



PROMOTING THE EFFICIENT AND SUSTAINABLE
USE OF WATER

Sales Forecasting and Rate Model

Version 1.0

User Guide

AUGUST 2014

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1 About This Guide

This document is divided into the following chapters:

- **Chapter 1, About This Guide** describes the intended audience for this guide.
- **Chapter 2, Introducing the Sales Forecasting and Rate Model** provides an overview of the tool.
- **Chapter 3, Important Terminology** defines key terms and concepts used throughout the guide.
- **Chapter 4, Getting Started** explains the structure of the model and how to set it up for use.
- **Chapter 5, Using the Rate Design Module** guides you through how to use the Rate Design Module to evaluate alternative rate designs under both normal and drought conditions.
- **Chapter 6, Using the Revenue Simulation Module** guides you through how to use the Revenue Simulation Module to evaluate the performance of alternative rate designs over a five-year forecast period.
- **Chapter 7, Run the Demo** walks you through a series of exercises to help you learn the model using the Demo data that comes with the model.
- **Chapter 8, Rate Design Module Calculations** explains the underlying calculations used to calculate annual water sales and revenues in the Rate Design Module.
- **Chapter 9, Revenue Simulation Module Calculations** explains the underlying calculations used to implement the rate performance simulation.
- **Chapter 10, Getting Weather Data** lists several public sources of data for compiling historical weather information for your service area.
- **Chapter 11, Visual Basic Macros** lists the Visual Basic macros that drive the backend of the model and provides a brief explanation of what each one does.

1.1 Who Should Use It

This guide is intended for users with different degrees of knowledge and experience with AWE's Sales Forecasting and Rate Model. The guide provides first-time users an overview of the purpose and uses of the model, describes system and software requirements, and explains how to set up and use the model to design and evaluate water rate structures. More experienced users will find the guide a useful reference document for using the model. This guide assumes that you have basic knowledge of the Windows operating system and Excel.

1.2 Model Use Disclaimer

The Sales Forecasting and Rate Model is free software and comes with ABSOLUTELY NO WARRANTY. Users are advised that rate development and revenue forecasting is a multi-step process that includes (1) determination of system revenue requirements, (2) functional allocation of costs, (3) attribution of functionally allocated costs to specific customer classes or individual customers, and (4) design of rates and charges. The Sales Forecasting and Rate Model is designed to assist utilities with the last step – design of rates and charges. It is not designed to estimate or allocate utility revenue requirements. Users unfamiliar with water utility rate design are strongly encouraged to consult rate development reference manuals from Alliance for Water Efficiency, California Urban Water Conservation Council, or American Water Works Association prior to using this model.

2 Introducing the Sales Forecasting and Rate Model

2.1 Purpose

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 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

2.2 Model Modules

The model is divided into two modules: the **Rate Design Module** and the **Revenue Simulation Module**.

2.2.1 The Rate Design Module

With the **Rate Design Module** you can harness your historical billing data to evaluate the performance of your current volumetric rates or proposed new volumetric rates. This module can help you answer questions such as: *What effect would increasing the rate in our top tier by 15% have on water demand? Will shifting to seasonal rates cause overall water use to increase or decrease? What block rate design could allow us to preserve our current level of revenue while reducing overall demand? How should we adjust our rates to support our water demand management objectives during water shortages? What proportion of customer bills will increase (or decrease) under our proposed rates when compared to our current rates?* Answers to these

questions are important to the development of effective water rates, and the **Rate Design Module** is designed to help you answer them.

How does the Rate Design Module work? At the core of the Rate Design Module are bill tabulations you provide the model for each of your customer classes. A bill tabulation shows the number of customer bills at various levels of water usage during a specified period of time. You construct bill tabulations from the billing records of your utility. The Rate Design Module requires bill tabulations for two periods: an off-peak and peak period, which you will specify when you setup the model for the first time. Using the bill tabulation data, the model calculates how moving from your current to a proposed rate schedule would impact your water demands and water sales revenues. In making these calculations, it accounts for not only the distribution of customer water use from your bill tabulations, but also the effect that raising or lowering the cost of water has on customer water demands.

What Rate Designs can be used with the Rate Design Module? You have great flexibility in the rate designs you can evaluate with the Rate Design Module. You can specify uniform, seasonal, block, or seasonal block rates. Block designs can have as many as five different block levels. The number of blocks, size of blocks, and rates within blocks can each differ by season and by customer class.

How are impacts of water shortages on water sales and revenue modeled? In Step 5: Drought Rate Adjustments you can input the water use curtailment stages for your utility's drought/shortage response plan. You can specify up to four curtailment stages and input the level of expected water use curtailment by customer class for each stage. The model combines this information with your bill tabulation data to calculate the expected change in your water sales and revenues under your proposed rates for each curtailment stage. You can also use the model to determine what adjustments you would need to make to your proposed rates in order to meet specific revenue or demand reduction objectives for each stage of shortage.

What are some limitations to this approach? Results generated by the Rate Design Module tie-back directly to your bill tabulation data. Thus, if water usage for the year selected for the bill tabulation was abnormally low or high due to climatic or economic conditions, the results generated by the model may not be representative of your normal conditions. If possible, the selection of bills for tabulation should reflect a year in which average conditions prevail. Given bill tabulations that are representative of normal conditions for your utility, the Rate Design Module can only evaluate how your current and proposed rate schedules will perform on average. While this is incredibly important information for financial planning, it is only part of the picture. It is also important to have an understanding of how much year-to-year variability in

performance to expect. The **Revenue Simulation Module** is designed to help you address that question.

2.2.2 The Revenue Simulation Module

Other questions, equally important to rate design and utility financial planning, that the **Rate Design Module** is not able to answer include questions like: *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?* These questions all concern prediction when future states of the world are uncertain. For near-term water sales forecasting the key uncertainties are weather, growth of accounts, and possible need for water use curtailment in response to drought or other causes of supply shortfall. The **Revenue Simulation Module** is designed to help answer sales revenue planning questions addressing risk and uncertainty. It uses historical weather data for your service area along with information you provide the model about future account growth and risk of water use curtailment to simulate your water demands and sales revenues over a five-year planning period for a wide range of possible future weather, growth, and shortage conditions. Using the **Revenue Simulation Module** you can assess how well or poorly your current or proposed rates are likely to perform over a five-year period given uncertain weather, growth, and adequacy of supply.

Why simulate? Simulation allows you to examine how variability in key determinants of water demand may affect your near-term water sales and revenue. Using the information generated by the model you can evaluate not only the range of possible outcomes but also the likelihood of a given outcome. This gives you the ability to examine rate schedule performance and revenue risks in ways the **Rate Design Module** and similar traditional approaches to near-term revenue forecasting can't.

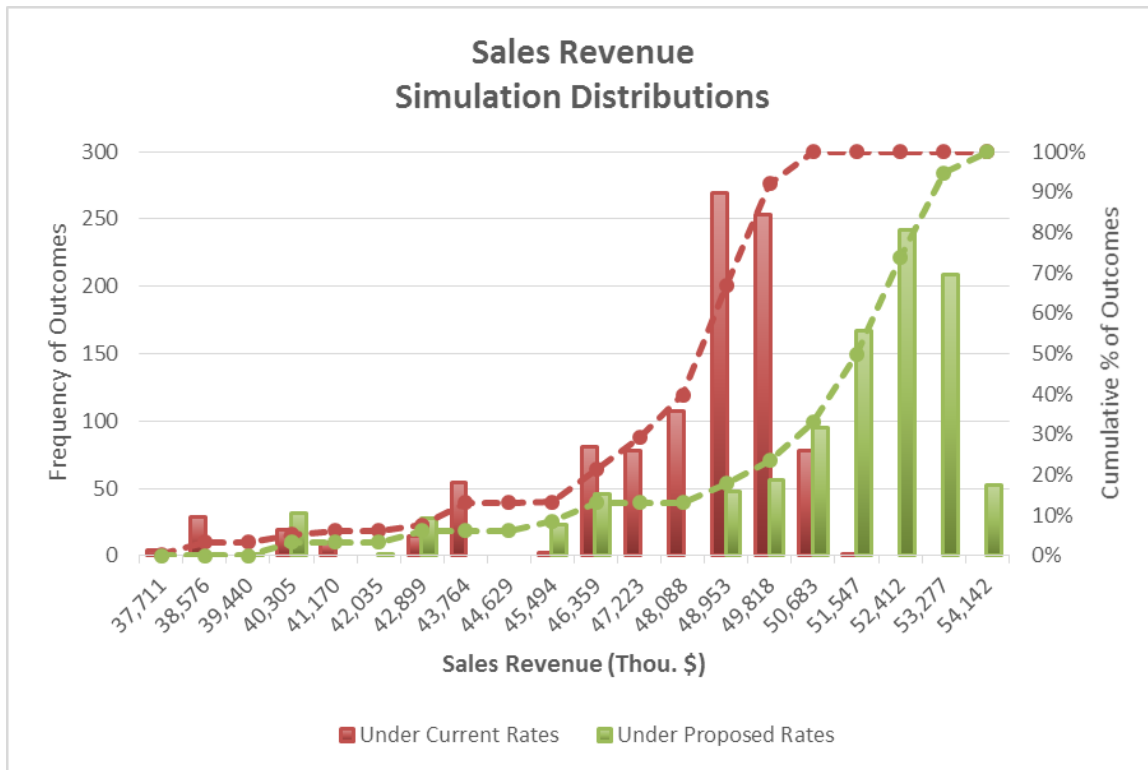
The traditional approach to near-term revenue forecasting in the water sector is based on averages. Average water use per account is multiplied by the expected growth in the number of accounts to yield the expected sales volume, which in turn is used to calculate the expected sales revenue under a given rate design. The process by which these expectations are developed can be quite sophisticated and data-driven. But at the end of the day, they represent just one of many possible future states of the world. The obvious limitation of this approach is what happens if things don't turn out as expected? Usually this is handled by developing scenarios. For example, low, medium, and high growth scenarios. Or with and without conservation scenarios. Adding scenarios to the forecast is useful because it helps bound the range of possible outcomes. But scenario analysis can take you only so far because of two key

issues. First, while scenario analysis helps define the range of possible outcomes, it doesn't provide any quantitative information on the likelihood of the outcomes that fall within this range. Planning for the worst case scenario may not make sense unless there is a significant chance it will occur. Similarly, building a plan around an optimistic outcome may be foolhardy if there is a good chance something worse will happen. Armed with a set of scenarios, decision-makers must apply their own subjective probabilities to the likelihood of each one occurring. This is a good way to introduce bias to the analysis. Second, the number of relevant scenarios can quickly become unmanageable, even when only a few variables are changing. If there is only one variable of interest -- say account growth -- and three possible outcomes -- say low, medium, and high -- then there are just three scenarios to contend with. But if another variable is added to the analysis -- say rainfall -- and there are again three possible outcomes -- say dry, average, wet -- now there are nine possible scenarios. Adding another variable with only three possible outcomes increases the scenarios to 27. And adding a fourth variable increases the number of scenarios to 81! No one can be expected to mentally juggle 81 scenarios when trying to make a decision. Inevitably this results in picking and choosing which scenarios to present to decision makers, which is another way to let bias creep into the analysis.

Simulation addresses both problems by converting forecast model parameters -- such as account growth or rainfall -- that are traditionally assigned values by the analyst -- into random variables that follow probability distributions. Each time the forecast model is run, it generates new values for the random variables using their probability distributions. Running the model once yields one possible scenario. Running it twice yields two possible scenarios. Running it a 1000 times yields a large sample of possible scenarios, which can then be analyzed to determine the likeliest outcome, the variability of outcomes, the likelihood of a given outcome, or the likelihood of the outcome being above or below some threshold. Thus, simulation allows decision makers to consider all possible scenarios as well as the likelihood of their occurrence.

An example of the type of information generated by simulation is given in Figure 1 below. It shows the simulated distribution of sales revenue for two different rate schedules, where account-growth, weather, and water use curtailment parameters are allowed to vary over the simulation. A quick glance at Figure 1 reveals a number of important insights. First, revenue under the proposed rate schedule can be expected to exceed revenue under the current rate schedule over the full range of possible weather, growth, and curtailment scenarios. Second, while the proposed rate schedule is most likely to generate revenue in the range of \$50 to \$53 million, there is a non-negligible risk that revenue will turn out to be significantly lower than this. In fact there is about a one-in-five chance that revenue will fall below \$50 million and about a one-in-ten chance it will fall below \$45 million.

Figure 1. Simulation Distributions of Sales Revenue



Which parameters vary in the simulation? There are many determinants of near-term water demand, but the four that often have the greatest impact on utility revenue are: (1) weather, (2) account growth, (3) water use curtailments, and (4) rates. The effect of weather on water demand is well studied. Unusually dry or hot periods push demands up, while unusually wet or cool periods push demands down. How much up or down depends on the extent of outdoor water use within a system, but for many water systems in the western United States, it is not unusual for extremes in weather to swing demands by +/- 10%. The impact of account growth on demands is straightforward. Lower or higher than expected growth will translate directly into lower or higher than expected water sales. Variability in growth can be specific to a particular class of water use -- as may occur if an industry served by the utility is in transition -- or general to all rate classes -- as may occur as a consequence of broad economic recession or expansion. The impact of water use curtailments is also straightforward and something that can be analyzed directly using the **Rate Design Module**. Sales revenue will decline more or less proportionally to the level of curtailment, assuming rates are left unchanged during the curtailment. The key uncertainty is whether or not a curtailment will be required over the forecast period. In the case of drought-induced curtailments, this is driven to a large extent by weather and hydrology. Thus there is usually a correlation between variability in weather and variability in water use curtailment. The last of the four key determinants of near-term demands, rates, is a special case

in the simulation. Since the purpose of the simulation is to evaluate sales revenue performance under the current and proposed rate schedules, these are not varied for the simulation. Rather, the simulation is run under each rate alternative so that differences in their performance can be evaluated. This is illustrated in the above figure, where it is clear that the proposed rates shift the distribution of sales revenue significantly to the right relative to where it would be under the current rates.

How Does the Simulation Vary the Weather, Account Growth, and Water Use Curtailment Parameters?

Weather Variability: The model uses a simulation technique called indexed sequential simulation to evaluate the impact of weather on near-term demand. Given historical data on monthly precipitation and average maximum daily air temperature, the model randomly draws 5-year sequences of these data for use in each simulation trial. For example, if the model is given 30 years of precipitation and temperature data spanning the period 1980 to 2009, on the first trial it may randomly draw the weather sequence for 1993-1997. On the second trial it may draw the weather for 1982-1986. It will continue to randomly draw weather sequences until all the model trials have run. In cases where there is not a full 4 years of data following the first year in the sequence -- in the previous example this would be the case for any sequences starting after 2005 -- the model wraps around to the beginning of the weather data. Thus, in the previous example the sequence starting in 2006 would be {2006, 2007, 2008, 2009, 1980}, while a sequence starting in 2008 would be {2008, 2009, 1980, 1981, 1982}. This is called sequence recycling and it is common to this type of simulation. For each weather sequence, the model adjusts average water use for each rate class based on how much the sequence deviates from long-term normal weather. The specific way the model does this is explained later in the User Guide. You provide the model with historical weather data for your service area in Step 6: Enter Weather Data. The model can accept up to 90 years of historical weather data. It's okay if you have less than 90 years of data. To get good results, however, you should provide at least 15 years of data. More, of course, is better. Later in the User Guide we give you suggestions on where you can get historical weather data for your service area.

Account Growth: The model assumes you have a pretty good idea how fast or slow accounts in each rate class are likely to grow in the near-term. In Step 7: Setup Simulation, you tell the model the expected growth rate over the next 5 years for each rate class, as well as the lower and upper bounds for this growth. You then select from one of three probability distributions constructed from these values to represent the uncertainty of future account growth. Further guidance on choosing among these probability distributions is given later in the User Guide.

