

Waterbalance Utility

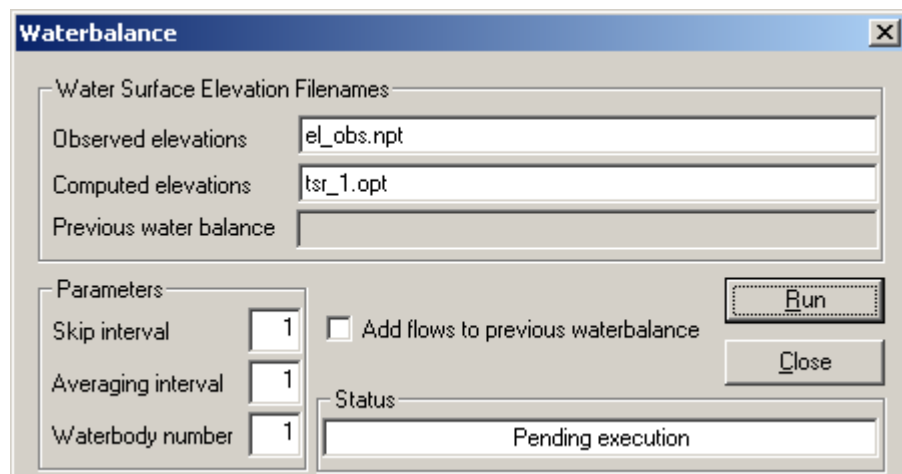
CE-QUAL-W2 Version 3.7

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## HOW TO USE THE WATER BALANCE UTILITY

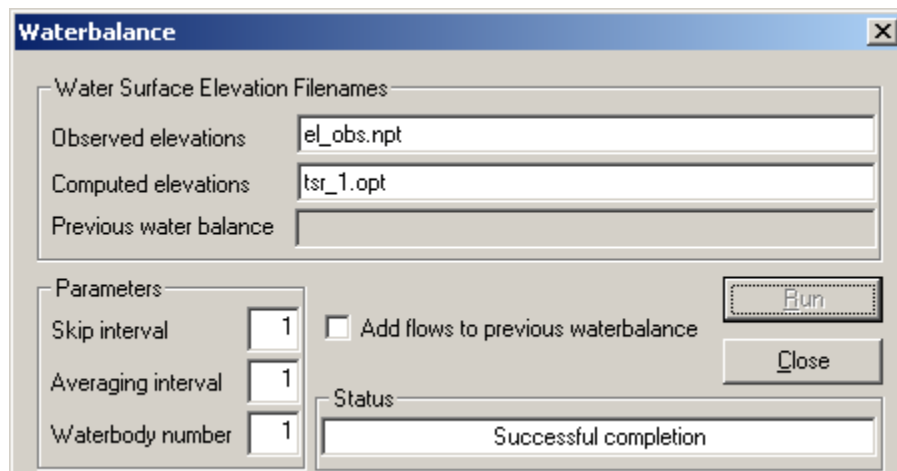
### RUNNING THE WATER BALANCE PROGRAM

When the executable is run, a window appears that allows the following inputs (note that the executable runs under the Windows operating system only):



The image shows a Windows-style dialog box titled "Waterbalance". It has a blue title bar with a close button (X) in the top right corner. The dialog is divided into several sections. The top section is labeled "Water Surface Elevation Filenames" and contains three text input fields: "Observed elevations" with the value "el\_obs.npt", "Computed elevations" with the value "tsr\_1.opt", and "Previous water balance" which is empty. Below this is a "Parameters" section containing three spin boxes: "Skip interval" set to 1, "Averaging interval" set to 1, and "Waterbody number" set to 1. To the right of these spin boxes is a checkbox labeled "Add flows to previous waterbalance" which is currently unchecked. Further right are two buttons: "Run" and "Close". At the bottom, there is a "Status" label followed by a text box containing the text "Pending execution".

When the dialog box first appears, default values populate the edit boxes. The user can then edit each one if the default values are not correct. Selecting Run will run the waterbalance utility to completion as show in the following dialog box.



This image shows the same "Waterbalance" dialog box as above, but after the "Run" button has been clicked. The "Status" text box now displays "Successful completion". All other elements, including the file names, parameters, and checkboxes, remain the same as in the previous state.

**Observed elevations filename.** This file consists of a Julian day and observed elevation as in the following example:

2000-2001 Oologah Reservoir observed water surface elevations

JDAY	ELO
90.792	195.453
90.833	195.456
90.875	195.459
90.917	195.441
90.958	195.444
91.000	195.450
91.042	195.441
91.083	195.441
91.125	195.447
91.167	195.441
91.208	195.444
91.250	195.438
91.292	195.432

This example is prepared similar to all other CE-QUAL-W2 time-varying inputs with a fixed format with eight columns each for the JDAY and ELO values. However, the utility will read in values using variable field lengths so long as the JDAY and ELO values are separated by a space. Data need not be at regular intervals that might cause a repeat of the same values. Better results will be obtained if the same values that repeat over a time interval are not included. Doing this compresses the time interval that the utility uses to compute the flows thus generating much larger flows over a shorter time interval, which is generally not desirable.

