Appendix I: Development of Constituent Loads

This appendix is in connection with Section 3.5.1 in the main report – Tributary and Watershed Inflow Concentrations. It is compiled from DRBC' presentations to its Model Expert Panel. The appendix aims to provide additional information on developing constituent loads.

1. Monitored Catchments

Multi-agency data collected at 87 stations was harmonized to produce a comparable dataset for use in modeling and analysis. Harmonization was done by 1) selecting and combining appropriate water-quality constituent names; 2) combining parameters into individual constituents (e.g., filtered/unfiltered ammonium), 3) converting all results to common units, 4) preferentially removing same-day replicate or duplicate samples, and 5) screening for statistical outliers or missing data.

At selected tributaries in which sample size (>=60) and periodicity were sufficient, water-quality boundaries were temporally enhanced using standard USGS regression techniques. Regression methods were implemented through two USGS-developed packages, Load Estimator (LOADEST) and the Weighted Regressions on Time, Season, and Discharge (WRTDS) tool. Model form in both packages is fundamentally similar in that both use logarithms of daily discharge, decimal time, and sine and cosine transformations of decimal time (season) to estimate concentration. WRTDS estimates parameter coefficients for each estimation point (any given combination of discharge and time) using a unique weighted regression for each day of the estimation period, applying greater weight to observations closer in time, discharge, and season to the estimation point. In contrast, LOADEST estimates parameter coefficients once for the entire dataset. In addition, WRTDS is less affected by gaps in sampling. Model performance was assessed using the metrics illustrated in Figure 1-1. In this example, the sample flows adequately reflected the range of flows at the Delaware River at Trenton, NJ, with all but the highest discharge values represented, for the model period. There is little to no structure in the residual plots, observed and estimated values show relative symmetry around the one-to-one line, and the flux bias statistic is near zero. If a particular model was deemed to have a good fit, these data were used at the appropriate water-quality boundary to add temporal resolution. The WRTDS model typically outperformed LOADEST in this study, thus it was utilized more often.