Water Use Curtailment: The simulation of water use curtailments is linked to the Drought/Shortage Stage curtailment levels you specify in Step 5: Drought Rate Adjustments. You have three options for simulating water use curtailment. Option 1 is to exclude water use curtailment from the simulation. By choosing this option you are assuming your water supplies can meet demand 100% of the time, at least over the five-year forecast period. Option 2 lets you associate each of the historical years for which you provide weather data with a drought/shortage curtailment stage. In doing so the question you need to answer is this: Given your current water supplies and demands, would you need to curtail customer water use if the weather and hydrology (and preceding years of hydrology for systems that have significant storage) were the same this year as it was in the historical year you are considering? This is the preferred option for simulating water use curtailment because it preserves the correlations between weather, hydrology, demand, and need for curtailment. If you do not have the information needed to make these associations, then you can choose the third option. Option 3 lets you specify the likelihood of occurrence for each of the drought/shortage stages you specify. For example, if historically your system has had no water use curtailments in 90% of years, you would enter 90% for Stage 0 – the default no shortage stage. The remaining 10% would then be distributed across the other stages according to the likelihood of each stage's occurrence. While this option does not preserve the correlations between weather, hydrology, demand, and need for curtailment, it provides a reasonable approximation of shortage risks and the impacts this will have on water sales and revenue over the five-year forecast period.

2.3 Computer Requirements

The Sales Forecasting and Rate Model requires Excel 2007 or later version running on Windows. Macros must be enabled in Excel.

What if I have a Mac? Unfortunately, due to incompatibilities between Mac and Windows versions of Excel, the model does not currently run on Excel for the Mac. However, if you have Windows emulating software on your Mac or you have a Bootcamp partition and can run Windows directly on your Mac, you can run the model in a native Windows environment from your Mac.

3 Important Terminology

In following sections of the User Guide we will refer to a number of terms and concepts that it will be helpful to be familiar with. In this section, we provide brief definitions and explanations of these key terms. We have divided them into the following categories:

- Water Billing and Rates
- Bill Impacts
- Drought Planning
- Monte Carlo Simulation
- Excel

Each category obviously encompasses a broad expanse of terminology and our aim here is not to cover it all. Rather, the focus is only on those terms and concepts most relevant to an understanding and use of the Sales Forecasting and Rate Model.

3.1 Water Billing and Rate Terminology

This guide uses the following water billing and rate terminology and concepts:

Bill Tabulation – A bill tabulation provides a summarization of customer bills and usages showing the number of bills rendered at various levels of water usage during a specified period of time. This model uses bill tabulations to evaluate revenue and sales of alternative rate designs. The model requires bill tabulations for each customer class for peak and off-peak time periods, which are defined by the user. The reader can consult the AWWA Manual M1 for instructions and examples on how to prepare bill tabulations.

Customer Class – The grouping of customers into homogenous classes for billing and other purposes. Typically, water utility customers may be classified as residential, commercial, and industrial. Some utilities may breakdown these general classes into more specific groups. For example, the residential class is often separated into single-family and multi-family subclasses. Similarly, accounts with dedicated irrigation meters may be placed in a separate landscape class.

Billing Unit – The volume unit upon which volumetric rates are based. In the U.S., the billing unit for M&I water rates is typically either hundred cubic feet (CCF) or thousand gallons (Thou. Gal.). In countries on the metric system, the billing unit is typically kilo litres (kL).

Billing Frequency – The frequency in which a utility renders bills to its customers. In the U.S., the billing frequency for most water utilities is either monthly, bi-monthly, or quarterly.

Customer Service Charge – A fixed charge applied to each customer bill. The customer service charge is usually designed to recover customer service and metering costs, as well as a portion of system capacity costs. Typically, the customer service charge is graduated with meter capacity.

Uniform Volume Rate – A single charge per billing unit for all water used.

Seasonal Volume Rates – Rates charged on volume of water use based on the cost of service variations with respect to system seasonal requirements. For example, higher rates may be charged during the summer months when the system peak occurs, which requires facilities not needed to meet lower winter loads.

Increasing Block Volume Rates – A schedule of rates applicable to blocks of increasing usage in which the usage in each succeeding block is charged at a higher unit rate than the previous blocks.

Rate Blocks – Elements of a schedule of charges for specific usages within certain defined volume and/or demand boundaries. For example,

Rate Schedule – The schedule of volume rates and customer service charges to the various customer classes and customers.

Current Rate Schedule – In the model, the current rate schedule is the schedule of volume rates and customer service charges that serve as the reference condition from which sales, revenue, and bill impacts of a proposed rate schedule will be measured. For most users, the current rate schedule will conform to the utility's current schedule of rates and charges, though this is not strictly required.

Proposed Rate Schedule – In the model, the proposed rate schedule is the schedule of rates and charges that is being compared to the current rate schedule. The proposed rate schedule can be any alternative schedule of rates and charges.

Drought Stage Rate Schedule – In the model, the drought stage rate schedule is an alternative schedule of rates and charges that would apply during a specific drought stage as part of implementation of the utility's drought/shortage response plan.

Demand Elasticity – A parameter that measures the responsiveness of water demand to changes in volumetric rates. Specifically, it measures the percentage change in demand given a one percent change in the volume rate. For normal goods like water, demand elasticity is a negative value, indicating that as price increases, demand decreases. Demand is termed inelastic if the demand elasticity is between 0 and -1. The vast majority of empirical studies have concluded that most municipal and industrial water demands are inelastic, with demand elasticity typically falling in the range 0 to -.5. A demand is said to be perfectly inelastic if the elasticity is 0, indicating that demand is completely independent of price. While it is not uncommon for water utility planning and rate studies to explicitly or implicitly adopt an assumption of perfectly inelastic water demand, such an assumption is contrary to the empirical evidence and can lead to distorted sales and revenue forecasts. If price is raised on an inelastic demand then the percentage decrease in demand will be proportionately less than the percentage increase in price and revenue will increase. Likewise, if price is decreased, then the percentage increase in demand will be proportionately less than the percentage decrease in price and revenue will fall. Understanding these relative changes is critical when predicting the effect of a change to the schedule of volume rates on water sales and revenues.

3.2 Bill Impacts Terminology

This guide uses the following bill impacts terminology and concepts:

Change in Average Bill – The percent difference in the annual water service cost between the current and proposed rate schedules for the average customer in a class. In the model, the average volume charges for the off-peak and peak seasons are added to the median service charge to calculate the average annual water service cost in a class.

Change in Median Bill – The percent difference in the annual water service cost between the current and proposed rate schedules for the median customer in a class. In the model, the median volume charges for the off-peak and peak seasons are added to the median service charge to calculate the median annual water service cost in a class.

Affordability Index – The ratio of the median annual water service cost for the primary residential customer class (typically single-family) and median household income for the area served by the utility. A rate schedule with an affordability index value of 2% or less is generally considered affordable.

Distribution of Bill Impacts – The distribution of percentage changes in bills between the current and proposed rate schedules. In the model, the distribution of bill impacts can be viewed by customer class either as a histogram or as a cumulative probability distribution.

3.3 Drought Planning Terminology

This guide uses the following drought planning terminology and concepts:

Drought/Shortage Response Plan – It is common for water utilities to adopt drought/shortage response plans that specify actions the utility will take for different stages of shortage. Typically these plans specify voluntary and/or mandatory curtailment levels by shortage stage. In some plans, curtailment levels vary by customer class. In others they are the same across all classes. In the model, the user can specify up to five shortage stages, where the first stage is the default no shortage condition.

Drought/Shortage Stage Curtailment Level – In the model, the drought/shortage stage curtailment level is the percent reduction in demand that would be requested of each customer class for a given drought/shortage stage.

Expected Compliance % -- In the model, the expected compliance % is the percentage of customers expected to comply with the drought/shortage curtailment level for a given drought/shortage stage.

Expected Curtailment – In the model, the expected curtailment is the product of the drought/shortage stage curtailment level and the expected compliance %. It represents the actual level of curtailment expected to be achieved for a given drought/shortage stage given that not all customers may comply with the curtailment request/order.

Revenue Neutral Drought Stage Rate Schedule – In the model, a rate schedule that if implemented for a given drought stage would yield the same total revenue as the proposed rate schedule under a no shortage condition.

3.4 Monte Carlo Simulation Terminology and Concepts

This guide uses the following Monte Carlo simulation terminology and concepts:

Monte Carlo Simulation – A widely used problem solving technique that uses random samples of parameters or inputs to a computer model to explore the behaviour of a complex system or process. In the AWE model, Monte Carlo simulation is used to assess the performance of the current and proposed rate structures over a five-year period while allowing for variability in weather, account growth, and need for water use curtailments.

Simulation Trial – A single run of the simulation model where results are based in part on the random draws of the model's uncertain parameters. The AWE model is set up so the user can

run 10, 100, 500, or 1000 trials. The results of each simulation trial are stored on the Simulation Output worksheet.

Simulation Summary Statistics – Statistics used to summarize the results of the simulation. The model provides the average, standard deviation, minimum, and maximum statistics for sales volume and revenue for each forecast year under the current and proposed rates.

Simulation Probability Distributions – The probability distributions for annual sales volume and revenue generated by the simulation. The model provides these distributions for each forecast year under the current and proposed rates.

Simulation Confidence Intervals – The range of an output variable such that for an X% confidence interval, the output variable would take on a value within this range in X% of the simulation trials. In the model, confidence intervals are provided for annual sales volume and revenue for each forecast year under the current and proposed rates. The user can set the level of confidence for the interval.

Sales Revenue Exceedence Probability – The probability that the simulated sales revenue will equal or exceed a revenue target set by the user. In the model, the user can calculate sales revenue Exceedence probabilities under the current and proposed rates for revenue in the first forecast year, 3-year cumulative revenue, and 5-year cumulative revenue.

3.5 Excel Terminology

This guide uses the following Excel terminology:

Workbook – a workbook is an Excel file containing a collection of worksheets, chart sheets, and possibly macros.

Worksheet – a worksheet is a spreadsheet inside an Excel workbook file. A workbook can contain multiple worksheets.

Worksheet Cell – worksheet cells are where data and formulas are stored on worksheets. Each cell on a worksheet has a unique address given by its row and column number. For example, a cell at the intersection of column B and row 5 has the cell address B5.

Cell Range – a cell range is a collection of worksheet cells. Cell ranges are usually, but not always, contiguous.

Worksheet Formula – a worksheet formula is a formula entered in one or more cells. A formula entered into multiple cells is called an array formula. Worksheet formulas use cells and cell ranges as their arguments.

Excel Chart – an Excel chart is a graph based on data stored in worksheet cell ranges. An Excel chart can reside on its own sheet or be embedded as a chart object on a worksheet. All of the charts in the Water Conservation Tracking Tool are embedded on worksheets.

Excel Macro – an Excel macro is a set of programming instructions that tell Excel to perform specific actions or tasks when the macro is executed.

Visual Basic for Applications – Excel macros use the programming language Visual Basic for Applications.

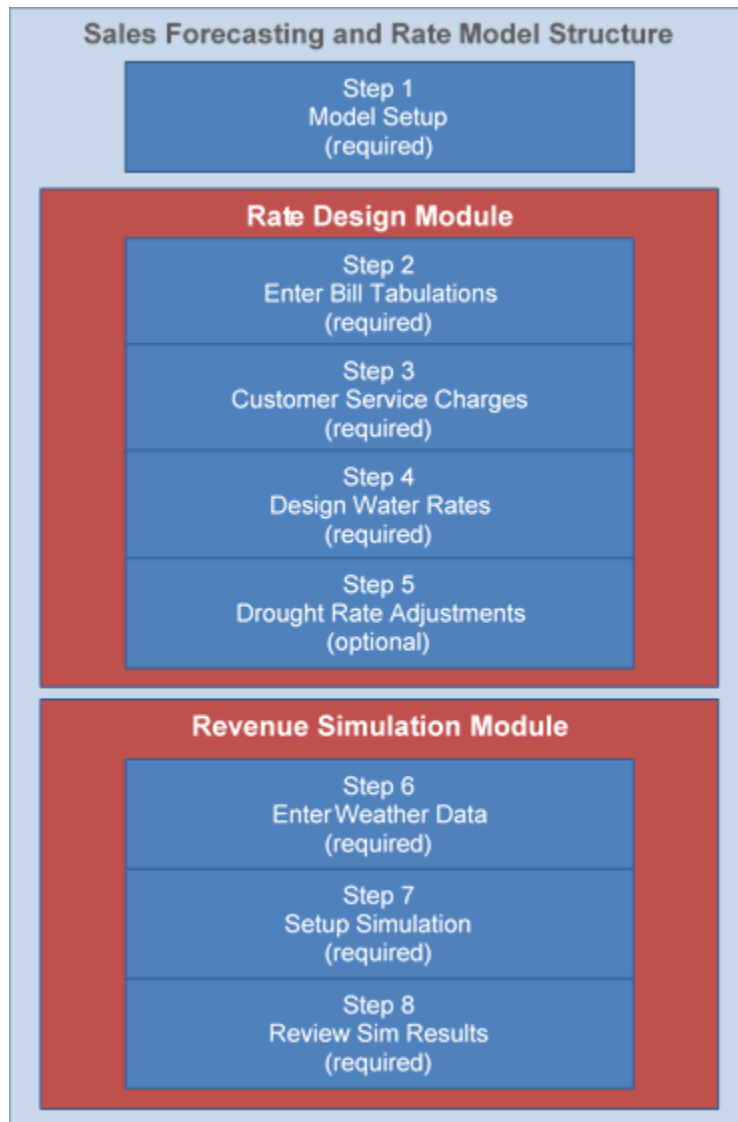
Visual Basic Editor – The Visual Basic Editor is used to create and edit macros in Excel. The Visual Basic Editor is part of the Excel application.

4 Getting Started

4.1 Model Structure

The model is organized as a sequence of steps you take to complete an analysis. Each step is contained on a separate worksheet. To use the Rate Design Module, you must complete Steps 1 through 4, and optionally Step 5. To use the Revenue Simulation Module you must also complete Steps 6 through 8. Figure 2 provides a schematic of the model structure.

Figure 2. Model Structure



4.2 Step 1: Model Setup

On the **Model Setup** worksheet, you enter basic information needed by the model. This worksheet must be completed before moving on to the other model steps. To setup the model, you will need to provide the following information:

Bill Tabulation Year – This is the year in which your bill tabulation data is based.

Model Units – There are three units the model needs to keep track of. The first is the volume unit you use with your water rates. You can choose between hundred cubic feet (CCF), thousand gallons (Thou. Gal.), or kilo liters (kL). The model also needs to know whether your precipitation and temperature data are in English or metric units.

Seasons – The model divides annual water use between Off Peak and Peak seasons. This allows the model to differentiate the change in water use given a change in rates by season (typically, demand in the Peak season is more responsive to rate adjustments than demand in the Off Peak season). It also allows you to specify different water rates for each season (seasonal rates). Use the drop-down lists to specify the first and last months for the Off Peak season. The model will then determine the months that are in the Peak season.

Maximum to Minimum Month Production Ratio – The model uses the ratio of maximum to minimum monthly system production to infer the relative importance of outdoor water use in your service area. Since outdoor use is more responsive than indoor use to deviations from normal weather patterns, this is important. You tell the model what ratio to use on the Model Setup worksheet. We recommend calculating this ratio for several recent years and then entering the average of your results.

Customer Classes – You can enter up to six separate customer classes in the model. You must specify at least one. Separate bill tabulations are required for each class you specify, so only specify classes if you are able to provide bill tabulations for them. If you have more than six customer classes, you have two choices. You can consolidate them into six classes, or you can divide them into two models. The latter approach will involve post-processing the results of the two models to get system-level results and therefore is the more complicated of the two options.

Median Household Income – You can specify the median household income in your service area and the model will use this information when assessing the affordability of your current and proposed rates.

Note: Be sure you have fully completed the [Step 1: Model Setup worksheet](#) before moving on to the other model steps.

