ERCOT Drought Risk Analysis: Water Supply Prediction Methodology

Prepared in Consultation with Black & Veatch

Water Supply Prediction Methodology

This document describes in greater detail the methodology used to predict future reservoir storage in ERCOT's drought risk prediction tool, which was developed as an Excel workbook. As part of this work, ERCOT has also developed a sample spreadsheet that demonstrates the prediction methodology for a generic reservoir. The tool was developed for ERCOT by Black & Veatch (B&V) during 2013-2014. The purpose of the tool is to provide both six- and 18-month advanced notice of those generation resources that are at risk of reaching low reservoir supply levels.

Background

In developing the tool, B&V initially considered several factors contributing to drought risk for power generation: generation type and cooling method, generation size, rainfall and runoff, reservoir storage volume, additional supply sources, water temperature, historical water usage, and level of intake or at-risk water level. However, after initial review B&V determined that the greatest risk of failure due to drought is directly related to the water storage in each of the relevant cooling water storage systems. Therefore, the tool uses information about total reservoir storage, at-risk levels (i.e., level of intake), and a prediction of future storage changes to estimate the time to failure for a given reservoir. ERCOT is considering for future work to add additional prediction capabilities to the tool and consider additional risk factors, such as temperature and precipitation forecasts.

The tool considers each reservoir that has a connection to an operating generation facility that uses water in any part of its operation.[1] ERCOT linked each hydro and thermal generating unit to its primary source of water supply based on responses to a generator survey on water supply, as well as additional research where necessary.

The reservoirs providing water supply to power generation generally fall into two categories: reservoirs fed by drainage basins (drainage-fed reservoirs) and reservoirs fed from rivers or other reservoirs (off-channel reservoirs). For drainage-fed reservoirs, the tool predicts future storage based on an analysis of historical changes in reservoir storage. For off-channel reservoirs, the tool predicts future storage based on evaporation and generator water usage calculations. The reason for the two different methodologies is due to the different design of the two types of reservoirs, as will be described below.