For example, the water surface elevation at day 91.083 should be deleted in the above example. Also note that the degree of accuracy in the observed elevations can have an impact on the computed flows. The above example will yield different water balance flows if the elevations are rounded off to two decimal places. If flows are computed at three and two decimal places for each date, the resulting files will have the following positive/negative flows at the given time intervals if repeating elevations are eliminated, assuming that the observed water surface elevation is constant at 195.453 m and 195.45, respectively, over the time period. It is up to the user to decide the necessary precision used in the observed water surface elevations.

JDAY	QWB	JDAY	QWB
90.792	+	90.792	-
90.833	+	90.958	+
90.875	+	91.000	-
90.917	-	91.083	+
90.958	+	91.125	-
91.000	+	91.292	
91.042	-		

91.125	+
91.167	-
91.208	+
91.250	-
91.292	

**Computed elevations filename.** The following shows an example output file (the ..... leader indicates that additional information is included in the time series output file, but is not included here):

```
Density placed inflow, point sink outflow
Default hydraulic coefficients
Default light absorption/extinction coefficients
Temperature simulation - run 29 turned WQ on
Tom Cole and Dottie Tillman - WES
```

Model run at 13:11:22 on 08/22/03

JDAY	DLT	ELWS.....
92.000	456.39	195.37.....
93.000	952.28	195.28.....
94.000	494.28	195.27.....
95.000	34.43	195.17.....
96.000	170.88	195.08.....
97.000	211.93	194.99.....
98.000	255.11	194.92.....
99.000	1459.08	194.78.....

The water balance utility reads in the [JDAY] and [ELWS] values and uses these in the water balance computations. The user must turn on time series output in the model control file and specify the segment at which the water surface elevation values are output (typically the segment next to the dam for reservoirs). Information on how to accomplish this is given in the User's Manual under the Time Series output file discussion.

**Add to previous water balance.** For various reasons, the water balance utility may not perfectly close the water balance the first time through the computations. Depending upon the discrepancies between computed and observed elevations, the utility may need to be used iteratively by rerunning the model using output from the first run of the water balance utility and then rerunning the water balance utility on the water surface elevations output in the new time series file. For a system with multiple branches, each iteration of the utility and the resulting output file can be saved as a separate file that is then incorporated as a distributed tributary for branch 2, then branch 3, etc. In the case of a system with only one branch, this approach cannot be used. Rather, the new flows generated at the second iteration need to be added to the previously computed flows and incorporated as an "improved" distributed tributary inflow file. This option allows the user to continue adding flows to the same inflow file.

The computed flows are contained in the “qwb.opt” file. For most simulations, these flows will generate water surface elevations sufficiently close to the observed elevations such that further refinement is unnecessary. However, as mentioned above, the solution may need to be iterated. Rarely, manual adjustment of the generated flows may be required. This is usually only needed when observed water surface elevations change significantly over a short time period.

**Previous water balance filename.** If the “Add to previous water balance” option is used, you must specify the existing water balance output file for the computed flows to be added to

**Skip interval.** Some reservoirs have a lot of noise in the observed water surface elevation data, such as in peaking hydropower operations, and this option allows the user to specify how many observed elevations are ignored when computing the flows between observed elevations. For example, if water surface elevations are available on an hourly interval, the resulting flows generated by the water balance utility can have large + and – flows that are completely unrealistic as opposed to using observed elevations on a daily basis taken during periods of no hydropower generation. In order to smooth out the computed flows, a skip factor of 24 would result in computed flows being output on a daily basis with all of the “noise” generated by hydropower operations ignored over the 24 hour period.

**Averaging interval.** This option computes a running average of the water surface elevation based on the input value. This is an additional aid to smooth out water surface elevation “noise”. For example, consider the case in which there is no inflow/outflow to the system, but there is considerable wind seiching. The water balance utility would compute alternating inflows and outflows from the system that, depending on the amount of seiching, could be very large when in reality there should not be any flows added to or subtracted from the system. Using a running average alone or in combination with skipping over a number of observed elevations specified in (4) can help alleviate many of the problems caused by an automated water balance computation.

**Waterbody number.** In the case of multiple waterbodies each of which has a separate bathymetry input file, the user must specify which waterbody (and thus which bathymetry file) the water balance is being computed for. This capability is necessary for modeling systems with multiple reservoirs.