5 Using the Rate Design Module

To use the **Rate Design Module** you must complete Steps 2 through 4, and optionally Step 5. In Step 2, you provide the model with bill tabulations for each of the customer classes you specified in Step 1. In Step 3, you specify your current and proposed customer service charges. In Step 4, you specify your current and proposed volumetric rates. In Step 5, you can optionally define and evaluate drought stage volumetric rates.

5.1 Step 2: Enter Bill Tabulations

On the **Step 2: Enter Bill Tabulations** worksheet, you enter bill tabulations for your Bill Tabulation Year for the customer classes you set up in Step 1. A bill tabulation provides a summarization of customer bills and usages showing the number of bills rendered at various levels of water usage during a specified period of time. Example tabulations for Single Family and Multi Family customer classes are shown in Figure 3. The tabulations in the figure are truncated at 30 CCF, but your actual tabulations will need to cover the full range of water use in each customer class and conform to the usage bins on the worksheet. If you are unfamiliar with the process of developing a bill tabulation from your billing data, you are strongly encouraged to consult the AWWA Manual M1, which provides detailed instructions and examples of how to prepare bill tabulations.

Note that separate bill tabulations are required for each season. You allocate bills to each season based on the date of the meter read for the bill. Allocate a bill to the peak season tabulation if its meter read date falls within the peak season you defined in Step 1. Otherwise, allocate it to the off-peak season. When you design volumetric water rates in Step 4, the model will assume that water use represented by the peak season bill tabulation will be subject to the rates you define for the peak season, while water use represented by the off-peak season tabulation will be subject to the rates you define for the off-peak season.

Note: Your bill tabulations provide the fundamental data needed by the Rate Design Module to evaluate revenue and sales of alternative rate designs for your utility. Thus, the importance of providing good, reliable data in this step cannot be overstated.

Figure 3. Example Bill Tabulation Entered in the Step 2 Worksheet

		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	
		Total Use of Bills		Total Use of Bills		Total Use of Bills		Total Use of Bills	
Usage Bin (CCF)		Bills in Bin	in Bin (CCF)	Bills in Bin	in Bin (CCF)	Bills in Bin	in Bin (CCF)	Bills in Bin	in Bin (CCF)
From	To								
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
16	16	7,782	124,512	1,630	26,080	72	1,152	20	320
17	17	7,235	122,995	1,537	26,129	76	1,292	24	408
18	18	6,863	123,534	1,603	28,854	77	1,386	17	306
19	19	6,423	122,037	1,584	30,096	77	1,463	29	551
20	20	5,987	119,740	1,616	32,320	81	1,620	22	440
21	21	5,429	114,009	1,656	34,776	93	1,953	20	420
22	22	5,174	113,828	1,691	37,202	71	1,562	29	638
23	23	4,890	112,470	1,655	38,065	91	2,093	25	575
24	24	4,532	108,768	1,664	39,936	98	2,352	30	720
25	25	4,107	102,675	1,610	40,250	87	2,175	34	850
26	26	3,936	102,336	1,663	43,238	84	2,184	27	702
27	27	3,502	94,554	1,619	43,713	88	2,376	35	945
28	28	3,281	91,868	1,655	46,340	107	2,996	36	1,008
29	29	3,055	88,595	1,657	48,053	87	2,523	34	986
30	30	2,830	84,900	1,532	45,960	88	2,640	29	870

5.2 Step 3: Customer Service Charges

On the **Step 3: Customer Service Charges** worksheet, you enter your current and proposed meter service charges. There are two sections to the worksheet.

In Section 1, shown in Figure 4, you enter the number of accounts by customer class and meter size. These counts should come from the data you compiled for the bill tabulations you entered in Step 2.

In Section 2, shown in Figure 5, you enter your current and proposed customer service charges, again by Customer Class and meter size. You also tell the model the frequency with which

these charges are rendered, which the model needs to know in order to calculate annual revenue from service charges.

Figure 4. Account Tabulation by Meter Size and Customer Class

1. Enter Number of Accounts by Meter Size in the Bill Tabulation Year

Enter the number of active accounts by meter size and Customer Class for the Bill Tabulation Year in the table below. Y tabulations you provided in Step 2.

Number of Accounts by Meter Size in Bill Tabulation Year							
Meter Size	Single Family	Multi Family	CII	Landscape	Not in use	Not in use	Total
5/8-Inch	52,004	450	1,109	1,316			54,879
3/4-Inch	412	117	246	545			1,320
1-Inch	640	776	695	2,096			4,207
1 1/2-Inch	3	661	436	1,912			3,012
2-Inch	3	406	322	1,674			2,405
3-Inch		14	34	30			78
4-Inch		69	80	43			192
6-Inch		17	15	6			38
8-Inch		1	5				6
10-Inch							0
12-Inch							0
16-Inch							0
Total	53,062	2,511	2,942	7,622	0	0	66,137

Figure 5. Specifying Customer Service Charges

2. Specify the Customer Service Charges for Current and Proposed Rates

Use the drop-down list to enter the billing frequency for your utility. Next, enter in the table below your Current and Proposed cust

Billing Frequency: Bills Per Year:

Service Charge Per Billing Period by Customer Class and Meter

Meter Size	Single Family		Multi Family		CII		Landscape	
	Current	Proposed	Current	Proposed	Current	Proposed	Current	Proposed
	(\$/Bill)	(\$/Bill)	(\$/Bill)	(\$/Bill)	(\$/Bill)	(\$/Bill)	(\$/Bill)	(\$/Bill)
5/8-Inch	\$37.81	\$37.81	\$34.37	\$37.81	\$34.37	\$37.81	\$34.37	\$37.81
3/4-Inch	\$51.56	\$56.71	\$51.56	\$56.71	\$51.56	\$56.71	\$51.56	\$56.71
1-Inch	\$85.93	\$94.52	\$85.93	\$94.52	\$85.93	\$94.52	\$85.93	\$94.52
1 1/2-Inch	\$171.85	\$189.04	\$171.85	\$189.04	\$171.85	\$189.04	\$171.85	\$189.04
2-Inch	\$274.97	\$302.46	\$274.97	\$302.46	\$274.97	\$302.46	\$274.97	\$302.46
3-Inch	\$549.93	\$604.93	\$549.93	\$604.93	\$549.93	\$604.93	\$549.93	\$604.93
4-Inch	\$859.27	\$945.20	\$859.27	\$945.20	\$859.27	\$945.20	\$859.27	\$945.20
6-Inch	\$1,718.54	\$1,890.40	\$1,718.54	\$1,890.40	\$1,718.54	\$1,890.40	\$1,718.54	\$1,890.40
8-Inch	\$3,093.38	\$3,402.71	\$3,093.38	\$3,402.71	\$3,093.38	\$3,402.71	\$3,093.38	\$3,402.71
10-Inch	\$4,983.77	\$5,482.15	\$4,983.77	\$5,482.15	\$4,983.77	\$5,482.15	\$4,983.77	\$5,482.15
12-Inch	\$7,389.73	\$8,128.70	\$7,389.73	\$8,128.70	\$7,389.73	\$8,128.70	\$7,389.73	\$8,128.70
16-Inch								

5.3 Step 4: Design Water Rates

On the **Step 4: Design Water Rates** worksheet, you enter your current and proposed volumetric water rates for each customer class you defined in Step 1. Your proposed rates can be any alternative rate structure. The model uses the bill tabulation data you entered in Step 2 to calculate the sales volume and revenue under each rate design.

5.3.1 Setting the Demand Elasticity Parameters

The demand elasticity parameter indicates the percentage change in water use given a 1 percent change from the current water rate. Thus, if the elasticity parameter is set to -0.25 and your proposed rate increases the current rate by 10%, the elasticity parameter would adjust water use down by -2.5% (-0.25 x 10%).

The first thing you do on this worksheet is set the demand elasticity parameters the model will use to adjust water use in response to changes in the cost of water under your proposed rates relative to your current rates. You set the demand elasticity parameters in the Demand Elasticity Table, shown in Figure 6. To the right of the Demand Elasticity Table are recommended short-run elasticity values for common customer classifications.

Figure 6. Setting Price Elasticity Assumptions

1. Set demand elasticity parameters
 Demand elasticity is a parameter that measures the responsiveness of water demand to changes in the volumetric rate. It measures the percentage change in demand given a 1 percent change in price. Enter the demand elasticity parameters for each Customer Class in the Demand Elasticity Table. For normal goods like water, the elasticity parameter is a negative number, typically between -0.0 and -0.5. Demand elasticity is typically greater in absolute value in the peak period than the off-peak period. Recommended values are provided for common Customer Classes in the table to the right. If you do not want to the model to include price effects when it calculates sales revenue for your proposed rates, then set the demand elasticity parameters to 0.

Customer Class	Demand Elasticity Table		Customer Class	Recommended Short-Run Elasticity Values	
	Off Peak	Peak		Off Peak	Peak
Single Family	-0.10	-0.20	Single Family	-.00 to -.10	-.10 to -.20
Multi Family	-0.05	-0.10	Multi Family	-.00 to -.05	-.05 to -.10
CII	-0.20	-0.25	Commercial/Industrial	-.15 to -.25	-.15 to -.25
Landscape	-0.25	-0.30	Landscape	-.20 to -.30	-.20 to -.30
Not in use	0.00	0.00			
Not in use	0.00	0.00			

Note: Demand is less responsive to changes in price in the short-run, where the stock of water using fixtures, appliances, and landscapes is largely fixed, than it is in the long-run, where the stock of water using assets can be adjusted. The elasticity parameters used with the model should reflect the responsiveness of demand to changes in price in the short-run. Be aware that many of the published estimates of water demand elasticity are based on cross-sectional data that yield estimates of long-run price elasticity. If you are taking estimates from the published literature or from previous analyses done for your service area, be sure to confirm that the estimates are for short-run rather than long-run price response.

Note: If you do not want the model to include price effects when it calculates sales revenue for your proposed rates, then set the demand elasticity parameters to zero.

5.3.2 Setting Current and Proposed Rates

After setting the demand elasticity parameters, you are ready to enter your current and proposed rates. You do this using the four tables to the right of each customer class label. These tables are illustrated in Figure 7 for a customer class labelled Single Family. In Figure 7, the current rate is set to a uniform rate of \$3/CCF. The proposed rate is a seasonal uniform rate charging \$2.50/CCF in the off-peak season and \$3.75/CCF in the peak season.

Figure 7. Customer Class Volumetric Rate Tables

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

Follow these guidelines for setting up specific rate designs:

Uniform and Uniform Seasonal Designs -- Enter the same rate for all five blocks. If you want the uniform rate to vary by season, set a different uniform rate for each season. The values in the Block column of the table are not important. Just be sure the same rate is in every row of the Rate column.

Block and Seasonal Block Designs: Enter the blocks and rates for each block level. You can specify up to 5 blocks. If you want fewer than 5 blocks -- say 3 -- then enter the same rate and block information for Block 4 and Block 5 that you did for Block 3, as illustrated in Figure 8. If you want seasonal block rates, you can specify different blocks and/or rates for each season, as illustrated in Figure 9.

Note: When setting block rates with fewer than 5 blocks, you must set any unused rows in the rate design tables to have the same values as the last block in your rate design. Thus, if you have a 3 block design, set the rows for block 4 and block 5 to be the same as block 3, as illustrated in Figure 7.

Figure 8. 3-Block Tiered Rate Example

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	\$2.50
Block 2	10	\$3.00	10	\$3.00	10	\$3.00	10	\$3.00
Block 3	15	\$3.00	15	\$3.50	15	\$3.00	15	\$3.50
Block 4	15	\$3.00	15	\$3.50	15	\$3.00	15	\$3.50
Block 5	15	\$3.00	15	\$3.50	15	\$3.00	15	\$3.50

Figure 9. Seasonal Tiered Rate Example with Added 4th Block in Peak Season

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	\$2.50
Block 2	10	\$3.00	10	\$3.00	10	\$3.75	10	\$3.00
Block 3	15	\$3.00	15	\$3.50	15	\$3.00	15	\$3.50
Block 4	15	\$3.00	15	\$3.50	15	\$3.00	20	\$4.00
Block 5	15	\$3.00	15	\$3.50	15	\$3.00	20	\$4.00

5.3.3 Sales and Revenue Performance by Customer Class

To the right of the rate design tables for each customer class there are tables and charts that summarize the estimated annual water sales and revenue under your current and proposed rates, as illustrated in Figure 10. These performance indicators are provided for each customer class as well as for the system as a whole.

Figure 10. Water Rate Performance Metrics

Customer Class	Off Peak Season	Peak Season	Rate Performance by Customer Class	Impact of Proposed Rates Relative to Current Rates																																																																				
Single Family	<table border="1"> <tr><th colspan="2">Current Rates</th><th colspan="2">Proposed Rates</th></tr> <tr><th>Block (CCF)</th><th>Rate (\$/CCF)</th><th>Block (CCF)</th><th>Rate (\$/CCF)</th></tr> <tr><td>5</td><td>\$3.00</td><td>5</td><td>\$2.50</td></tr> <tr><td>10</td><td>\$3.00</td><td>10</td><td>\$2.50</td></tr> <tr><td>15</td><td>\$3.00</td><td>15</td><td>\$2.50</td></tr> </table>	Current Rates		Proposed Rates		Block (CCF)	Rate (\$/CCF)	Block (CCF)	Rate (\$/CCF)	5	\$3.00	5	\$2.50	10	\$3.00	10	\$2.50	15	\$3.00	15	\$2.50	<table border="1"> <tr><th colspan="2">Current Rates</th><th colspan="2">Proposed Rates</th></tr> <tr><th>Block (CCF)</th><th>Rate (\$/CCF)</th><th>Block (CCF)</th><th>Rate (\$/CCF)</th></tr> <tr><td>5</td><td>\$3.00</td><td>5</td><td>\$3.75</td></tr> <tr><td>10</td><td>\$3.00</td><td>10</td><td>\$3.75</td></tr> <tr><td>15</td><td>\$3.00</td><td>15</td><td>\$3.75</td></tr> </table>	Current Rates		Proposed Rates		Block (CCF)	Rate (\$/CCF)	Block (CCF)	Rate (\$/CCF)	5	\$3.00	5	\$3.75	10	\$3.00	10	\$3.75	15	\$3.00	15	\$3.75	<table border="1"> <tr><th colspan="3">Annual Sales Volume</th></tr> <tr><th>Current</th><th>Proposed</th><th>% Change</th></tr> <tr><td>CCF</td><td>5,069,063</td><td>8,933,906</td><td>-3.7%</td></tr> </table>	Annual Sales Volume			Current	Proposed	% Change	CCF	5,069,063	8,933,906	-3.7%	<table border="1"> <tr><th colspan="3">Annual Revenue (Thou. \$)</th></tr> <tr><th>Current</th><th>Proposed</th><th>% Change</th></tr> <tr><td>Service</td><td>\$12,283</td><td>\$12,210</td><td>0.6%</td></tr> <tr><td>Volume</td><td>\$27,207</td><td>\$27,744</td><td>2.0%</td></tr> <tr><td>Total</td><td>\$39,470</td><td>\$40,054</td><td>1.5%</td></tr> </table>	Annual Revenue (Thou. \$)			Current	Proposed	% Change	Service	\$12,283	\$12,210	0.6%	Volume	\$27,207	\$27,744	2.0%	Total	\$39,470	\$40,054	1.5%
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City	<table border="1"> <tr><th colspan="2">Current Rates</th><th colspan="2">Proposed Rates</th></tr> <tr><th>Block (CCF)</th><th>Rate (\$/CCF)</th><th>Block (CCF)</th><th>Rate (\$/CCF)</th></tr> <tr><td>5</td><td>\$3.00</td><td>5</td><td>\$2.50</td></tr> <tr><td>10</td><td>\$3.00</td><td>10</td><td>\$2.50</td></tr> <tr><td>15</td><td>\$3.00</td><td>15</td><td>\$2.50</td></tr> </table>	Current Rates		Proposed Rates		Block (CCF)	Rate (\$/CCF)	Block (CCF)	Rate (\$/CCF)	5	\$3.00	5	\$2.50	10	\$3.00	10	\$2.50	15	\$3.00	15	\$2.50	<table border="1"> <tr><th colspan="2">Current Rates</th><th colspan="2">Proposed Rates</th></tr> <tr><th>Block (CCF)</th><th>Rate (\$/CCF)</th><th>Block (CCF)</th><th>Rate (\$/CCF)</th></tr> <tr><td>5</td><td>\$3.00</td><td>5</td><td>\$3.75</td></tr> <tr><td>10</td><td>\$3.00</td><td>10</td><td>\$3.75</td></tr> <tr><td>15</td><td>\$3.00</td><td>15</td><td>\$3.75</td></tr> </table>	Current Rates		Proposed Rates		Block (CCF)	Rate (\$/CCF)	Block (CCF)	Rate (\$/CCF)	5	\$3.00	5	\$3.75	10	\$3.00	10	\$3.75	15	\$3.00	15	\$3.75	<table border="1"> <tr><th colspan="3">Annual Sales Volume</th></tr> <tr><th>Current</th><th>Proposed</th><th>% Change</th></tr> <tr><td>CCF</td><td>2,373,225</td><td>2,344,510</td><td>-1.2%</td></tr> </table>	Annual Sales Volume			Current	Proposed	% Change	CCF	2,373,225	2,344,510	-1.2%	<table border="1"> <tr><th colspan="3">Annual Revenue (Thou. \$)</th></tr> <tr><th>Current</th><th>Proposed</th><th>% Change</th></tr> <tr><td>Service</td><td>\$2,416</td><td>\$2,658</td><td>10.0%</td></tr> <tr><td>Volume</td><td>\$7,120</td><td>\$7,077</td><td>-0.6%</td></tr> <tr><td>Total</td><td>\$9,536</td><td>\$9,735</td><td>2.1%</td></tr> </table>	Annual Revenue (Thou. \$)			Current	Proposed	% Change	Service	\$2,416	\$2,658	10.0%	Volume	\$7,120	\$7,077	-0.6%	Total	\$9,536	\$9,735	2.1%
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5.3.4 Bill Impact Indicators