Drainage-fed Reservoirs

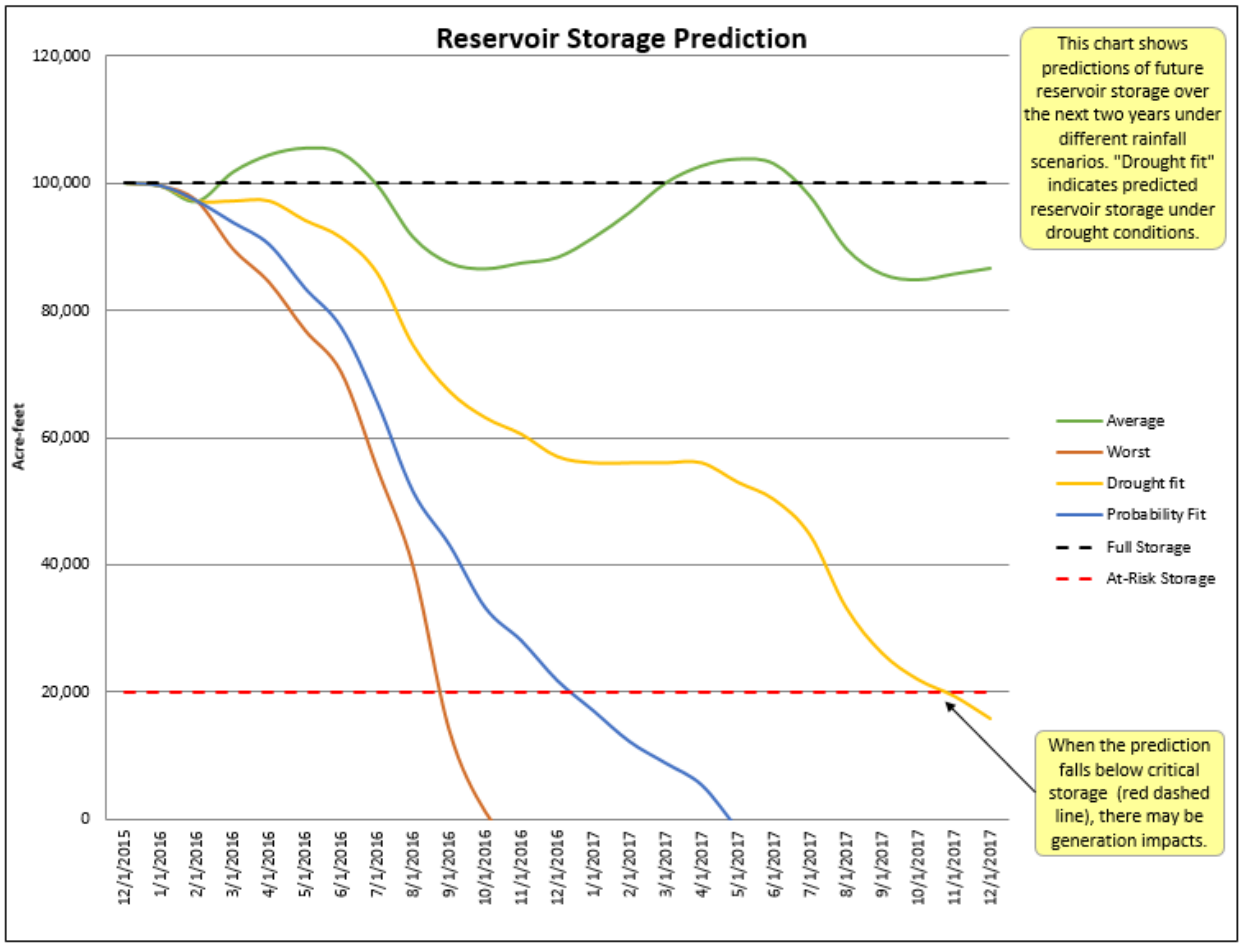
These types of reservoirs are fed from runoff from drainage basins. Current and historical reservoir water levels are available for most of these reservoirs from the Texas Water Development Board (TWDB) website[2] or other sources (e.g., U.S. Geological Survey (USGS), U.S. Army Corps of Engineers (USACE)). The available information is stored (in terms of elevation (ft)) in the spreadsheet in the box entitled "Historical Data" (Column Y). The current reservoir level is updated on a monthly basis, to enable up-to-date predictions.

Elevation-volume curves are available for most reservoirs from the TWDB or USGS. These curves link water levels (feet) to storage volume (acre-feet). The elevation-volume curve is stored in columns BS and BT. The tool uses this information to compute the storage volume associated with the historical elevation data (column Z, and the chart entitled "Historical Storage"), and the month to month change in storage volume (column AA). The table entitled "Historical Monthly Changes in Storage" (Columns BA to BP) shows the monthly changes in storage. All the data is then analyzed to enable percentiles of the data to be developed (Columns AR to AX).

[1] At this time the drought risk prediction tool is limited to surface water sources. ERCOT is considering refining the estimates of groundwater availability in future projects.
[2] For more information, visit http://www.waterdatafortexas.org/.

A “Drought Fit” prediction is used to simulate the storage changes in times of drought, and is developed in the table entitled “Monthly Changes in Storage – Statistics” (cells AR18 to AY31). For most of the reservoirs that are fed by natural drainage, the level of the 30th percentile is used as the guide for developing the monthly usage. In some cases, modifications to the 30th percentile are necessary. For example, some systems that have large releases for agricultural or flood control reasons that would be very unlikely under drought conditions. If these were included in the calculations they would skew many of the results. Any deviations from the use of the 30% percentile are described in the table below entitled “Explanation of Drought Fit.”

Once the drought fit is calculated, the associated storage change is then removed from the current reservoir level, in the table entitled “Reservoir Storage Predictions” (Columns AC to AL). These predictions are shown in the “Reservoir Storage Prediction” chart (Columns B to P and shown in Figure 1). The worst case (minimum value), drought fit (30th percentile or other value) and average (50th percentile) are shown on the reservoir prediction graph to enable an understanding of risk levels across different scenarios.