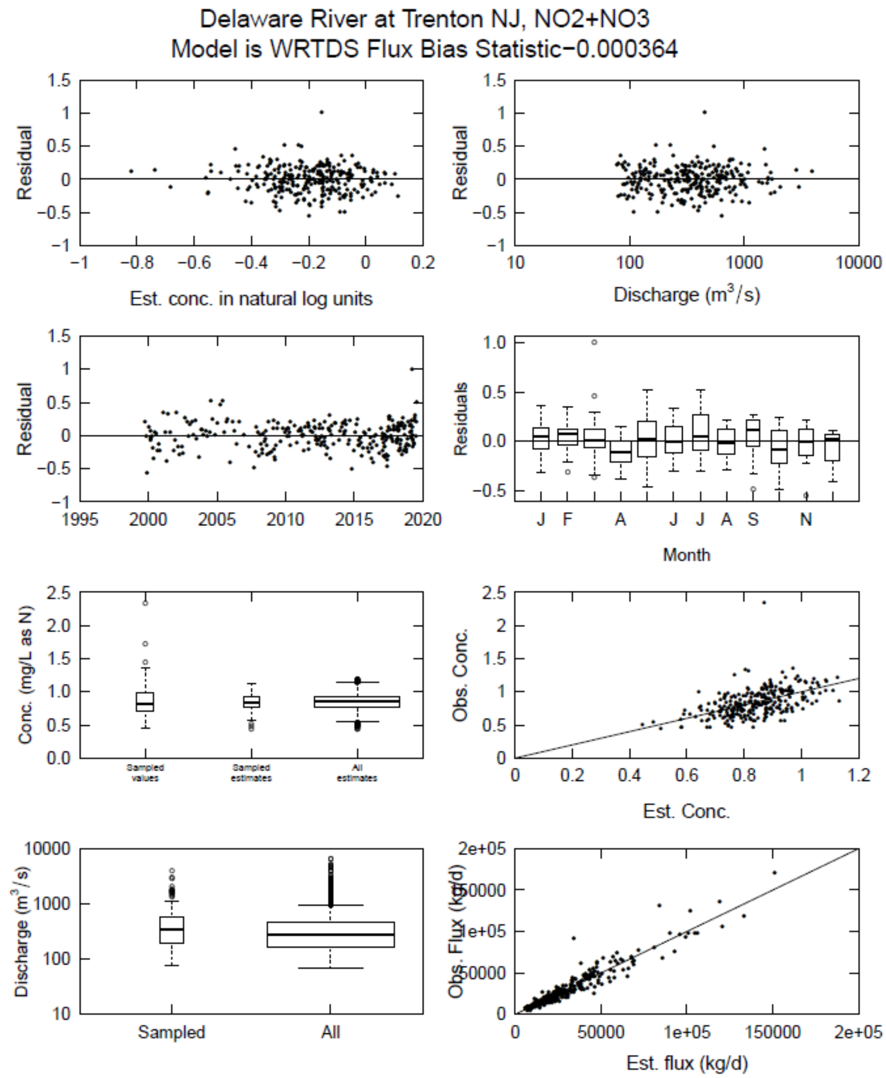

Figure 1-1. WRTDS flux bias diagnostic plots for NO2+NO3, Delaware River at Trenton New Jersey.

2. Unmonitored Catchments

In sparsely monitored or unmonitored portions of the Lower Delaware River Basin, cluster analysis was used to group catchments with similar characteristics for water-quality information transference. This was done via the following steps:

a) Hierarchical agglomerative clustering was conducted to classify more than 60 water-quality stations into four broad landscape types.
b) Water-quality data were composited by landscape, and standard quantiles were calculated for all constituents.
c) Flow files from the hydrodynamic model were imported and duration statistics were calculated. Each water-quality sample was classified by season and general hydrologic condition.
d) A constituent matrix was created by cluster group, season, and hydrologic condition using median values for each water-quality constituent.
e) For each unmonitored catchment, cluster group, season, and hydrologic condition were determined and assigned. Associated water-quality data from reference groups were read in and a synthetic constituent time series (daily) was created for input to the WASP model. The workflow in Figure 2-1 provides a generalized approach for assigning constituent concentrations to unmonitored catchments.