Bill impacts of your proposed rates relative to your current rates are summarized in Section 3 of the worksheet. The first table in this section, illustrated in Figure 11, shows the average and median annual water cost (service charge plus volumetric charge) under the current and proposed rate designs.

Figure 11. Average and Median Water Cost Table

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. down, stay the same, or go up -- and by how much. Charts showing the distribution of bill impacts for each customer

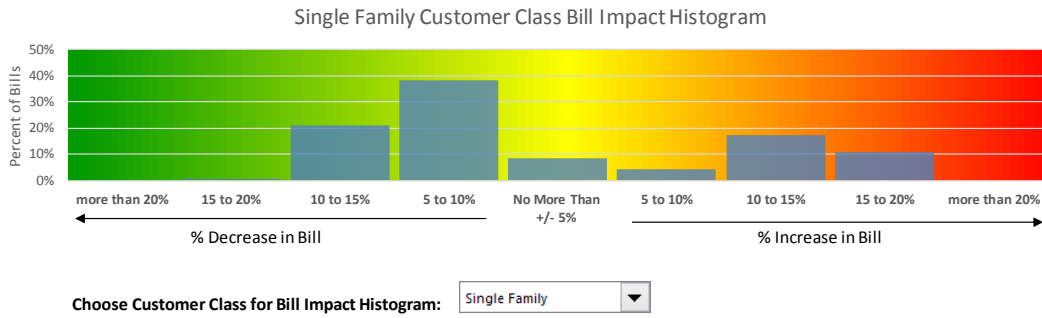
Customer Class	% Change in Average and Median Annual Water Service Cost by Customer Class					
	Average Annual Water Service Cost			Median Annual Water Service Cost		
	Current	Proposed	% Change	Current	Proposed	% Change
Single Family	\$777	\$805	3.5%	\$650	\$672	3.3%
Multi Family	\$4,254	\$4,393	3.2%	\$1,930	\$1,994	3.3%
CII	\$3,323	\$3,464	4.3%	\$1,481	\$1,556	5.0%
Landscape	\$5,599	\$6,094	8.8%	\$2,503	\$2,771	10.7%
Not in use						
Not in use						

The second table, illustrated in Figure 12, shows the percentage of bills that would increase or decrease under the proposed rate design, and by how much. This information is also displayed graphically as a histogram below the table, as illustrated in Figure 13. You can use the drop-down list below the histogram to choose which customer class to display in the chart.

Figure 12. Bill Impacts Table

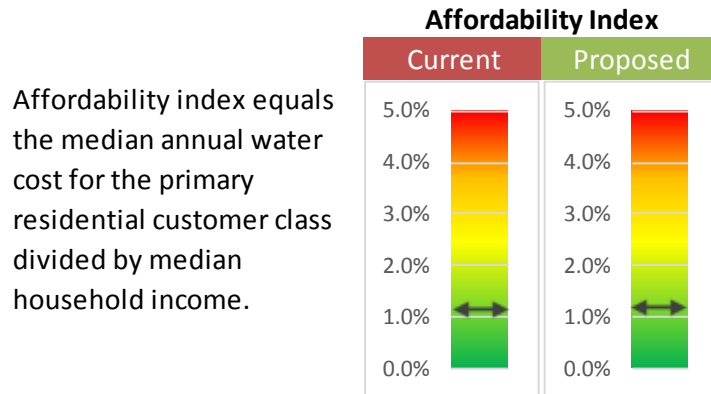
Customer Class	Bill Impacts Table								
	% of bills decreasing by				No More Than	% of bills increasing by			
	more than 20%	15 to 20%	10 to 15%	5 to 10%	+/- 5%	5 to 10%	10 to 15%	15 to 20%	more than 20%
Single Family	0%	0%	21%	38%	9%	4%	17%	11%	0%
Multi Family	0%	0%	20%	26%	19%	1%	6%	28%	0%
CII	0%	0%	15%	14%	23%	15%	14%	18%	0%
Landscape	0%	0%	19%	10%	13%	28%	4%	26%	0%
Not in use									
Not in use									

Figure 13. Bill Impacts Histogram



An affordability index, illustrated in Figure 14, is displayed to the right of the average/median cost of water table. This index reports the median annual water cost for the primary residential customer class as a percentage of the median household income you entered when you set up the model in Step 1.

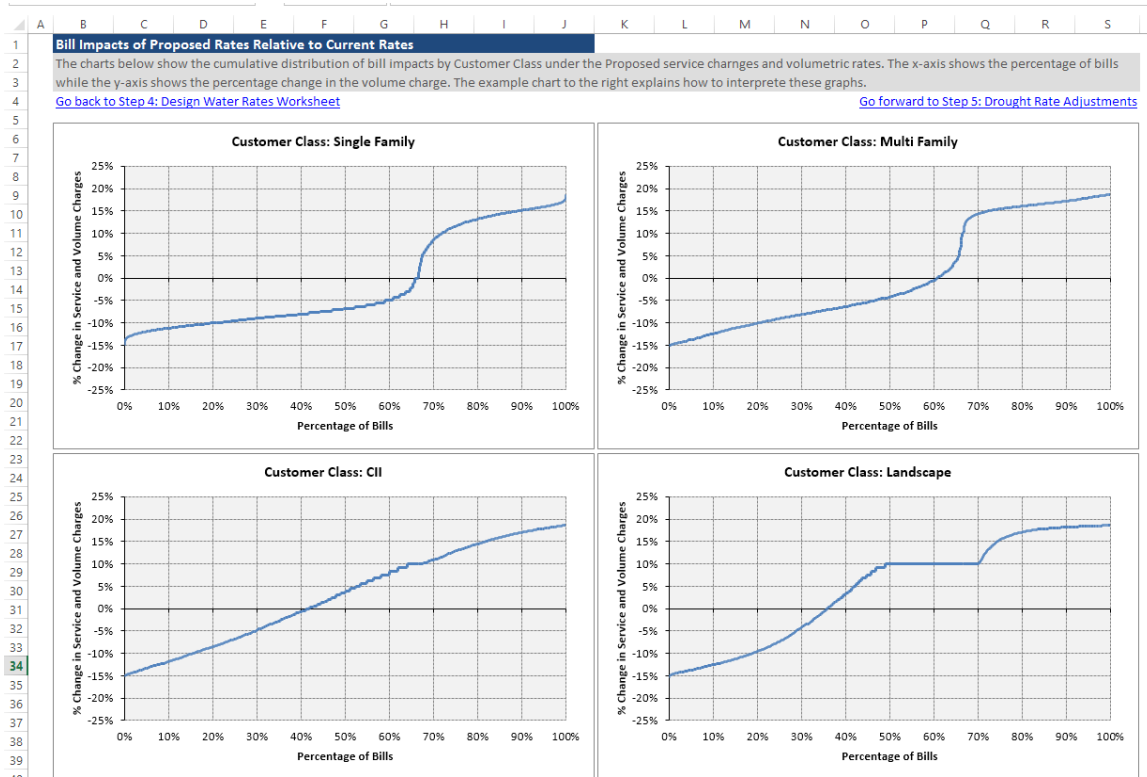
Figure 14. Rate Design Affordability Index



Note: While median annual water cost as a percentage of median annual income is a commonly used affordability indicator in the industry, it should not be the only consideration, or even necessarily the primary consideration, when assessing the affordability of water service. Other indicators that focus more directly on low income thresholds for the service area should also be considered when assessing water service affordability.

The distribution of bill impacts for the proposed rates relative to the current rates also are shown on the adjacent **Bill Impacts** worksheet, as illustrated in Figure 15. These charts show the cumulative distribution of bill impacts under the proposed rate design for each customer class.

Figure 15. Bill Impacts Cumulative Distributions

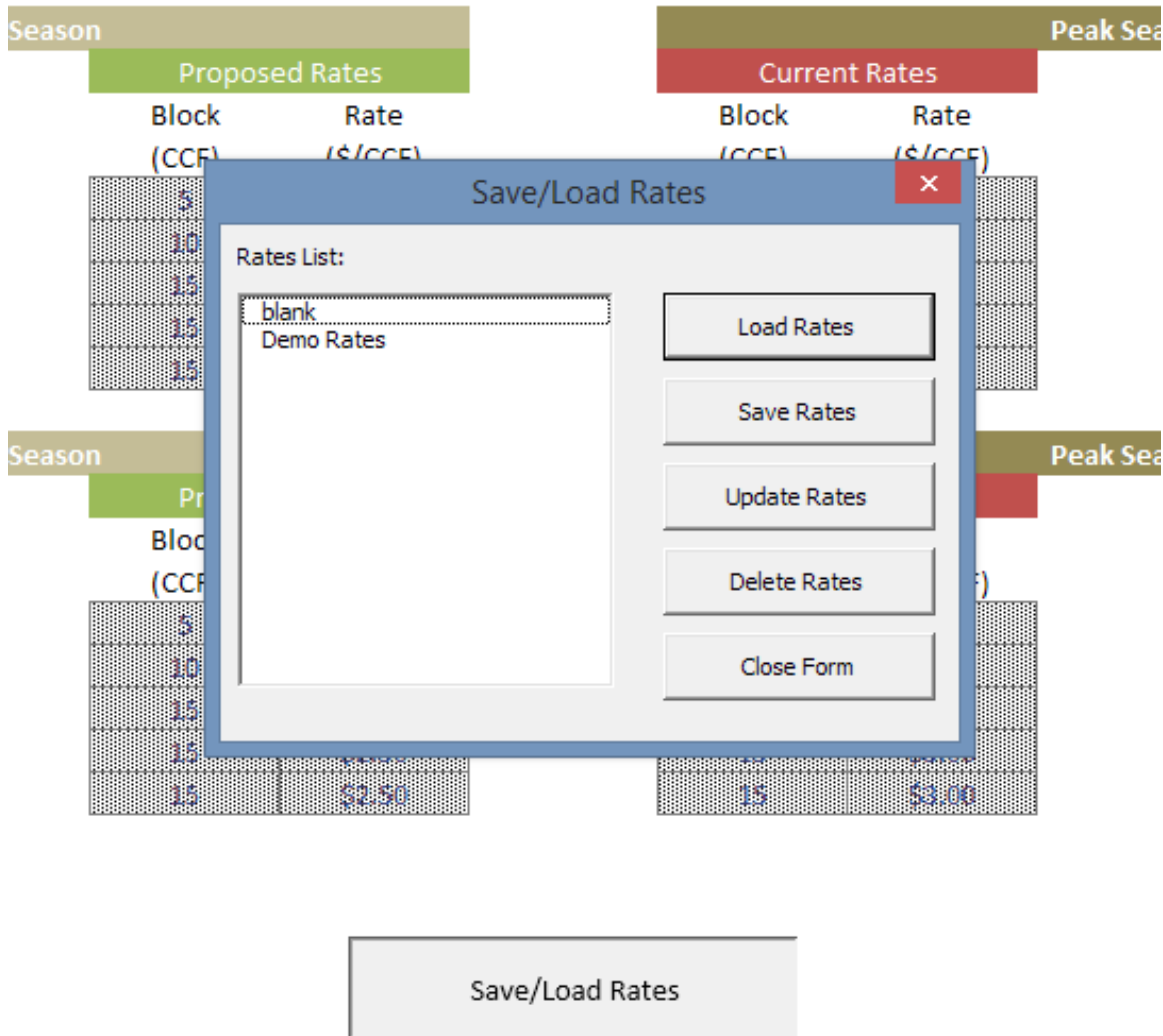


5.3.5 Saving Your Rate Designs

At the bottom of the volumetric rate tables is a button that brings up the Save/Load Rates Utility, illustrated in Figure 16, which lets you save the current and proposed service charges and volumetric rates you have just entered as a scenario for later use. You can also click this button to load or update previously saved rate designs.

Note: Saving your rate design saves the service charge and volumetric rate information you entered in Step 3 and Step 4. It does not save your model setup information you entered in Step 1 or the bill tabulation data you entered in Step 2.

Figure 16. Save/Load Rates Utility



5.4 Step 5: Drought Rate Adjustments

It is common for water utilities to adopt drought/shortage response plans that specify actions the utility will take for different stages of shortage. Typically these plans specify voluntary and/or mandatory curtailment levels by shortage stage. In some plans, curtailment levels vary by customer class. In others they are the same across all classes. Water use curtailment can have a significant impact on utility revenues and financial stability. This worksheet allows you to evaluate these impacts for your proposed rates. You can also use the worksheet to determine how your proposed rates would need to be adjusted in each drought/shortage stage in order to maintain your sales revenue at the pre-drought level.

This worksheet has three sections. In Section 1, you enter your customer class water use curtailment levels by drought/shortage stage. In Section 2, you can examine how sales revenue under your proposed rates would be impacted by each drought/shortage stage. You can also use the tables in Section 2 to adjust your proposed rates under each stage. For example, you can use the tables to develop revenue neutral rates for each drought stage. Section 3 provides a calculator you can use to quickly adjust your proposed rates so they are revenue neutral for a given drought/shortage stage.

5.4.1 Specify Curtailment Levels for Drought/Shortage Stages

Enter your customer class curtailment levels (as a percent of normal use) in the Drought/Shortage Stage Customer Class Curtailment Levels Table, which is illustrated in Figure 17. If you have fewer than 4 stages, enter the last curtailment level in the unused stages. Stage 0 is the default No Shortage condition. Do not modify the settings for this stage.

Next, for each stage, enter the expected compliance rate. The compliance rate can vary by stage. For example, stages with voluntary curtailment may have lower compliance than stages where curtailment is mandatory and enforced. The expected curtailment level for a stage is the product of the stage's curtailment level and the expected compliance rate. This is shown in the Expected Curtailment portion of the table.

