0	70.1	70.9	74.6	81.3	89.2	84.5	83.1	75.7	62.6	57.1	Stage 1	1
1987	55.2	62.1	64.8	76.2	78.8	81.5	80.9	83.9	82.6	77.7	63.6	55.2	Stage 0	0

Drought Stage association table

Additional Resources

- www.waterrf.org
  - WaterRF 4175 - A Balanced Approach to Water Conservation in Utility Planning, 2012.
  - www.waterrf.org/ExecutiveSummaryLibrary/4175_ProjectSummary.pdf
  - WaterRF 2935 – Water Efficiency Programs for Integrated Water Management, 2007.
  - http://www.waterrf.org/ExecutiveSummaryLibrary/91149_2935_profile.pdf
- www.financingsustainablewater.org
  - AWE Handbook-Building Better Water Rates for an Uncertain World
  - http://www.financingsustainablewater.org/tools/building-better-water-rates-uncertain-world
  - AWE Sales Forecasting and Rate Model: Open Source Drought Rates
  - http://www.financingsustainablewater.org/tools/awe-sales-forecasting-and-rate-model

Free tools and examples at….

http://probabilitymanagement.org/sip-math.html

and

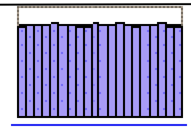
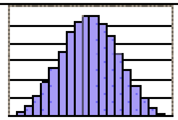
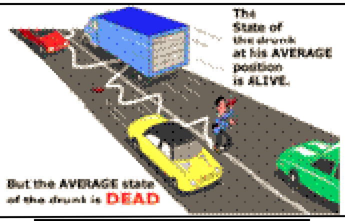
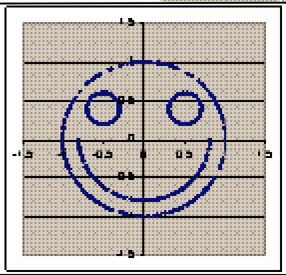
http://probabilitymanagement.org/models.html

The Free SIPmath™ Tools to facilitate the creation of such models:

http://probabilitymanagement.org/tools.html

Mindle = A Handle for the Mind

Five Basic Mindles for Grasping Uncertainty

Green Words Things you know already	Mindles Things to improve your grasp	Things to Remember	Things to Forget
Uncertainty vs. Risk	Risk is in the eye of the beholder.	**Risk Attitude**	**UTILITY THEORY**
Uncertain Number	SHAPE 	**Distribution, Histogram Cumulative Distribution Percentiles**	**RANDOM VARIABLE**
Combinations of Uncertain Numbers	SHAPE 	**Diversification Flaw of Averages (weak form)**	**VARIANCE, STANDARD DEVIATION, CENTRAL LIMIT THEOREM**
Plans Based on Uncertain Numbers		**Flaw of Averages (strong form)**	**FUNCTIONS OF RANDOM VARIABLES, JENSEN'S INEQUALITY**
Interrelated Uncertain Numbers		**Scatter Plot**	**STATISTICAL DEPENDENCE, CORRELATION, COVARIANCE**

S. Savage: *Flaw of Averages,* overview on p 47. One chapter on each mindle.

Save the date

- Click on hyperlink below
- http://events.r20.constantcontact.com/register/event?oeidk=a07eb2lk97u9fd05b26&llr=lr9yi7pab
- Use the Super Super Secret code **ANTE246** for a discount on your registration fee.

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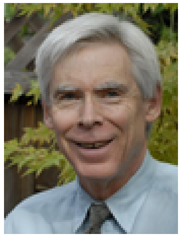

Sam Savage
Executive Director, Probability Management.org and author of *The Flaw of Averages*

Doug Hubbard
President of Hubbard Decision Research and author of *How to Measure Anything*

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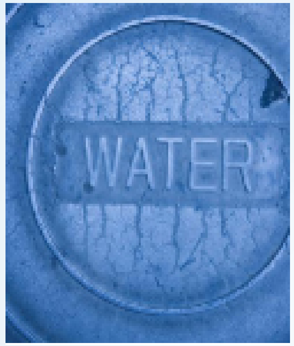
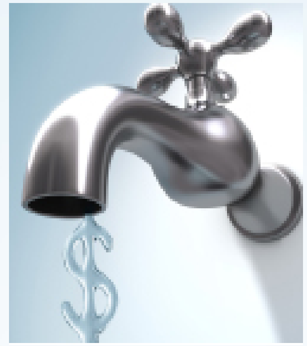
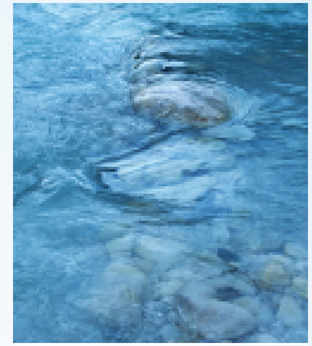
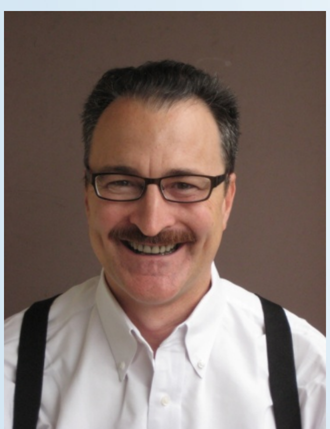


Building Better Water Rates for an Uncertain World



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