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Chesapeake Bay Streamflow Hydrologic Base and Critical Period Diagnostics

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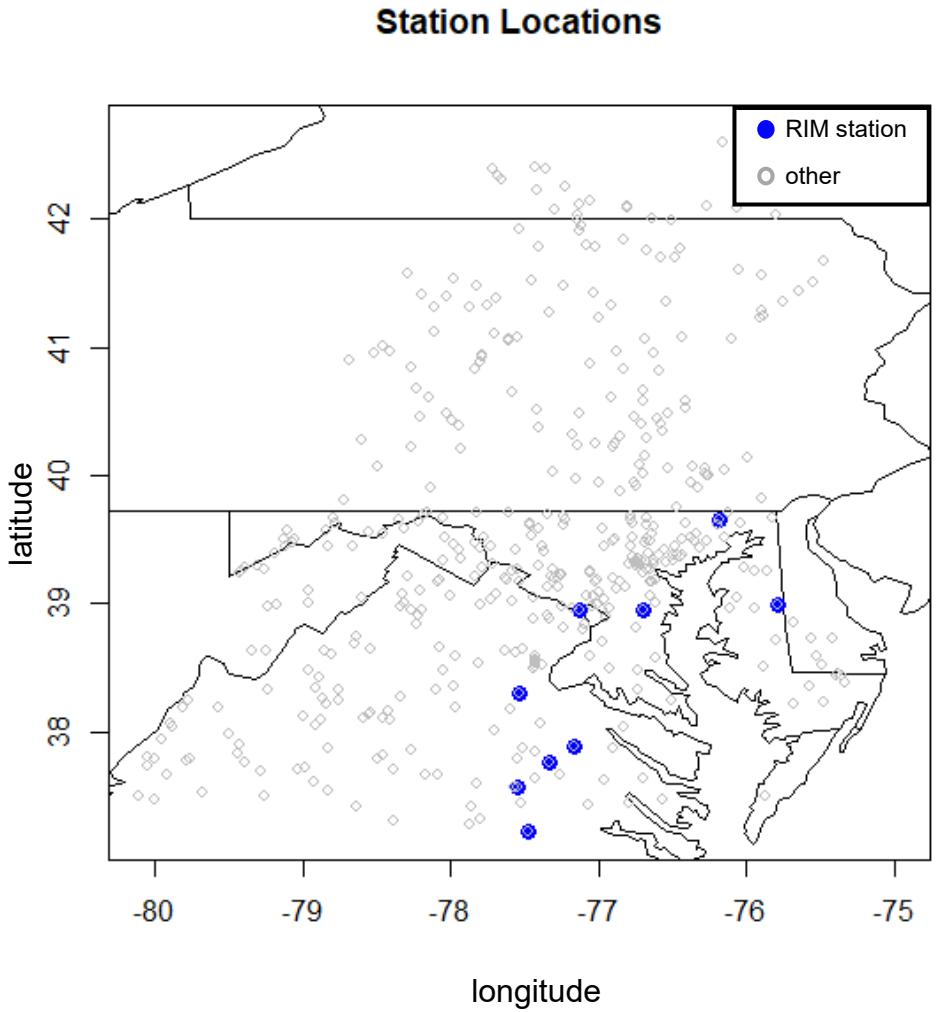
What Are the Hydrologic Base Period and Critical Period?

- **Hydrologic Base period:** A 10-year window of historical streamflow used to represent "typical" hydrology for the Bay watershed - the reference conditions against which nutrient and sediment loads are modeled (limited to 1985-2022)