Figure 17. Drought/Shortage Stage Customer Class Curtailment Levels Table

1. Specify Curtailment Levels for Drought/Shortage Stages

1. Enter the Customer Class curtailment levels for each stage. If you have fewer than 4 stages, enter the 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 stage. For example, stages with voluntary curtailment may have lower compliance than stages where curtailment is mandatory and enforced. The expected curtailment level for a stage is the product of the stage's curtailment level and the expected compliance rate.

Customer Class	Drought/Shortage Stage Customer Class Curtailment Levels Table					Expected Curtailment				
	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%
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5.4.2 Rate Performance by Drought/Shortage Stage

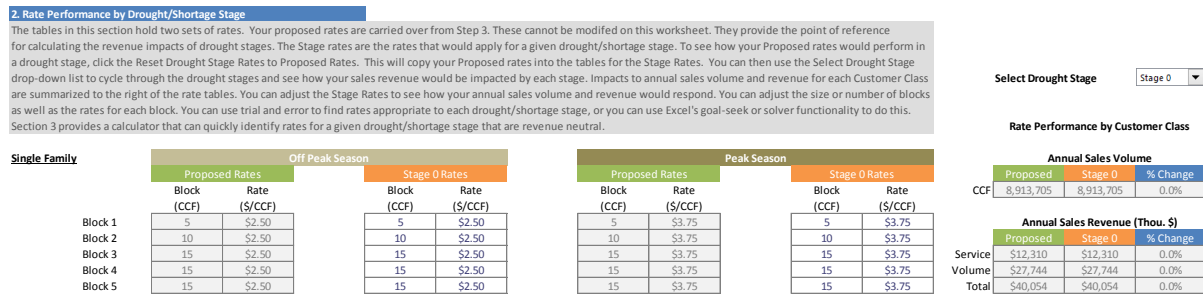
The tables in Section 2 of the worksheet, as illustrated in Figure 18, hold two sets of rates:

1. Your proposed rates are carried over from the Step 3 worksheet. These cannot be modified on this worksheet. They provide the point of reference for calculating the revenue impacts of drought stages.
2. The Stage rates are the rates that would apply for a given drought/shortage stage.

To see how your proposed rates would perform in a drought stage, click the Reset Drought Stage Rates to Proposed Rates button, which is located at the bottom of the tables. This will copy your proposed rates into the tables 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 each stage.

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 volume and 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/shortage stage, or you can use Excel's goal-seek or solver functionality to do this. Section 3 of the worksheet provides a calculator that can quickly identify rates for a given drought/shortage stage that are revenue neutral.

Figure 18. Drought/Shortage Stage Rate Tables

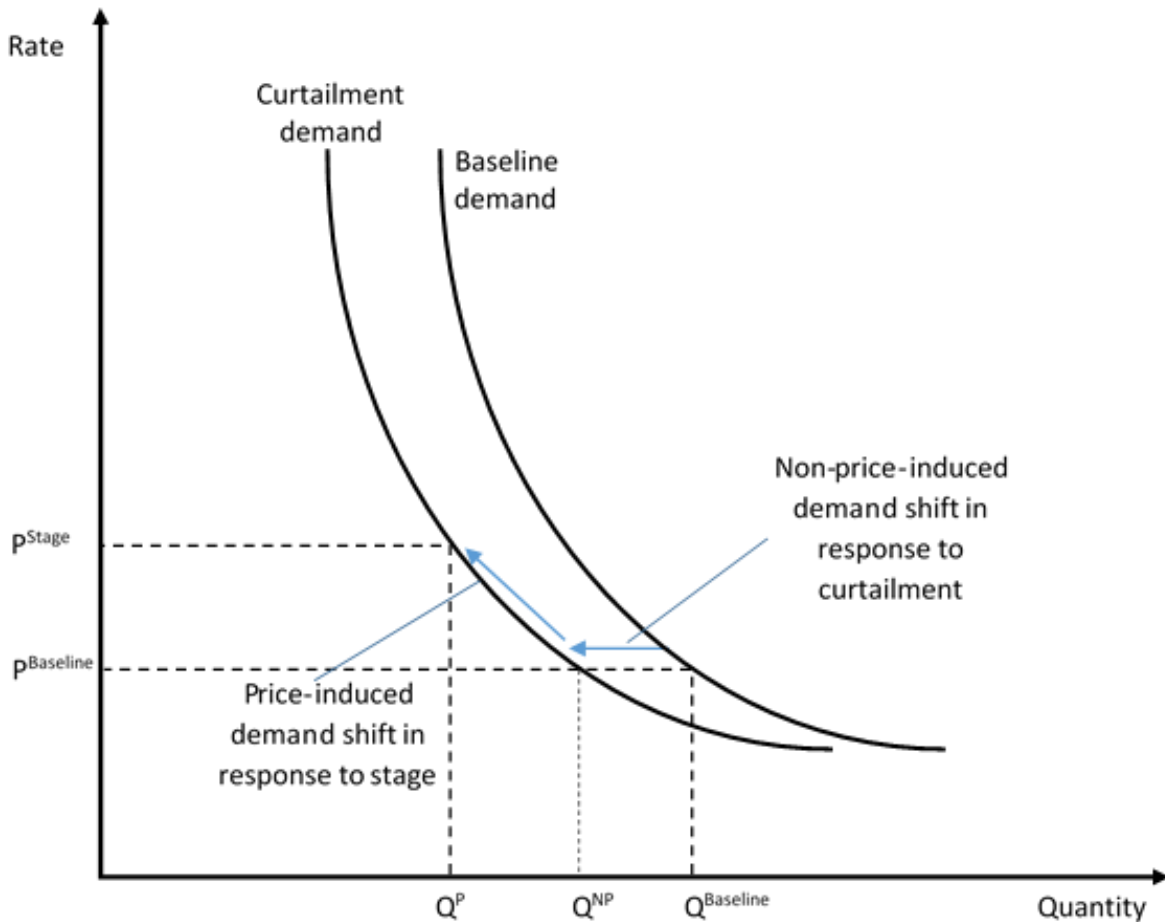


Note: To calculate the effect of the drought stage rates, the model first rescales the bill tabulation data based on the expected curtailment levels. This yields the non-price adjustment to consumption. It then uses the demand elasticity parameters to adjust water use based on the rate adjustment. This is depicted graphically in Figure 19. The first adjustment can be represented as a leftward shift of the demand curve. The second adjustment is a movement up the demand curve.

5.4.3 Calculate Revenue Neutral Rates by Drought Stage

Section 3 of the worksheet is the revenue neutral rates calculator, as shown in Figure 20. The calculator will quickly find a set of rates for a given drought/shortage stage that will generate the

Figure 19. Drought Curtailment and Stage Rate Adjustment to Demand



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 if there was 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. Make desired adjustments to the block widths for the Stage Rates in the Stage Rates tables above.

4. Click the Find Revenue Neutral Rates button.

Figure 20. Revenue Neutral Rate Calculator

Choose Drought Stage to Evaluate:

Choose Method for Calculating Revenue Neutral Rates:

Leave or Adjust Rate in Block?

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

Find Revenue Neutral Rates

Reset Drought Stage Rates to Proposed Rates

Save/Load Rates

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.

6 Using the Revenue Simulation Module

To use the **Revenue Simulation Module** you must already have set up the model (Step 1), provided bill tabulations (Step 2), and entered your current and proposed rates (Steps 3 and 4). In order to include water use curtailment effects in the simulation you also must have completed Section 1 of the Step 5 worksheet.

6.1 Step 6: Enter Weather Data

On this worksheet you enter historical monthly precipitation and temperature data for your service area. The model will use this data to simulate how your demands may vary in response to deviations from normal weather patterns. You can enter up to a maximum of 90 years of historical data. Your historical data must be contiguous -- there cannot be gaps between years. It also must be complete across months. The model will ignore years where these conditions are not met. It is not required that you provide data for all 90 years. For example, if you only have data for the period 1982-2012 you can enter that in the appropriate rows of the tables. To get reliable results, however, it is strongly recommended you enter at least 15 years of data. Consult the user guide for information on weather data sources.

Note: See Chapter 10 – Getting Weather Data – for suggestions for getting historical weather data for your service area.

6.2 Step 7: Setup Simulation

On this worksheet you specify the assumptions for the sales volume and revenue simulation and set the number of simulation trials the model will calculate. For each simulation trial, the model will calculate sales volume and revenue under your current and proposed rate designs for a new 5-year sequence of account growth, weather, and drought stage occurrence. This will generate sample distributions of possible sales volumes and revenues for each rate design. These distributions are summarized in Step 8: Review Sim Results. The raw output from the simulation is stored in the Simulation Output worksheet.

6.2.1 Choose Rates to Simulate

If you want to run the simulation for different rates than the ones currently loaded in the model, use the Save/Load Rates utility to load the rates you wish to use.

6.2.2 Set the Account Growth Rates

How fast your customer base is growing will impact your future sales volumes and revenues. If growth is slower or faster than expected you may find your revenues are significantly diverging from your projections. Usually there is some degree of uncertainty about future account growth. The simulation model will capture this uncertainty based on the values you enter in the Forecasted Account Growth Rates table, which is shown in Figure 21.

1. Enter your best estimate of future growth rates in the Expected column.
2. Bracket these estimates with lower and upper values in the Lower and Upper columns.

The model will use the values you enter in the table to generate a stochastic 5-year forecast of account growth for each simulation trial based on the probability distribution you select from the drop-down list to the right of the table (see Figure 21). The following are guidelines for selecting which probability distribution to use:

- Use the **Normal Distribution** if you want to include the possibility that growth will turn out to be lower or higher than the Lower and Upper limits you specified in the table. Based on your best judgment, set the Lower so that the chance that growth turns out to be **less than** this amount is about 5%. Similarly, set the Upper so that the chance growth turns out to be **more than** this amount is about 5%.
- Use the **Triangular Distribution** if you are confident growth will never be **less than** the Lower or **more than** the Upper, and values between these limits are progressively less likely the further they are from Expected.
- Use the **Uniform Distribution** if you are confident growth will never be **less than** the Lower or **more than** the Upper, and growth rates between these limits are equally likely to occur.

Figure 21. Forecasted Account Growth Rates Table

Customer Class	Forecasted Account Growth Rates For Next 5 Years			Distribution: <input type="text" value="Normal"/>
	Lower	Expected	Upper	
Single Family	0.50%	0.75%	0.80%	
Multi Family	0.80%	1.00%	1.20%	
CII	0.50%	0.75%	1.00%	
Landscape	0.20%	0.30%	0.40%	
Not in use				
Not in use				

Note: Set the Lower and Upper growth rates to the Expected rate if you want to treat account growth as a certain rather than an uncertain variable in the simulation.

Note: Set the Lower, Upper, and Expected growth rates to 0 if you do not want to include any account growth in your simulation.

6.2.3 Specify Likelihood of Water Use Restrictions

In this section of the worksheet, you specify how the model will handle the possibility of water use restrictions over the five-year simulation period. You have three choices:

1. You can choose to exclude water use restrictions from the simulation.
2. You can choose to associate the drought/shortage stages you specified in Step 5 with each of your historical weather years you entered in Step 6.
3. You can choose to associate simple probabilities of occurrence with each of the drought/shortage stages you specified in Step 5.

Use the drop-down list in this section of the worksheet to make your selection (see Figure 22). If you choose None from the drop-down list, nothing further is required.

Figure 22. Choose Method for Simulating Impact of Drought/Shortages

Choose Method for Simulating Impact of Droughts/Shortages on Sales Volumes and Revenues:

Drought Stage	Likelihood of Occurrence	Cumulative Probability
Stage 0	85.00%	85.00%
Stage 1	5.00%	90.00%
Stage 2	5.00%	95.00%
Stage 3	3.00%	98.00%
Stage 4	2.00%	100.00%
	100.00%	

Table Instructions: For each stage, enter the likelihood of occurrence. For example, if historically your system has had no water use curtailments in 90% of years, you would enter 90% for Stage 0. The remaining 10% would then be distributed across the other stages according to the likelihood of each stage's occurrence. The sum of the occurrence likelihoods must sum to 100%.

Associating Step 5 Drought/Shortage Stages with Step 6 Weather Data

If you are including the possibility of water use restrictions over the five-year simulation period, the preferred method is to associate the drought/shortage stages you entered in Step 5 with the weather data you entered in Step 6. You do this in Section 4 on the Step 6 worksheet. An example is shown in Figure 23. In making these associations, the question you need to answer is this: Given your current water supplies and demands, would you need to curtail customer water use if the weather and hydrology (and preceding years of hydrology for systems that have significant storage) were the same this year as it was in the historical year you are considering? This is the preferred option for simulating water use curtailment because it preserves the correlations between weather, hydrology, demand, and need for curtailment. If you do not have the information needed to make these associations, then you can choose the third option.

Note: When associating your historical weather data with your drought/shortage stages, do not base the associations on what actually happened in the historical year. Rather, base the association on the answer to this question: Given your current water supplies and demands, would you need to curtail customer water use if the weather and hydrology (and preceding years of hydrology for systems that have significant storage) were the same this year as it was in the historical year you are considering?

Figure 23. Associating Historical Weather Years with Drought/Shortage Stages

3. Enter Monthly Average Maximum Air Temperature (degrees F)													4. Enter Drought Shortage Stages (Optional)	
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.													For each drought/shortage stage, enter the index of the historical year that would have applied if the weather and hydrology were the same as the historical year. You can then have the drought/shortage stage associated with the historical year. This is explained further in the User Guide.	
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

Using the Drought Stage Probabilities Table

If you are unable to associate your drought/shortage stages with your historical weather data, but you still want to include the possibility of water use restrictions over the five-year simulation period, then you will need to complete the Drought Stage Probabilities Table. For each stage, enter the likelihood of occurrence. For example, if historically your system has had no water use curtailments in 90% of years, you would enter 90% for Stage 0. The remaining 10% would then be distributed across the other stages according to the likelihood of each stage's occurrence. The sum of the occurrence likelihoods must sum to 100%.

Figure 24. Drought Stage Probabilities Table

Choose Method for Simulating Impact of Droughts/Shortages on Sales Volumes and Revenues:

Drought Stage Probabilities Table		
Drought Stage	Likelihood of Occurrence	Cumulative Probability
Stage 0	85.00%	85.00%
Stage 1	5.00%	90.00%
Stage 2	5.00%	95.00%
Stage 3	3.00%	98.00%
Stage 4	2.00%	100.00%
	100.00%	

Table Instructions: For each stage, enter the likelihood of occurrence. For example, if historically your system has had no water use curtailments in 90% of years, you would enter 90% for Stage 0. The remaining 10% would then be distributed across the other stages according to the likelihood of each stage's occurrence. The sum of the occurrence likelihoods must sum to 100%.

Note: When using the Drought Stage Probabilities Table, the probabilities you enter in the Likelihood of Occurrence column must sum to 100%.

6.2.4 Choose Number of Simulation Trials to Run

Use the drop-down list to select the number of simulation trials (see Figure 25). For each trial, the model will calculate sales volume and revenue under your current and proposed rates for a new 5-year sequence of account growth, weather, and drought stage occurrence. The greater the number of trials the longer the simulation will take. On most computers a 10 trial simulation will take under a second to run, a 100 trial simulation will take under 10 seconds, a 500 trial simulation will take about 40 seconds, and a 1000 trial simulation will take about a minute and a half. When setting up and testing the model, set the number of trials to 10 or 100. You can view the raw simulation output on the **Simulation Output** worksheet and the processed results on the **Step 8: Review Simulation Results** worksheet. When you are satisfied with your model setup, set the number of trials to 500 or 1000 and run the final simulation.