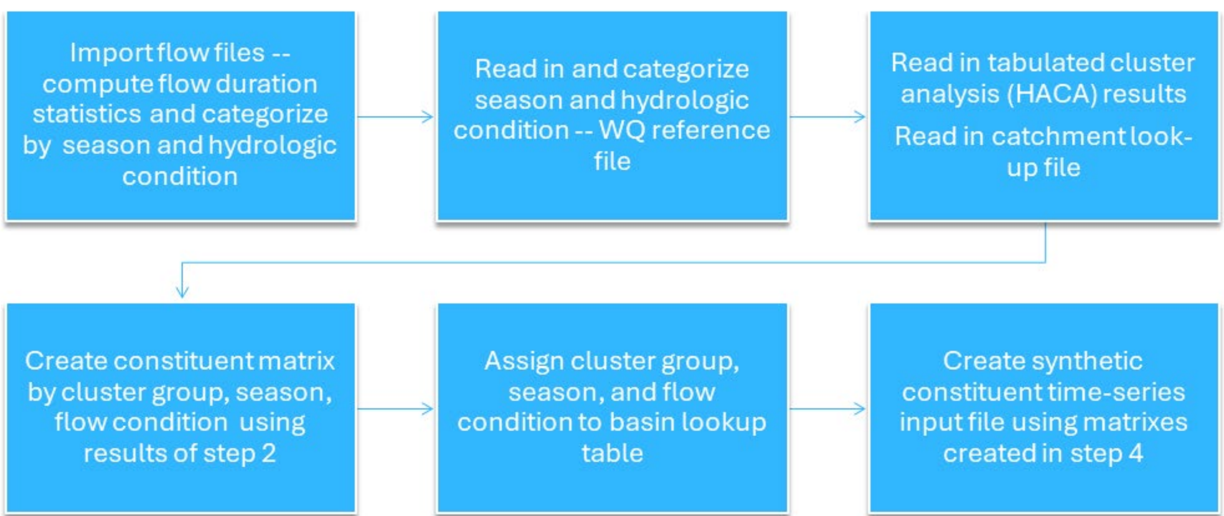

Figure 2-1. Generalized workflow for assignment of water quality to unmonitored catchments.

Figure 2-2 summarizes loading methods by catchment. Continuously monitored data and daily constituent files from statistical models are paired with 84 percent of inflows to the Lower Basin, including the Delaware River at Trenton, direct measurements with limited estimated data, 9 percent and, despite the geographic extent, daily constituent files estimated via environmental classification are paired with only 7 percent of total basin flows.

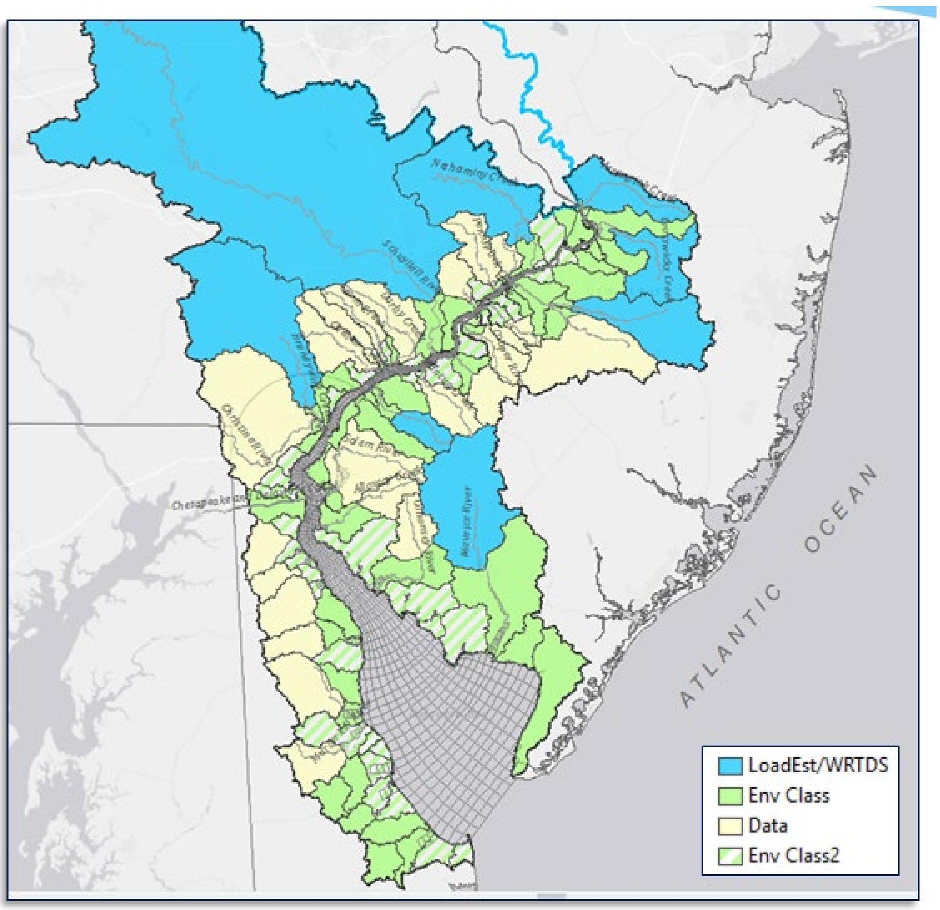

Figure 2-2. Map of the Lower Delaware River Basin and load method summary.