## INCORPORATING THE COMPUTED FLOWS INTO THE SIMULATION

The water balance utility can be used for lakes and reservoirs in which water surface elevations are a function of inflows and controlled outflows from the system. The utility computes the flows necessary to match observed water surface elevations (typically taken at the dam) and outputs them to the “qwb.opt” file. This file is composed of a Julian date and an inflow ( $\text{m}^3 \text{sec}^{-1}$ ). The flows can be either positive or negative. Temperatures and/or constituent concentrations must also be provided in the corresponding temperature and constituent concentration input files if the computed flows are incorporated as inflows to the system. ***The water balance utility does not provide this information***, but this information needs to be provided by the user depending upon how the computed flows are incorporated into the simulation. Considerable thought should go into how best to incorporate temperature and constituent concentrations and is discussed in more detail below.

Note that negative flows use temperatures/concentrations in the waterbody when calculating the impact on the system of these flows rather than the temperatures/concentrations in the corresponding inflow temperature and constituent concentration files. This ensures that negative flows generate no change in temperature or constituent concentrations. However, positive flows can impact simulation results and care must be taken as to how the flows are incorporated into the simulation.

The flows required to complete the water balance are computed as a step function. If they are incorporated into the model as an additional inflow or outflow whose current values are being linearly interpolated, such as a branch inflow, then the resulting water balance will not be correct. Typically, the flows in the qwb.opt file are first included as a distributed tributary inflow assigned to the mainstem branch and interpolation [DTRIC] is turned “OFF”. The corresponding distributed tributary inflow temperatures are usually set to air temperatures in the qdt\_br1.npt file. When running water quality, care must be taken as to what constituents should be included in the corresponding inflow constituent concentration file. Typically, only DO values are included if the distributed tributary option of incorporation is used, and they are set to saturated values corresponding to the observed air temperatures. Keep in mind that if the water balance flows are incorporated as branch inflows, then the mass loading of organic matter and nutrients will be increased as well.

The branch corresponding to the distributed tributary inflow is usually assigned to the mainstem branch of a reservoir. Using a distributed tributary minimizes the impact of the flow, temperature, and/or water quality associated with the distributed tributary by distributing the flow throughout all segments in a branch weighted by surface area. Be aware that large flows as a result of large errors in inflow/outflow measurements can and have had a significant impact on temperature and water quality calibration in the surface layers. Usually, this is not a problem, but sensitivity analyses should be conducted to see if the flow and associated temperature/constituent concentrations have an impact on the simulation results. If so, then the following discussion is of particular relevance.

As emphasized previously, a great deal of thought should go into how the flows generated from the water balance utility are incorporated into the simulation. As discussed previously, these are typically incorporated as distributed tributary inflows so as to minimize the impact of the flows on the simulation. However, this may not always be the best, most accurate, or most realistic method. For example, suppose that the water balance flows are consistently negative. This would indicate that either inflows are consistently overestimated or outflows are consistently underestimated. Obviously, incorporating the flows as a positive increase in the outflows as opposed to subtracting them from the inflows can potentially have a very significant impact on simulation results. In this case, sensitivity analyses should be conducted to determine which method improves the simulation results. If, say, hypolimnetic temperatures are consistently being underestimated, then incorporating the flows into a hypolimnetic outflow could improve the simulation results. Conversely, if hypolimnetic temperatures were being overpredicted, then the inflows should probably be reduced. The key point to keep in mind is that there are a number of different ways to incorporate the computed flows, and they generally should all be tested to determine the best way to incorporate the computed flows into the simulation.

As another example, consider the case in which the generated flows are consistently positive and a branch in which sometimes significant inflows are ungauged. In this case, a sensitivity analyses should be performed to determine if incorporating the flows or a portion of the flows into the ungauged branch inflow improves model results. Oftentimes, the model can be used as a guide as to how best to incorporate the computed flows into the simulation.

## REAL WORLD EXAMPLE

Walter F. George is a U.S. Army Corps of Engineer reservoir located on the Chattahoochee River in Alabama. The reservoir is operated as a peaking hydropower facility. During calibration, the model consistently underpredicted hypolimnetic temperatures by 0.5-1°C. Wind sheltering could be adjusted to increase hypolimnetic temperatures, but this adjustment always adversely impacted thermocline depth. After considerable thought, it was concluded that including possible seepage at the dam might improve hypolimnetic temperature predictions. A portion of the distributed tributary flows were incorporated as an additional outflow at the bottom of the dam. The final value used was  $5 \text{ m}^3 \text{ sec}^{-1}$ , which was less than 1% of the average outflows, and brought hypolimnetic temperatures into almost exact agreement with observed temperatures. Further investigation of the outflows revealed that during times of no power generation, an additional flow of  $5.1 \text{ m}^3 \text{ sec}^{-1}$  was specified in a file that was not originally sent as part of the outflow data. Thus, the model pointed the way as to how best to incorporate the computed flows and was a surprisingly accurate indicator of what was actually occurring in the prototype.