Figure 25. Choose Number of Simulation Trials**4. Choose number of simulation trials to run**

Use the drop-down list to select the number of simulation trials. For each trial, the model will calculate sales volume and revenue under your Current and Proposed rates for a new 5-year sequence of account growth, weather, and drought stage occurrence. The greater the number of trials the longer the simulation will take. On most computers a 10 trial simulation will take under a second to run, a 100 trial simulation will take under 10 seconds, a 500 trial simulation will take about 40 seconds, and a 1000 trial simulation will take about a minute and a half. When setting up and testing the model, set the number of trials to 10 or 100. You can view the raw simulation output on the Simulation Output worksheet and the processed results on the Step 8 Review Sim Results worksheet. When you are satisfied with your model setup, set the number of trials to 500 or 1000 and run the final simulation.

Choose Number of Simulation Trials:

6.3 Step 8: Review Simulation Results

This worksheet summarizes the simulation results. There are five sections to the worksheet. Section 1 provides summary statistics for sales volume and revenue under your current and proposed rates. Section 2 shows the distributions of sales volume and revenue by forecast year. Section 3 shows confidence intervals for sales volume and revenue by forecast year for confidence levels you specify. Section 4 calculates exceedence probabilities for annual and cumulative revenue targets you specify. Section 5 lets you graphically step through each simulation trial.

6.3.1 Simulation Summary Statistics

Simulation summary statistics for water sales and revenue (service charge revenue plus volumetric rates revenue) are provided for your current and proposed rates for each forecast year, as illustrated in Figure 26. The average, standard deviation, minimum, and maximum statistics are provided.

Figure 26. Simulation Summary Statistics

1. Simulation Summary Statistics

Summary statistics for the simulation are provided in the following tables. The average value shows the central tendency while the standard deviation indicates the degree of variability. The minimum and maximum values define the range of outcomes.

----- Results based on 100 simulation trials -----

Under Current Rates						Under Proposed Rates					
Sales Volume (CCF)						Sales Volume (CCF)					
	Year 1	Year 2	Year 3	Year 4	Year 5		Year 1	Year 2	Year 3	Year 4	Year 5
Avg	15,380,921	15,510,718	15,612,832	15,761,313	15,857,409	Avg	15,145,490	15,273,577	15,374,602	15,521,173	15,615,476
St Dev	886,549	885,892	919,977	878,039	870,808	St Dev	873,519	873,205	906,569	865,591	858,515
Min	12,254,361	12,331,505	12,365,842	12,459,189	12,499,686	Min	12,070,660	12,146,786	12,180,683	12,272,795	12,312,769
Max	16,200,382	16,345,223	16,511,164	16,646,903	16,828,925	Max	15,964,343	16,107,314	16,271,112	16,405,105	16,584,778

Sales Revenue (Thou. \$)						Sales Revenue (Thou. \$)					
	Year 1	Year 2	Year 3	Year 4	Year 5		Year 1	Year 2	Year 3	Year 4	Year 5
Avg	\$69,935	\$70,474	\$70,932	\$71,530	\$71,972	Avg	\$71,799	\$72,349	\$72,813	\$73,420	\$73,879
St Dev	\$2,660	\$2,658	\$2,762	\$2,639	\$2,626	St Dev	\$2,694	\$2,687	\$2,796	\$2,667	\$2,654
Min	\$60,555	\$60,917	\$61,076	\$61,515	\$61,702	Min	\$62,231	\$62,600	\$62,762	\$63,210	\$63,402
Max	\$72,393	\$73,015	\$73,728	\$74,310	\$75,092	Max	\$74,193	\$74,854	\$75,563	\$76,079	\$76,946

6.3.2 Sales Volume and Revenue Distributions

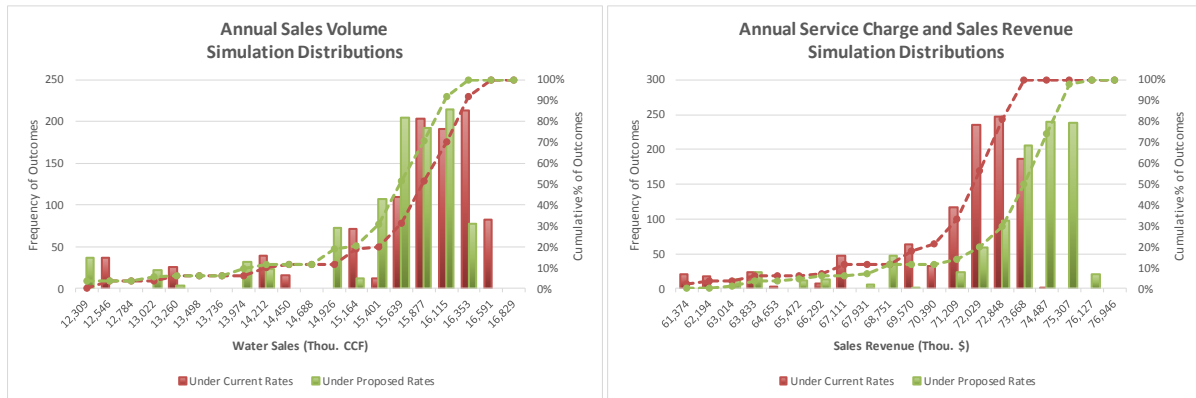
In Section 2 of the worksheet, simulation distributions for annual sales volume and revenue under your current (red) and proposed (green) rates are provided. Use the drop-down list to select the year to show.

Figure 27. Sales Volume and Revenue Distributions

2. Sales Volume and Revenue Distributions

The charts below show the frequency and cumulative distributions for simulated sales volume and revenue. The cumulative distributions (the dashed lines in the charts) show the likelihood of sales volume or revenue being above or below the corresponding value on the x-axis. The frequency distributions (the bars) show the likelihood that sales volume or revenue will fall between the value indicated on the x-axis and the value to its left.

Use the drop-down to choose the forecast year to display:



6.3.3 Sales Volume and Revenue Confidence Intervals

A 95% confidence interval indicates the range of values such that 95% of all simulation outcomes fall within this interval. Similarly, for a 90% confidence interval, 90% of all simulation

outcomes would fall within the interval. More generally, for an x% interval, x% of all simulation outcomes would fall within the interval. This means the probability that the outcome variable will take on a value in the indicated range is x%.

The charts in this section of the worksheet show confidence intervals (by year) for sales volume and revenue under your current and proposed rates. You can use the drop-down list to select the desired confidence level for the intervals. As you select higher levels of confidence you will note the intervals widen to accommodate the broader range of potential outcomes.

Figure 28. Sales Volume and Revenue Confidence Intervals

3. Sales Volume and Revenue Confidence Intervals

A 95% confidence interval indicates the range of values such that 95% of all simulation outcomes fall within this interval. Similarly, for a 90% confidence interval, 90% of all simulation outcomes would fall within the interval. This means the probability that the outcome variable will take on a value in the indicated range is x%. The charts below show confidence intervals (by year) for sales volume and revenue under your Current and Proposed rates. You can use the drop-down list to select the desired confidence level for the intervals. As you select higher levels of confidence you will note the intervals widen to accommodate the broader range of potential outcomes.

Use drop-down to select confidence level for sales volume and revenue confidence intervals:



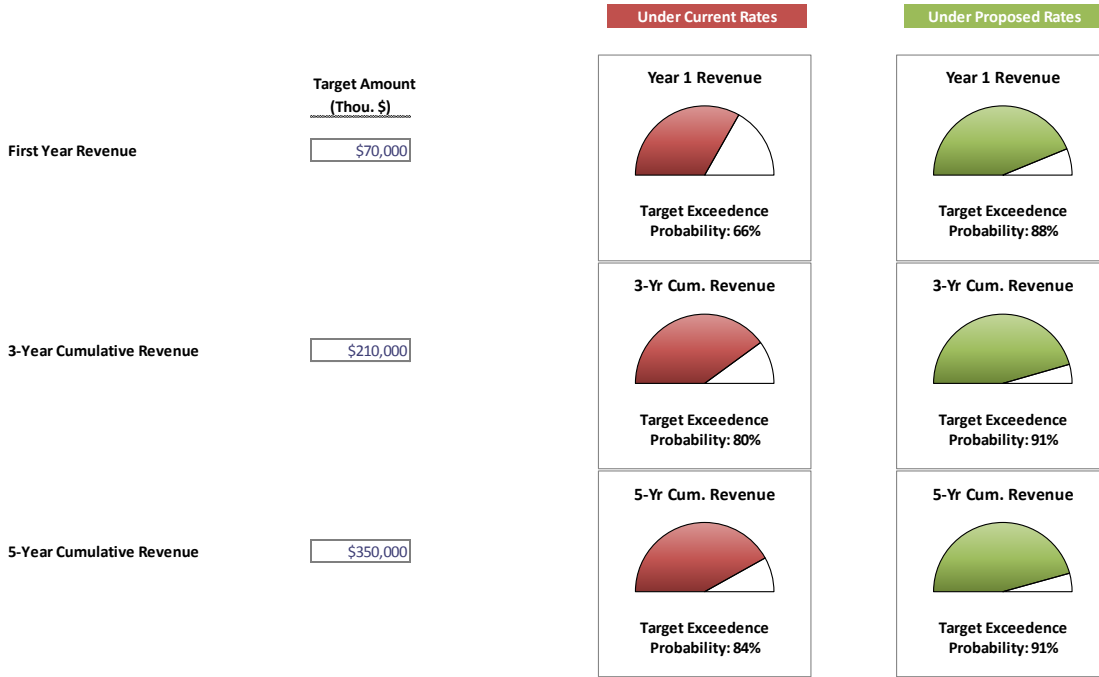
6.3.4 Sales Revenue Exceedence Probability

An exceedence probability indicates the likelihood of a variable taking on a value equal to or greater than some target value. In this section of the worksheet you can calculate exceedence probabilities for revenue under your current and proposed rates based on revenue targets you specify. This is illustrated in Figure 29. You can specify revenue targets for your first-year revenue, your 3-year cumulative revenue, and your 5-year cumulative revenue.

Figure 29. Revenue Exceedence Probabilities

4. Determine Sales Revenue Exceedence Probability

The sales revenue exceedence probability gives the probability that sales revenue will equal or exceed a target revenue. Use the Target Cells below to see the likelihood of meeting a revenue target under your Current and Proposed rates.



6.3.5 Stepping Through the Simulation Trials

In the last section of the worksheet you can graphically step through the simulation trials using the slider below the Simulation Trial charts. This is illustrated in Figure 30.

Note: Click the Animate Simulation button to have the charts step through the simulation trials automatically.

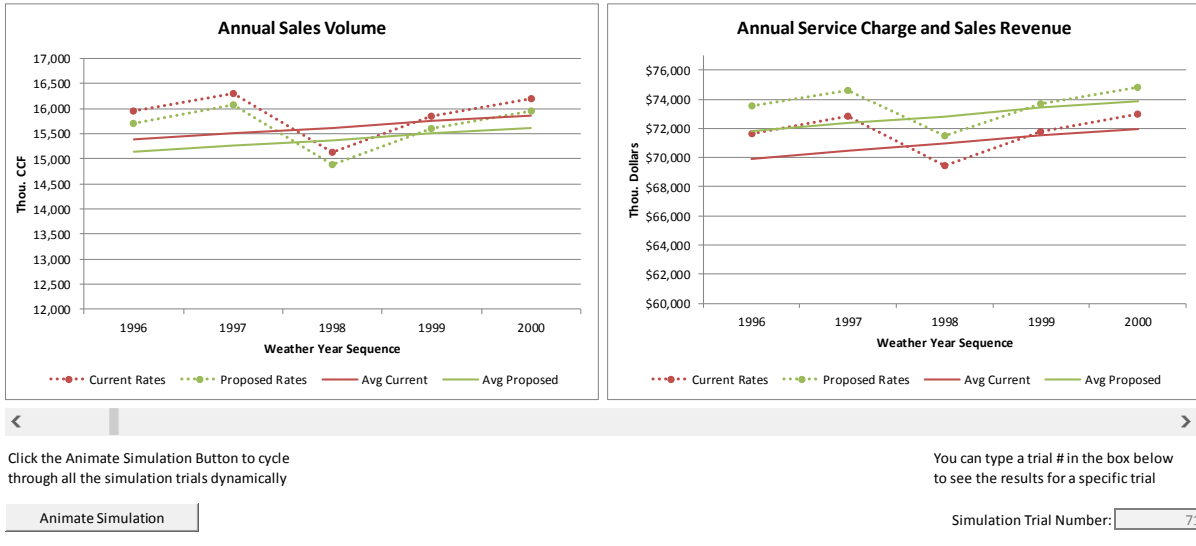
Note: You can go to a specific simulation trial number by entering it in the Simulation Trial Number box below the right-hand chart (see Figure 30).

Figure 30. Step Through Simulation Trials

5. Step Through the Simulation Trials

You can use the slider bar below the charts to step through each trial of the simulation. The charts display the simulated sales volume and revenue for each forecast year along with the averages across all the trials. The x-axis labels will show the weather year sequence used in the trial. Click the Animate Simulation button to cycle through all the simulations dynamically. If you want to see even more detail, you can access all the simulation output on the Simulation Output worksheet.

Simulation Trial #: 71



6.3.6 Simulation Output Worksheet

Results of the last run simulation are stored on the Simulation Output Worksheet. You can review all of the raw data from the simulation on this worksheet.

Note: The data on the Simulation Output Worksheet will get overwritten the next time you run a simulation. If you do not want to lose your simulation results, save the data on the worksheet before running your next simulation. An easy way to do this is by making a copy of the worksheet.

7 Run the Demo

The Demo lets you learn about the model interactively by working through a series of exercises using the Demo data that comes with the model.

7.1 Loading the Demo Data

Go to the **Model Overview and Instructions** worksheet and click the Run Demo button at the bottom of the worksheet. This will load the demo data into the model.

Note: Loading the Demo data will overwrite existing data in the model. To avoid accidentally overwriting your existing data, we suggest making a copy of your workbook before running the Demo.

7.2 Demo Model Setup

Go to the **Step 1: Model Setup** worksheet and review the model setup for the Demo. You should see the following:

Bill Tabulation Year	2012
Billing Units	CCF
Precipitation Units	In
Temperature Units	F
Off-peak Season	Oct - Apr
Peak Season	May – Sep
Max to Min Monthly Production Ratio	3.25
Number of Customer Classes	4
Class 1	Single Family
Class 2	Multi Family
Class 3	CII
Class 4	Landscape
Class 5	Unused
Class 6	Unused
Median Household Income	\$55,000
Primary Residential Class	Class 1

7.3 Demo Bill Tabulations

Go to the **Step 2: Enter Bill Tabulations** worksheet. Look over the bill tabulations for each customer class. The Demo bill tabulations are based on data from an actual utility, though the data has been fuzzed up a bit before being used here.

7.4 Setting the Service Charge

Go to the **Step 3: Customer Service Charges** worksheet. Familiarize yourself with the different sections of the worksheet. When you first load the Demo data, the current and proposed service charges are the same. Try making the some changes to the worksheet. Each time you make a change, observe how service charge revenue, summarized at the bottom of the worksheet, is affected. Here are some changes to try:

1. Change the billing frequency from bi-monthly to monthly? Did service charge revenue go up or down? Now change it to quarterly and see what impact this has on service charge revenue. When you are done, set it back to bi-monthly.
2. Change the number of accounts in Section 1 of the worksheet and see how this impacts annual service charge revenue.
3. Change the proposed service charges in Section 2 of the worksheet and see how this impacts annual service charge revenue.
4. When you are done, go to the **Model Overview and Instructions** worksheet and click the Run Demo button at the bottom of the worksheet. This will ensure that the original Demo values for this worksheet are restored.

7.5 Designing Seasonal Rates

Go to the **Step 4: Design Water Rates** worksheet. Familiarize yourself with the different sections of the worksheet. When you first load the Demo data the current and proposed volumetric rates are identical. In this exercise you will create proposed seasonal rates. Follow these steps.

