

Appendix 8

Approved Early-Season Water Supply Forecasts:

The following early-season forecast equations have been approved by the CRTOC for Treaty purposes¹:

Dworshak	November and December equations (April-July volume)
Libby	December equation (April-August volume)
Mica	December equations (February-July, April-August volumes)
Arrow (total)	December equations (February-July, April-August volumes)
Duncan	December equations (February-July, April-August volumes)

For all other forecasts required for early-season purposes or outside the water supply forecast season, the 71-year median volume will be used unless otherwise agreed upon by the CRTHC and the CRTOC.

Volumes Used for Flood Control Purposes During the July – December period:

During the July through October period, flood control computation will be based on the 71-year median volumes for all projects. In November, flood control will be based on the 71-year median volumes for all projects except Dworshak which will be based on the November early-season forecast. In December, flood control will be based on the 71-year median volumes for all projects except Dworshak, Duncan, and Libby, which will be based on their December early-season forecasts.

Developing January-July Volumes from Statistical Forecast Volume Periods for VECCs:

Whether early-season or within season, calculating the January-July volume forecast period from a smaller or different statistical volume forecast period will be done by the following methodology:

1. For the Canadian projects (Mica, Arrow and Duncan), a February – July volume forecast is available. To complete the January through July period, the historic 71-year average volume for January will be added to the February – July forecast to complete the January-July period.
2. For volume forecasts supplied by the NWRFC and the USBR, the January-July volume forecast is provided so no additional computation is required.

3. For Libby and Dworshak the forecast equations provide an April-August and April-July forecast, respectively. To convert the shorter volume forecast periods to a January-July forecast, the following will occur in the order listed:
 - If an observed value is available for January, February, and/or March, then that observed value is used for its respective month.
 - If a forecast is available for the month the AER/TSR is being produced, then the forecast is used for that month only.
 - If none-of-the-above are available, then the monthly average from the 71-year 2000 Level Modified Flow set will be used for each missing month.

Example: For the first TSR produced in February, the Dworshak January-July period would be computed as follows:

Dworshak observed January volume + Dworshak forecasted volume for the month of February + the Dworshak March 71-year average + Dworshak April-July forecast from the USACE February 1 forecast equation

In the case of Libby, the forecast equations produce an April through August volume. To remove the month of August volume from this forecast, in order to produce an April through July forecast, the following procedure is used:

- Determine what percent of average the April-August volume forecast is based on the 71-year average for the period
- Multiply this same percentage by the average August volume (based on the 71-year average)
- Subtract this value from the April through August forecast to get an April through July forecast
- Once the April through July forecast is determined, continue with step 3 above to complete the January through July forecast

Error Statistics to be used for Treaty Purposes:

Under the recommendation of the CRTHC, the CRTOC endorsed the use of the Cross Validation Standard Error (CVSE) for all Treaty purposes when available for the respective equations and volume forecast periods.

For volume periods where a forecast equation is available and a CVSE has been computed, the CVSE will be used. If the CVSE is not available for an equation, the Standard Error will be used. When median volumes are used in the absence of an approved equation, the standard error (RMSE) about the 71-year median will be used as the error statistic.

For required periods which are created from the smaller forecast periods (i.e. Apr-Jul forecast to a Jan-Jul forecast), the CVSE for the larger period will be derived by creating the larger forecast period as described in the “Developing January-July Volumes from Statistical Forecast Volume Periods for VECCs” section of this document for each of the historic years used in developing the equation. Once this historic volume forecast set is created, the CVSEs can then be calculated using the leave-one-out cross-validation process. The CVSEs can be found in Table 1.

Computation of Hedges:

Under the recommendation of the CRTHC, the CRTOC endorsed using the appropriate t-statistic based on the equation’s historic sample size for computation of the hedges used to compute the 95% exceedance value. As described by Randy Wortman in Attachment 1 and 2, the t-statistic should vary depending on the sample size used to develop the CVSE or SE. Generally, equations were developed using a consistent number of historic years, however, Libby and Dworshak used 2-3 sets of historic years to develop their forecast equations (the number below each t-statistic is the historic sample size used to develop the equations). Transitioning from 2-3 different t-statistics for any given project could lead to confusion. The CRTHC evaluated the difference in t-statistics for the various data sets and determined that a fixed t-statistic value provided some consistency in methodology across the different forecast dates, with only a very small sacrifice of technical precision. Therefore, for each project a single t-statistic will be used based on the historic data set most frequently used for the development of the project’s forecast equations.

Based on the current equations¹, their associated sample size, and the consistent value decision, the following t-statistics will be used (the number below each t-statistic is the historic sample size that the CVSE was developed on). For projects where the median volume is used absent an approved volume forecast procedure, the t-statistic for a 71-year record will be used:

T-Statistic Table

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Mica		1.688 (37)							
Arrow Total		1.688 (37)							
Duncan		1.688 (37)							
Dworshak	1.680 (44)	1.680 (44)	1.680 (38)						
Libby		1.680 (55)	1.680 (29)	1.680 (43)	1.680 (43)	1.680 (43)	1.680 (43)	1.680 (43)	1.680 (43)
All other projects (based on 71-year record)	1.667 (71)	1.667 (71)							

The hedges to be used to compute the one-sided 95% confidence limit, calculated using the errors and the appropriate t-statistic from above, can be found in Table 1.

Monthly Distribution Factors:

The monthly distribution factors will be calculated on the 71-year 2000 Level Modified Flow data set for use in TSR streamflow forecast development and coordination and for AOP/DOP applications. The 71-year monthly distribution factors will be implemented starting with the 2013 AOP and the 2008 DOP. Further explanation of the development of the monthly distribution factors is found in Attachment 3. The monthly distribution factors, determined from the 71-year 2000 Level Modified Flow record, can be found in Table 2.

Development of Streamflow Forecasts for TSR Purposes:

Treaty Storage Regulation (TSR) modeling is done twice a month. Monthly (semi-monthly for April and August) streamflow forecasts are developed through a coordinated process and then submitted by the USACE and the BPA for implementation in TSR/AER modeling. In order to provide a common methodology and consistency when coordinating streamflows and to provide an opportunity to blend near-term knowledge with long term historic shaping, the following procedures were developed:

January through June Forecast Season:

First TSR of the Month:

1. The forecast for the current month is coordinated with appropriate organizations or agencies.
2. The residual volume (January-July volume less observed whole months and coordinated forecast for current month when in the January-July timeframe) is shaped using the monthly distribution factors to come up with the remaining monthly streamflow values.

Second TSR of the Month:

1. The forecasts for the remainder of the current month and the following month are coordinated with the appropriate organizations or agencies.
2. The residual volume (January-July volume less observed whole months and coordinated forecasts for current month and subsequent month) is shaped using the monthly distribution factors to come up with the remaining monthly streamflow values.

July through December Forecast Season:

First and second TSR of the month:

1. For projects with approved early-season water supply forecasts available in November and/or December (Mica, Arrow, Duncan, Libby, and Dworshak), the January-June procedure above is applied to forecast volumes to determine the required monthly streamflow forecasts.
2. For all other months and all other projects, the monthly values are either based on median streamflows or on forecast values that are coordinated between the appropriate organizations and agencies.

¹ Mica, Arrow (total), Duncan: (2006) BC Hydro VoDCa Statistical Seasonal Volume Forecast Equations for the Canadian Columbia River Treaty Projects
Dworshak: (2005) Dworshak Water Supply Forecast – 2005 Update to Statistical Forecast Equations
Libby: (2005) Water Supply Forecasting Models for Libby, MT