Note: The “Probability Fit” is a user-selected value that allows users to view predictions based on different percentiles of the historical data. The percentile shown in the chart is based on the 50th percentile of data.

Figure 1: Reservoir Storage Prediction Example

Off-Channel Reservoirs

Off-channel reservoirs are generally kept at close to full storage and fed by a secondary water source.[3] Since reservoir level data for these reservoirs is driven by the man-made inputs (of which volume data are generally not available) a different risk model is necessary. Instead of basing predictions on historical data, water losses from evaporation and usage by the generation resource are calculated under the assumption that there is no inflow to the reservoir and no transfers from other sites are available, representing a worst-case scenario.

Current and historical reservoir levels are available for a few off-channel reservoirs, but most do not have this information available publicly. Therefore, the "Estimated Storage" table (Columns W to AA) estimates storage under the assumption that the reservoir is generally kept at or close to full levels. ERCOT surveys the owners of generation resources that use off-channel reservoirs, as per the procedures outlined in Appendix 4, to validate this assumption.

Similarly, elevation-volume curves are generally unavailable for these types of reservoirs. Instead, a storage profile is created based on known information about the depth, elevation, and total storage of the reservoir (Columns BB to BE).

Instead of percentiles based on historical information, the "Drought Fit" (Columns AI to AR) is calculated based estimated storage losses from evaporation from the lake and consumption by the generation resource. The reservoir evaporation was calculated using a pan evaporation average for the area where the reservoir is situated (there were three locations used – West Texas, East Texas and I-35 Corridor).[4] The area chosen provided a monthly evaporation constant in inches which was used to calculate a reduction in the reservoir level. The amount of water consumed by the generation resource was added to this calculation and is estimated by multiplying the unit's annual generation (apportioned on a monthly basis) by an assumed water consumption amount (gal/MWh). The water consumption per MWh assumption varies depending on the generation type and cooling system type.

As with drainage-fed reservoirs, these storage changes are subtracted from the assumed full condition in columns AC through AG, and the results are shown in the chart entitled "Reservoir Prediction" in columns B to P.

At-Risk Reservoir Levels

The level at which a reservoir becomes at risk can vary between reservoirs and generation units. An intake structure may be near the top level of the lake, or it may be very close to the base. By default, the tool assumes at-risk levels at 20% of total storage for drainage-fed reservoirs and 50% of total storage for off-channel reservoirs (see table entitled "Reservoir Details" in columns Q to T). The values are set at different default levels due to the different modes of operation for the two types of reservoirs. In addition, information reported to ERCOT on the generator surveys was used as a way to check these assumptions, and in some cases they were modified to reflect generator-specific conditions.

Prediction of Months Until At Risk

For both drainage-fed and off-channel reservoirs, predictions of the number of months to at risk (the number of months before the water levels become at risk in that specific reservoir) are made. This is

[3] ERCOT is considering refining the linkages between off-channel reservoirs and their secondary water sources in future work.

[4] Evaporation estimates were adapted from the U.S. Geological Survey report: Harwell, G.R. *Estimation of Evaporation from Open Water – A Review of Selected Studies, Summary of U.S. Army Corps of Engineers Data Collection and Methods, and Evaluation of Two Methods for Estimation of Evaporation from Five Reservoirs in Texas, 2012*. Available at http://pubs.usgs.gov/sir/2012/5202/pdf/sir2012-5202.pdf.

done in the table entitled “Risk” (Columns Q to T and Figure 2). Each reservoir is included in the monthly drought risk report, and the total amount of capacity and annual energy associated with reservoirs potentially at risk within 6 and 18 months is reported.

Risk	Average	Worst	Drought Fit
Months to Empty	45	8	29
Months to At Risk	45	6	20

Figure 2: Risk Table Example