1. Scroll to Row 33 of the worksheet. This is where the rate tables for the Single Family class start. Set the proposed rates for the off-peak season to \$2.50 for all blocks. Set the proposed rates for the peak-season to \$3.75 for all blocks. Does this cause Single Family annual sales to decrease by 1.7% and total annual revenue to increase by 1.4%?
2. Copy your proposed Single Family off-peak and peak rates into the proposed rates tables for the other customer classes. Do you understand why the changes in annual sales and total revenue are not the same among the customer classes? There are two things going on. First, look at the elasticity parameters at the top of the worksheet. They differ by customer class, which means each class is expected to respond differently to a change in the price for water. The Multi Family class is the least responsive and the Landscape class is the most responsive. Is this consistent with the reported changes in annual sales volume? Second, the proportion of total class water use in the peak season differs across the customer classes. (You can confirm this from the bill tabulations.) The Landscape class has a larger share of its total use in the peak season and therefore more of its water use faces an increase in price. This also causes it to adjust its demands more than the other classes.
3. Does it seem odd that water use went down but revenue went up? This is because the elasticity parameters are all less than 1 (in absolute value). This means we are treating water demand as inelastic. If price is raised on an inelastic demand then the percentage decrease in demand will be proportionately less than the percentage increase in price and revenue will increase. Likewise, if price is decreased, then the percentage increase in demand will be proportionately less than the percentage decrease in price and revenue will fall. Understanding these relative changes is critical when predicting the effect of a change to the schedule of volume rates on water sales and revenues. In the case of our seasonal rates we are both lowering the off-peak rate and raising the peak rate. Whether demand responds up or down depends on the relative amounts by which these two rates are changed and the proportion of overall demand occurring in each season. It gets complicated fast, which is why a model like this one is useful! As an experiment, try setting the Single Family proposed peak rate to \$3.50 instead of \$3.75. What happens to annual revenue for the Single Family class? Now set the peak rate back to \$3.75 and let's move on.
4. Scroll to Row 104. Let's look at how the proposed rates impact customer bills. Are the bill impacts the same across customer classes? Which customer class is likely to be

least happy with the new rates? Are bills likely to increase more than 20% for any customer classes? Are bills more likely to decrease or increase for the Multi Family class? Is this true for the other classes? Do the proposed rates cause a significant change in affordability, as measured by the Affordability Index?

5. Go to the **Bill Impacts** worksheet. Looking at the chart for the Single Family class, can you determine the percentage of bills that will decrease under the proposed rates? If not, look over the How to Interpret the Bill Impact Charts and then try again.
6. Go back to the **Step 4 Design Water Rates** worksheet.
7. Let's save these rates so we can access them later. Click the Save/Load Rates button. Click the Save Rates button in the dialog. Enter the name Seasonal Demo Rates and click OK. Click Close Form.

7.6 Drought Rate Adjustments

Go to the **Step 5: Drought Rate Adjustments** worksheet. Familiarize yourself with the different sections of the worksheet. The seasonal rates you developed in the previous exercise are carried forward to this worksheet. In this exercise you will explore how these rates would perform under different drought/shortage stages and how to adjust them to maintain revenue neutrality. Follow these steps.

1. Let's first copy the proposed rates into the Stage Rates tables. Scroll down to Row 98. Click the Reset Drought Stage Rates to Proposed Rates button. Click Yes when you are asked if you want to continue.
2. The Stage Rates are now identical to your proposed rates. Go to Row 32 and set the Drought Stage to Stage 0 if it is not already. The sales volumes and revenue should now be identical for the proposed and Stage rates.
3. Set the Drought Stage to Stage 1. What effect does this have on Single Family water sales and revenue? Why are water sales and revenue unaffected for the CII and Landscape classes?

4. Set the Drought Stage to Stage 2. What effect does this have on total water sales and revenue? Yikes! That's not good for the financial wellbeing of this utility. Let's see if we can address this revenue shortfall.
5. Scroll down to Row 125. Make sure the Drought Stage to Evaluate is set to Stage 2. Let's add a new tier to the Stage rates that will be designed to collect enough revenue to offset the shortfall caused by the need to have customers curb their water use.
6. On Row 127, set the method for calculating revenue neutral rates to Method 2.
7. Scroll up to the Stage Rates tables and do the following. Set Blocks 4 and 5 for the Single Family class to 20 CCF. Set Blocks 4 and 5 for the Multi Family class to 30 CCF. Set blocks 4 and 5 for the CII and Landscape classes to 40 CCF. Make sure to do this for both the peak and off-peak seasons.
8. Scroll down to Row 129. In the Leave or Adjust Rate in Block? table, set the cells for Block 1, Block 2, and Block 3 to Leave. Set the cells for Block 4 and Block 5 to Adjust. This will cause the calculator to only adjust the rates in Blocks 4 and 5.
9. Click the Find Revenue Neutral Rates button and wait for Excel to adjust your rates.
10. Go to Row 103 and confirm that the adjusted stage rates are revenue neutral. Review the rate adjustments in the Stage Rates tables. The rate for Blocks 4 and 5 should be \$3.08 in the off-peak season and \$4.61 in the peak season. Is this what you got?
11. Save your revenue neutral Stage 2 rates as a rate scenario named Stage 2 Rates.

7.7 Simulate Performance of Seasonal Rates

Go to **Revenue Simulation Module** worksheet and read the overview for the module. When you are done, go to the **Step 7: Setup Simulation** worksheet. Familiarize yourself with the different sections of the worksheet. In this exercise you will explore how the seasonal rates you developed earlier are likely to perform over a 5-year forecast period. Follow these steps.

1. Click the Save/Load Rates button and load the Seasonal Demo Rates you saved previously.
2. Go to Section 2 of the worksheet and confirm that Distribution is set to Normal.
3. Go to Section 3 of the worksheet and select None for the method for simulating the impact of drought/shortages on sales volumes and revenues. For the initial simulation we will assume there is no risk of having to impose water use restrictions.
4. Go to Section 4 of the worksheet and choose 500 for the number of simulation trials and click the Run Simulation button. The simulation should take about a minute to run. When it alerts you it's done, click OK. You should now be on the **Step 8 Review Sim Results** worksheet.
5. Scroll to Section 2 of the worksheet. These charts show the distribution of annual water sales volume and revenue. Does the distribution of water sales volume shift to the left or right under the proposed seasonal rates? How about annual revenue? How do these distributions change over the forecast period? (Hint: use the drop-down list to cycle through the forecast years.)
6. Scroll to Section 3 of the worksheet. These charts provide confidence intervals for water sales volume and annual revenue for each forecast year. If it is not already, set the confidence level to 95%. Now set the confidence level to 75%. Can you explain why the charts got narrower? Can you be 75% certain annual revenue in Year 5 will be greater than \$72 million? (Hint: if the confidence interval sits above this amount the answer is yes.) Set the confidence level back to 95%. Can you be 95% certain annual revenue in Year 5 will be greater than \$72 million? (Hint: if the confidence interval extends below this amount the answer is no.)
7. Go to Section 4 of the worksheet. Set the target for first year revenue to \$72 million (Hint: enter 72000). What is the likelihood revenue will equal or exceed this target under the current rates? The proposed rates?
8. Set the 3-year cumulative revenue target to \$216 million, which is three times the first year target. Set the 5-year cumulative revenue target to \$360 million, which is five times the first year target. Write down the first year, 3-year cumulative, and 5-year cumulative

exceedence probabilities for the proposed rates. Can you explain why you are more likely to meet the 5-year target than the 3-year target, and the 3-year target than the first year target? (Hint: one reason has to do with the number of accounts served over the forecast period, but there is something else at play as well.)

9. Go to Section 5 of the worksheet. Use the scroll bar below the charts to step through some of the simulation trials. Is it surprising to see how much sales can vary over the forecast period?
10. Let's go back to the **Step 7 Setup Simulation** worksheet. Go to Section 3 of the worksheet and choose Use Step 6 Data as the method for simulating the impact of drought/shortages on sales volumes and revenues.
11. Go to Section 4 of the **Step 6 Enter Weather Data** worksheet. Here you will see how the historical weather years have been associated with the drought stages.
12. Go back to the **Step 7 Setup Simulation** worksheet and run the simulation again.
13. When the simulation is finished scroll to Section 4 on the **Step 8 Review Sim Results** worksheet. Compare the target exceedence probabilities you wrote down previously to the ones now displaying? Did the possibility of water use curtailment have a significant impact? Did the likelihood of meeting the targets go up or down?
14. Go to Section 5 of the worksheet and step through the simulation trials. See if you can pick out the years were water use restrictions were in effect.

8 Rate Design Module Calculations

The calculations of water demand and revenue are done on the **Class_Model** worksheets. There are six of these worksheets, one for each customer class the user may define. Each worksheet is divided into two main sections. The first section, which extends from Row 1 to Row 265 holds the calculations for the Step 3 and Step 4 rate design calculations. The second section, which extends from Row 266 to Row 524, holds the calculations for the Step 5 drought rate adjustments. Each section is divided into two seasons. Columns D:T contain the calculations for the Off-Peak season. Columns V:AM contain the calculations for the Peak season. The calculations are the same for each season, differing only in terms of the underlying bill tabulation data and block, rate, and elasticity parameters. The following sections of this chapter describe these calculations.

8.1 Step 3 and 4 Sales and Revenue Calculations

For point of reference, the following discussion references worksheet column addresses for the calculations for the Off-Peak season. The calculations for the Peak season are analogous.

Bill Tabulation Data (worksheet columns D:E) – The bill tabulation data are imported from the **Step 2 Bill Tabulations** worksheet.

Current Rates - Avg Use/Bill (worksheet column G) – This column calculates the average use per bill by bill tabulation usage bin under the current rates. It is equal to the total use of bills stopping in the bin (column E) divided by the number of bills in the bin (column D).

Current Rates - Avg Rate/Bill (worksheet column H) – This column calculates the average rate paid for the average use/bill in each usage bin. Let i be the index of rate blocks ($i = 1, 2, \dots, 5$). Let B_i be the switch point for the i th block. Let R_i be the rate for the i th block. Let U be the average use for bills in the bin. Let AR be the average rate. AR is calculated as follows:

$$AR = \begin{cases} UR_1, & U \leq B_1 \\ (U - B_1)R_2 + B_1R_1, & U \leq B_2 \\ (U - B_2)R_3 + (B_2 - B_1)R_2 + B_1R_1, & U \leq B_3 \\ (U - B_3)R_4 + (B_3 - B_2)R_3 + (B_2 - B_1)R_2 + B_1R_1, & U \leq B_4 \\ (U - B_4)R_5 + (B_4 - B_3)R_4 + (B_3 - B_2)R_3 + (B_2 - B_1)R_2 + B_1R_1, & U > B_4 \end{cases}$$

Current Rates – Avg Vol Charge/Bin (worksheet column I) – This column calculates the average volume charge per bill for bills in each usage bin. It is the product of the average use/bill (column G) and the average rate/bill (column H).

Current Rates – Median Service Charge (worksheet column J) – This column calculates the median service charge for the customer class. It is equal to the median annual service charge divided by the number of bills per year. Both of these quantities are imported from the **Step 3 Customer Service Charges** worksheet. The median annual service charge is defined as the charge paid by the median meter size for the customer class. The median meter size is calculated from the accounts data in the Number of Accounts by Meter Size in Bill Tabulation Year table on the **Step 3 Customer Service Charges** worksheet. The number of bills per year is based on the billing frequency set by the user (monthly, bi-monthly, or quarterly).

Current Rates – Water Sales Revenue from Bills in Bin (worksheet column K) – This column calculates the revenue from water sales for bills in each usage bin. It is the product of the number of bills in the bin (column D) and the average volume charge for the bin (column I).

Proposed Rates – Relative Rate Change (worksheet column M) – This column calculates the percentage change in the average rate under the proposed rates relative to the current rate. It is calculated by dividing the average rate under the proposed rates by the average rate under the current rates and then subtracting 1. The average rate under the proposed rates is calculated in the same manner as for the current rates (see above).

Proposed Rates – Adjusted Average Use/Bill (worksheet column N) – This column calculates the adjusted average use under the proposed rates. Let U be the average use for bills in the bin under the current rate (column G). Let D be the relative rate change (column M). Let e be the price elasticity. Let AU be the adjusted average use. AU is calculated as follows:

$$AU = U(1 + eD)$$

Proposed Rates – Total Use (worksheet column O) – This column calculates the total adjusted use in each bill tabulation bin under the proposed rates. It is the product of the number of bills in the bin (column D) and the adjusted average use per bill (column N).

Proposed Rates - Avg Rate/Bill (worksheet column P) – This column calculates the average rate paid per bill for the adjusted average use under the proposed rates. It is calculated in the

same manner as described above for the current rates, but substituting the proposed rates for the current rates and adjusted average use (column N) for average use (column G).

Proposed Rates – Avg Vol Charge/Bin (worksheet column Q) – This column calculates the average volume charge per bill for bills in each usage bin under the proposed rates. It is the product of the adjusted average use/bill (column N) and the average rate/bill (column P).

Proposed Rates – Median Service Charge (worksheet column R) – This column is calculated the same way as column J, substituting the proposed service charges for the current service charges.

Proposed Rates – Water Sales Revenue from Bills in Bin (worksheet column S) – This column calculates the revenue from water sales for bills in each usage bin under the proposed rates. It is the product of the number of bills in the bin (column D) and the average volume charge for the bin under the proposed rates (column Q).

Proposed Rates – Bill Impact (worksheet column T) – This column calculates the percentage change in the average bill under the proposed rates relative to the current rates. It is calculated by dividing the sum of the average volume charge (column Q) and median service charge (column R) under the proposed rates by the sum of the average volume charge (column I) and median service charge (column J) under the current rates.

8.2 Step 5 Sales and Revenue Calculations

The calculations of average use/bill, average rate, relative rate change, adjusted average use, total use, and water sales revenue in the drought rate adjustments model, which extends from Row 266 to Row 524, are done in the same way as described in the previous section with one exception. Adjusted use is scaled by the Rationing Multiplier (cell B270), which adjusts water use for expected compliance with the curtailment level for the Drought/Shortage stage selected by the user.

8.3 Step 4 Average and Median Water Cost Calculations

The average and median annual water service costs reported in the % Change in Average and Median Annual Water Service Cost by Customer Class table on the **Step 4 Design Water Rates** worksheet are calculated as follows.

Average Water Service Cost – For a given customer class, let R1 and R2 be revenue from water sales in the Off-Peak and Peak seasons, respectively. Let B1 and B2 be the number of bills in the Off-Peak and Peak seasons, respectively. Let N1 and N2 be the number of months in the Off-Peak and Peak seasons, respectively. Let AS be the average annual service charge. Let AC be the average water service cost. AC is calculated as follows:

$$AC = 12 \left[\frac{R1 N1}{B1 12} + \frac{R2 N2}{B2 12} \right] + AS$$

AS is calculated in the Step 3 Customer Service Charges worksheet for the current and proposed service charges. R1 and R2 are calculated in the **Class_Model** worksheets for the current and proposed rates. B1 and B2 are from the bill tabulations entered by the user.

