What is the significance of the Long-Term Average Hydrologic Period and the Critical Period?

Long-Term Average Hydrologic Period (HP)

The Long-Term Average Hydrologic Period is used to calibrate the Main Bay model with observed monitoring data for that time-period. It is also used to determine the relative nutrient and sediment contributions of each major state river basin to the Bay, and therefore how the overall target load is split among them. In simple terms, if the nutrient loads were a pie, the hydrologic period would be used to divide it fairly between the states. A 10-year window is used to represent the average long-term hydrology of the watershed because we can't simulate our entire 47-year record and be efficient with computing time.

Critical Period (CP)

The Critical Period is a 3-year window within the Long-Term Average Hydrology representing a high-flow period across the watershed and is used to set the overall size of the nutrient reductions needed to meet water quality standards in the Bay. Statistically we are looking for conditions that have a 10% chance of happening in any year, or a 10-year storm event. This return period is defined in the 2010 TMDL. The critical period sets the overall size of the reduction pie.

Research Question: Is the current average hydrologic period and critical period[1] still appropriate for use in the Phase 7 Model, or are there better alternatives?

Investigator – Dr. Robin Glas (USGS)
Assignment - Evaluate the 1978-2025 hydrologic record to determine the best statistical fit for a 10-year average hydrologic period that is representative of average flows over that period of record. Within that 10-year window find a three-year period that will have a return period[2] of approximately 10 years to represent the critical period.

- Multiple statistical testing methods were used to identify and rank 10 year windows from 1978-2025
    - MAPD – Mean Absolute Percent Difference between the mean flow of the candidate 10-year window and the long-term reference period.
    - Deweighted – Komolgorov-Smirnov (K-S) test statistic. Reflects the largest difference in the distributions between the 10-year candidate window and the long-term reference period. Can be anywhere on the distribution, not just the central tendency.
- The statistical analysis yielded several options that were ranked in order of their merits using the statistical methods described above.
- The period from 1998-2007 had the best combined score of the statistical methods for determining the average hydrologic period, and the best fit of a 3 year period with a likelihood of recurrence was 2004-2006 (return period = 11.8 years).

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[1] The critical period is a specific timeframe when environmental conditions combine to make a water body most vulnerable to pollution. (e.g. TMDL limits)

[2] A return period represents a statistical estimate of the average time between events of a specific magnitude, such as an extreme storm surge, high streamflow, or pollutant loading concentration.

- Our current average hydrologic period of 1991-2000 ranked 4th in the combined statistical analysis scoring. Previously, the 2010 TMDL assessment of the average 10-year hydrologic period the 1991-2000 ten-year average was ranked first and the 1993-1995 critical period had a 10 year recurrence because the shorter 32-year reference period was from 1978 to 2009.
    - Our current critical period of 1993-1995 has a return period of 3.8 years when assessed with the longer 48-year 1978-2025 reference period.
    - A more appropriate critical period in this hydrologic window is 1996-1998 which has a return period of 9.4 years if the 48-year 1978-2025 reference period was used to assess the critical period.

Options:

- **New (1998–2007 HP, 2004-2006 CP): HP** Composite flow is ~1.7% lower than Status Quo. Mixed signals by station. Susquehanna slightly up (+1.8%), Potomac notably down (−12.3%). **CP** Composite flow is +14% higher, driven largely by Susquehanna (+22.3%). Southern rivers are down (lower than status quo)
- **Hybrid (HP 1991-2000, CP 1996-1998**) – HP no change, CP Composite flow is +11.9% higher. Broad increases across all stations. Choptank +46%, Potomac +33%, others +13–24%.
- **Status Quo – no change**

Recent analysis vs. prior analysis of average hydrologic period and critical period.

Dimension	Recent Analysis	Previous Analysis (2010 TMDL)
Period of record	Uses the most recent 47 years of observed data.	Used a 20-year window, statistically extended back to 1930.
Years included	Limited to post-1978 records.	Included the early-1970s wet period and two drought periods.
Stations included	All nine River Input Monitoring (RIM) stations, plus data from below the RIM stations.	Used all nine stations for the base analysis; reduced to the Susquehanna and Potomac for the long-period (1930–2009) analysis.
Weighting basis	Weights each tributary by its nitrogen and phosphorus contribution (the pollutants addressed by the TMDL).	Weighted each tributary by flow volume.
Data adjustments	Uses observed values directly; no record extension or de-trending was required, as no significant trend was detected and the observed record was long enough to stand on its own.	Applied statistical record extension and de-trending to address a long-term increasing flow trend.
Average Hydrologic Period Monitoring stations	**402 stations** Including 241 traditional fixed, 98 continuous monitoring, 61 DataFlow segments, 2 profilers	**261 stations**

Dimension	Recent Analysis	Previous Analysis (2010 TMDL)
Critical Period Monitoring Stations	**319 stations** 207 traditional fixed, 71 continuous monitoring, 41 DataFlow segments, which are areas sampled by boat-mounted sensors that record conditions while moving through tributaries or regions 5.6 million dissolved oxygen observations	**230 stations** 65,000 dissolved oxygen observations
Timing	Introduces unknowns in hydrology for model calibration/loading the estuarine model – may cause delay	