Median Water Service Cost -- For a given customer class, let M1 and M2 be the median volumetric charge in the Off-Peak and Peak seasons, respectively. Let N1 and N2 be the number of months in the Off-Peak and Peak seasons, respectively. Let MS be the median annual service charge. Let MC be the median water service cost. MC is calculated as follows:

$$MC = 12 \left[M1 \frac{N1}{12} + M2 \frac{N2}{12} \right] + MS$$

MS is calculated in the Step 3 Customer Service Charges worksheet for the current and proposed service charges. M1 and M2 are calculated in the **Class_Model** worksheets for the current and proposed rates as follows. The distribution of volumetric charges in each season is approximated as log-normal. Let m be the mean of the volume charges calculated from the bill tabulation. Let v be the variance of the volume charges calculated from the bill tabulation. Let mu be the location parameter of the log-normal distribution describing the shape of the distribution of volume charges. Then mu can be recovered from m and v as follows:

$$mu = \ln \left(\frac{m^2}{\sqrt{v + m^2}} \right)$$

The median volumetric charge, M, of the distribution of volume charges can be recovered from the location parameter, mu, as follows:

$$M = e^{mu} = \frac{m^2}{\sqrt{v + m^2}}$$

9 Revenue Simulation Module Calculations

9.1 Calculation of Weather Effects

Seasonal demands are adjusted for weather effects using the California Urban Water Conservation Council's GPCD Weather Normalization Methodology.¹ Deviations from average precipitation and temperature by month are calculated on the **Step 6 Enter Weather Data** worksheet using the weather data entered by the user. Demand adjustment factors for precipitation and temperature are then calculated using the demand adjustment parameters in the **Weather Adjustment Tables** worksheet. These calculations are performed in the Monthly Demand Adjustment for Precipitation and Monthly Demand Adjustment for Temperature tables on the **Step 6 Enter Weather Data** worksheet (these tables start on Row 212 of the worksheet). The monthly demand adjustments for precipitation and temperature are then summed to get the combined monthly weather effect. These calculations are performed in the Monthly Demand Adjustment for Combined Effect of Precipitation and Temperature table on the **Step 6 Enter Weather Data** worksheet.

The monthly combined weather effects are then formed into weighted average effects for the Off-Peak and Peak seasons. Two weights are applied to calculate the weighted average. The first weight is derived from the monthly seasonal shape coefficients for annual water demand estimated by Bamezai (2011). The monthly seasonal shape coefficients and corresponding weights are reproduced in Table 1.

Table 1. Monthly Seasonal Shape Coefficients and Corresponding Weights

Month	Jan	Feb	Mar	Apr	May	Jun
Coeff.	0.000	-0.107	0.082	0.230	0.434	0.554
Weight	1.000	0.899	1.085	1.259	1.543	1.740
Month	Jul	Aug	Sep	Oct	Nov	Dec
Coeff.	0.671	0.665	0.559	0.437	0.156	0.047
Weight	1.956	1.944	1.749	1.548	1.169	1.048
Coefficients are from Bamezai (2011), Table 8.						

¹ Bamezai, Anil. 2011. "GPCD Weather Normalization Methodology." Final Report Submitted to the California Urban Water Conservation Council. December 13, 2011.

The second weight is derived from the billing frequency entered by the user, which in combination with the seasonal definitions, also set by the user, determines the fraction of water usage days in each month represented by bills in the Off-Peak and Peak bill tabulations. Table 2 provides an example of the Peak season weights for monthly, bi-monthly, and quarterly billing frequencies when the Peak season is defined as May-Sep. Note that the Off-Peak season weights equal one minus the Peak season weights. These weights can be interpreted as showing the percentage of consumption represented by bills read in the month that falls in the Peak season. For example, the weights for May indicate that the percentage of consumption represented by bills read in that month falling in the Peak season is 50% if billing frequency is monthly, 25% if billing frequency is bi-monthly, and 16% if billing frequency is quarterly.²

Table 2. Billing Frequency Weights for May-Sep Peak Season

Bill Freq.	Jan	Feb	Mar	Apr	May	Jun
Monthly	0.00	0.00	0.00	0.00	0.50	1.00
bi-monthly	0.00	0.00	0.00	0.00	0.25	0.75
Quarterly	0.00	0.00	0.00	0.00	0.16	0.5
Bill Freq.	Jul	Aug	Sep	Oct	Nov	Dec
monthly	1.00	1.00	1.00	0.50	0.00	0.00
bi-monthly	1.00	1.00	1.00	0.75	0.25	0.00
quarterly	0.84	1.00	1.00	0.84	0.5	0.16

Given the above two weights, the weighted average seasonal weather effect is calculated as follows. Let i be the index of months ($i = 1, 2, \dots, 12$). Let W_i be the combined weather effect for month i . Let C_i be the weight for the seasonal shape coefficient for month i . Let F_i be the billing frequency weight for month i . Then the seasonal average weather effect, AW , is calculated as:

$$AW = \frac{\sum_i W_i C_i F_i}{\sum_i C_i F_i}, \quad \forall i \text{ in season}$$

The weighted seasonal average weather effects for each historical weather year are calculated in the Seasonal Weighted Average Combined Effect table on the **Step 6 Enter Weather Data** worksheet.

² These weights are based on the assumption that meter reading is evenly distributed across the days in the year.

9.2 Weather Normalization of Bill Tabulation Data

Before applying the historical weather effects to water use represented by the bill tabulations, this use needs to be weather normalized. This is necessary because the weather effects derived from Bamezai (2011) are relative to a normal weather condition. Weather normalization is accomplished by multiplying the seasonal consumption in the bill tabulations by the reciprocal of the seasonal weighted average weather effect for the Bill Tabulation Year.

Note: In order for the model to weather normalize the bill tabulation data prior to using it in the Revenue Simulation Module, the Bill Tabulation Year has to be represented in the historical weather time series data. If the historical weather data does not include the Bill Tabulation Year, the model will skip the normalization step.

9.3 Customer Class Account Growth Forecast

The customer account growth rate assumptions set by the user on the **Step 7 Setup Simulation** worksheet are transformed into stochastic growth rate variables on the **Simulation Sequence** worksheet. The user selects whether to represent the stochastic growth rate using a normal, triangular, or uniform probability distribution. The transformation for each distribution is done as follows.

Normal Distribution – The model uses the Extended Pearson-Tukey Approximation to recover the mean and variance of a normally distributed random variable from the Lower, Expected, and Upper growth rates entered by the user on the **Step 7 Setup Simulation** worksheet. For a given customer class, let g be the annual growth rate over the 5-year forecast period. Assume g is normally distributed with mean m and variance v . Let L , E , and U be the Lower, Expected, and Upper growth rates entered by the user. The mean, m , and variance, v , of g are recovered from L , E , and U as follows:

$$m = 0.63E + 0.185(L + U)$$

$$v = 0.63(E - m)^2 + 0.185[(L - m)^2 + (U - m)^2]$$

The probability density function for the growth rate variable, g , is then:

$$f(g|m, v) = \frac{1}{\sqrt{2\pi v}} e^{-\frac{(g-m)^2}{2v}}$$

Triangular Distribution – For a given customer class, let g be the annual growth rate over the 5-year forecast period. Assume g follows a triangular distribution. Let L , E , and U be the Lower, Expected, and Upper growth rates entered by the user. The probability density function for the growth rate variable, g , is then:

$$f(g|L, E, U) = \begin{cases} 0, & g < L \\ \frac{2(g-L)}{(U-L)(E-L)}, & L \leq g \leq E \\ \frac{2(U-g)}{(U-L)(U-E)}, & E < g \leq U \\ 0, & g > U \end{cases}$$

Uniform Distribution -- For a given customer class, let g be the annual growth rate over the 5-year forecast period. Assume g follows a uniform distribution. Let L and U be the Lower and Upper growth rates entered by the user. The probability density function for the growth rate variable, g , is then:

$$f(g|L, U) = \begin{cases} \frac{1}{U-L}, & L \leq g \leq U \\ 0, & g < L \text{ or } g > U \end{cases}$$

9.4 Simulation Sequence Worksheet and Simulation Calculations

The **Simulation Sequence** worksheet is used by the Revenue Simulation Module to generate the random weather sequences, associated peak and off-peak season weather effects on water use, water use curtailment % for each forecast year, and customer class account growth factors for each forecast year. Each time the workbook is recalculated, new sequences for these variables are generated on this worksheet by the model.

When a simulation is run, the workbook is recalculated n times where n is the number of trials set by the user (e.g. 100). This yields n randomly generated sequences for weather (and associated weather effect), water use curtailments, and customer account growth factors. The model saves these sequences to the **Simulation Output** worksheet. For each sequence, the model adjusts the water use and number of accounts represented by the bill tabulations for seasonal weather effects, curtailment %, and account growth. It then uses the adjusted water use and number of accounts and bills to calculate water sales, water sales revenue, and service

charge revenue under the current and proposed rate designs. These calculations are done in the same way as described in Chapter 8. However, for sake of computational efficiency the calculations are implemented with Visual Basic rather than done on a worksheet using spreadsheet formulas. The resulting annual sales volume and service charge and volumetric revenue are then saved to the **Simulation Output** worksheet.

10 Getting Weather Data

There are a number of sources for historical weather data you can access to compile the weather data needed to use the **Revenue Simulation Module**. This chapter lists some of these sources.

Note: Make sure you are aware of units the weather data are provided in. This is not always selectable with the websites listed below and you may need to do some conversions so that it can be used with the model. The model can take precipitation data reported in inches or centimeters and temperature data reported in degrees F or degrees C.

NOAA

Web Address <http://www.ncdc.noaa.gov/cdo-web/>

Climate Data Online (CDO) provides free access to NOAA's National Climatic Data Center's (NCDC) archive of historical weather and climate data. These data include quality-controlled daily, monthly, seasonal, and yearly measurements of temperature, precipitation, wind, and degree days as well as radar data and 30-year climate normals. This is a good source of historical weather series that can define the shape of likely weather outcomes.

Download of the monthly weather measures required by the *AWE Sales Forecasting and Rate Model*—precipitation and maximum air temperature—can be accomplished from the above website using the following steps:

1. Select DataSets from the above web page.
2. Expand (click on Plus sign) Monthly Summaries
3. Click on Search Tool
4. Set Date Range
5. Select "Search for"
6. Enter a Search term that corresponds with the "Search For" option selected
7. Click Search
8. Click Add to place data in Cart
9. View Cart items
10. Select Output format and click continue
11. Check data types for custom output (Precipitation and Air Temperature) and click continue

12. Enter email address for data download link to be sent to and click Summit Order

CIMIS

Web address: <http://www.cimis.water.cas.gov>

The California Irrigation Management Information System (CIMIS) is a program of the Office of Water Use Efficiency (OWUE), California Department of Water Resources (DWR) that manages a network of over 120 automated weather stations in the state of California. CIMIS was developed in 1982 by DWR and the University of California, Davis to assist irrigators in managing their water resources efficiently.

Estimated parameters (such as ETo, net radiation (Rn), dew point temperature, etc.) and measured parameters (such as solar radiation (Rs), air temperature (T), relative humidity (RH), wind speed (u), etc.) are stored in the CIMIS database for unlimited free access by registered CIMIS data users.

Daymet

Web address: www.daymet.ornl.gov

The data distributed through this web site are generated from the Daymet model and have broad applications over a wide variety of scientific and research fields including hydrology, terrestrial vegetation growth models, carbon cycle science, and regional to large scale climate change analysis. Developed by Dr. Peter E Thornton to fulfill the need for daily climatological data necessary for plant growth model inputs, Daymet generates daily, gridded surfaces of temperature, precipitation, humidity, and radiation over large regions and takes into account areas of complex terrain.

Daymet data has been updated for 1980-2012 and expanded to include the United States, Mexico, and Canada (south of 52 degrees North) as station density allows. Data can be downloaded for a single 1-km x 1-km pixel as a text file of daily data for all Daymet variables, or as a gridded tile of daily data for each Daymet variable. Annual climatological summaries are also available for some Daymet variables.

11 Visual Basic Macros

The backend of the Sales Forecasting and Rate Model is programmed in Visual Basic for Applications. This chapter lists the macros included in the model and provides a brief description of their purpose. The macros can be accessed from the Visual Basic Editor, which is integrated with the Excel application.

11.1 mSubs

Macros in the mSubs module include the following.

KillSplashScreen – this macro unloads the splash screen that is displayed when the model is opened.

AnimateCharts – this macro animates the charts in Section 5 of the **Step 8 Review Sim Results** worksheet.

SetChtScrollBar – this macro sets properties of the chart scroll bar for the charts in Section 5 of the **Step 8 Review Sim Results** worksheet.

SetYaxisScale – this macro sets y-axis scale properties for charts.

BillImpacts – this macro creates the sorted bill impact data needed to generate the bill impact charts on the **Bill Impacts** worksheet. It runs each time the **Bill Impacts** worksheet is activated by the user.

RevNeutralRatesButton – this macro calls the SetRevenueNeutralRates macro when the user clicks the Find Revenue Neutral Rates button on the **Step 5 Drought Rate Adjustments** worksheet.

SetRevenueNeutralRates – this macro implements the Revenue Neutral Rates Calculator on the **Step 5 Drought Rate Adjustments** worksheet.

SetRateFormulas – this macro sets worksheet formulas used by the Revenue Neutral Rates Calculator on the **Step 5 Drought Rate Adjustments** worksheet.

SetRateValues -- this macro sets worksheet cell values used by the Revenue Neutral Rates Calculator on the **Step 5 Drought Rate Adjustments** worksheet.

GoalSeek – this macro implements Excel's Goal Seek functionality to calculate revenue neutral drought rates.

ResetRatesButton – this macro calls ResetDroughtRates when the user clicks the Reset Drought Stage Rates to Proposed Rates button on the **Step 5 Drought Rate Adjustments** worksheet.

ResetDroughtRates – this macro resets the drought stage rates to the proposed rates on the **Step 5 Drought Rate Adjustments** worksheet.

RunSimulation – this macro runs the simulation subroutines when the user clicks the Run Simulation button on the **Step 7 Setup Simulation** worksheet.

GenerateSimulationSequences – this macro generates the sequences for weather (and associated weather effect), water use curtailments, and customer account growth factors and writes them to the **Simulation Output** worksheet.

SimulateServiceCharges – this macro calculates simulated annual service charge revenue.

SimulateSales – this macro calculates simulated annual sales volume and revenue

VolAndRev – this macro calculates annual sales volume and revenue. It is called by the SimulateSales macro.

SimulationStatus – this macro updates the simulation status text on the **Step 7 Setup Simulation** worksheet while the simulation is running.

11.2 mFunctions

Macros in the mFunctions module include the following.

AverageRate – this function returns the average volumetric rate paid for water use. It takes water use and the vectors of blocks and rates as arguments. It is called by the VolAndRev macro.

design – this function returns the name of the rate design (current, proposed, drought). It takes a rate design index value as its argument. It is called by various macros used to save/load rate scenarios and to load the data used by the Demo.

11.3 mDemo

Macros in the mDemo module include the following.

runDemoButtonClick – this macro calls the loadDemo macro when the user clicks the Run Demo button on the **Model Overview and Instructions** worksheet.

loadDemo – this macro loads the Demo data into the model.

setDemoModelParameters – this macro sets the model parameters for the Demo. It is called by loadDemo.

setDemoWeather– this macro loads the weather data for the Demo. It is called by loadDemo.

setDemoAccts -- this macro loads the class account data for the Demo. It is called by loadDemo.

setDemoBillTabs – this macro loads the bill tabulations for the Demo. It is called by loadDemo.

setDemoRates – this macro loads the current and proposed rates for the Demo. It is called by loadDemo.

11.4 mScenarios

Macros in the mScenarios module include the following.

loadScenarioForm – this macro loads the Load/Save Rates form when the user clicks the Save/Load Rates button.

11.5 frmScenario

Macros in the frmScenario code module include the following.

DeleteScenarioButton_Click – this macro calls the DeleteScenario macro when the user clicks the Delete Scenario button on the Load/Save Rates form.

DeleteScenario – this macro deletes the scenario selected by the user.

LoadScenarioCancelButton_Click – this macro Load/Save Rates unloads form when the user clicks Close Form button.

LoadScenarioOKButton_Click – this macro loads the rate scenario selected by the user into the model.

SaveScenarioButton_Click – this macro calls saveScenario when user clicks the Save Scenario button.

saveScenario – this macro saves a new rate scenario to the **Saved Rates** worksheet.

setName – this macro gets the name for the saved scenario from the user. It is called by SaveScenarioButton_Click.

getValues – this macro gets the rates from the model to save as a new scenario. It is called by SaveScenarioButton_Click.

UpdateScenarioButton_Click – this macro calls updateScenario when the user clicks the Update Scenario button on the Load/Save Rates form.

updateScenario – this macro updates the scenario selected by the user with the rates currently in the model.