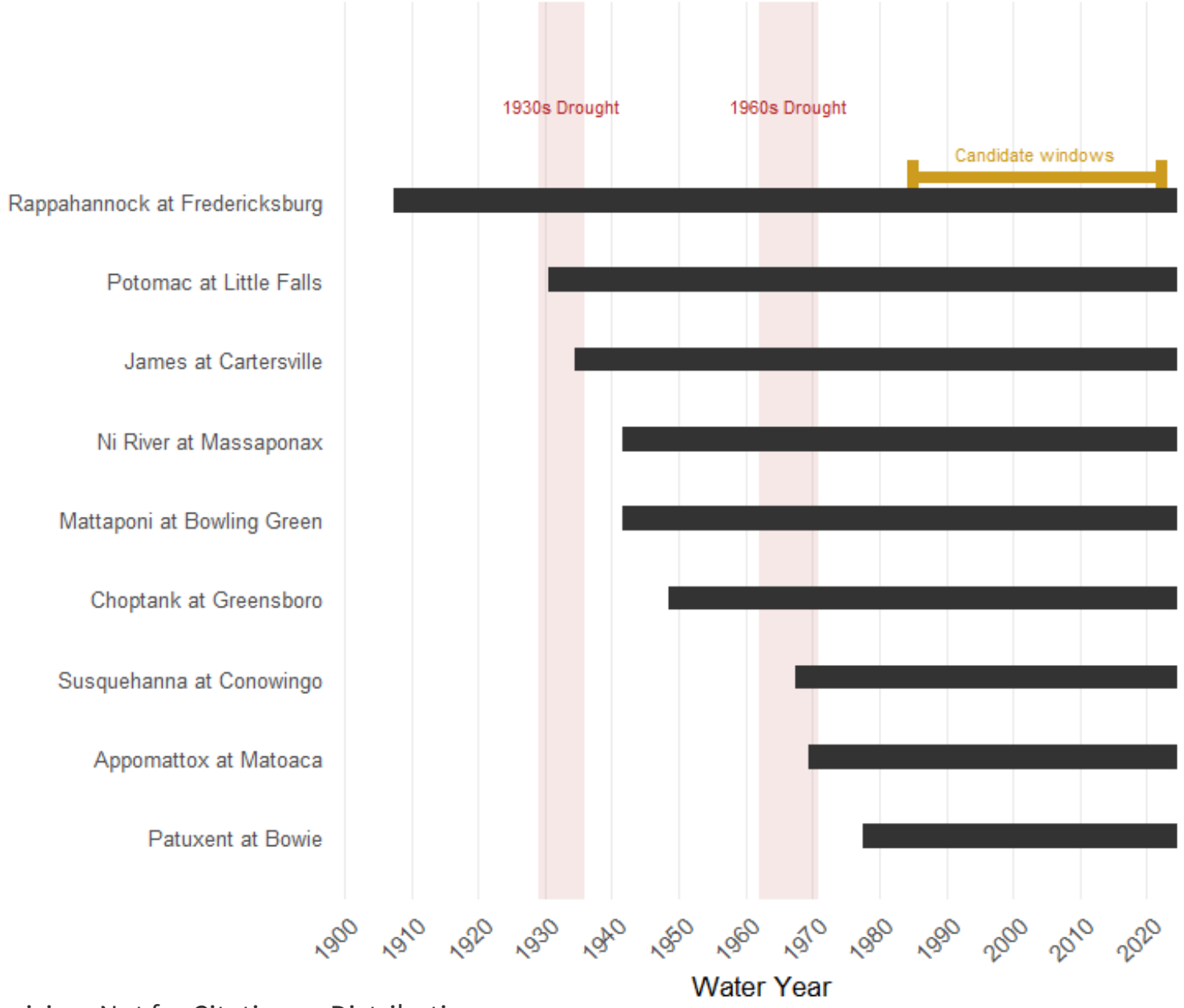
- **Critical period:** A 3-year window within the base period representing unusually high flow conditions - when nutrient and sediment delivery to the Bay is greatest and load reduction targets are most demanding (non-extreme)

Study area - RIM and tributary flow gages

- 9 River Input Monitoring (RIM) stations monitor direct inputs to the Bay - primary drivers of nutrient and sediment loading
- Interior tributary stations characterize watershed hydrology
- RIM stations weighted **95%** in composite score - consistent with their dominance of Bay inflow
- RIM weights applied using Phase 6 N adjusted ratios



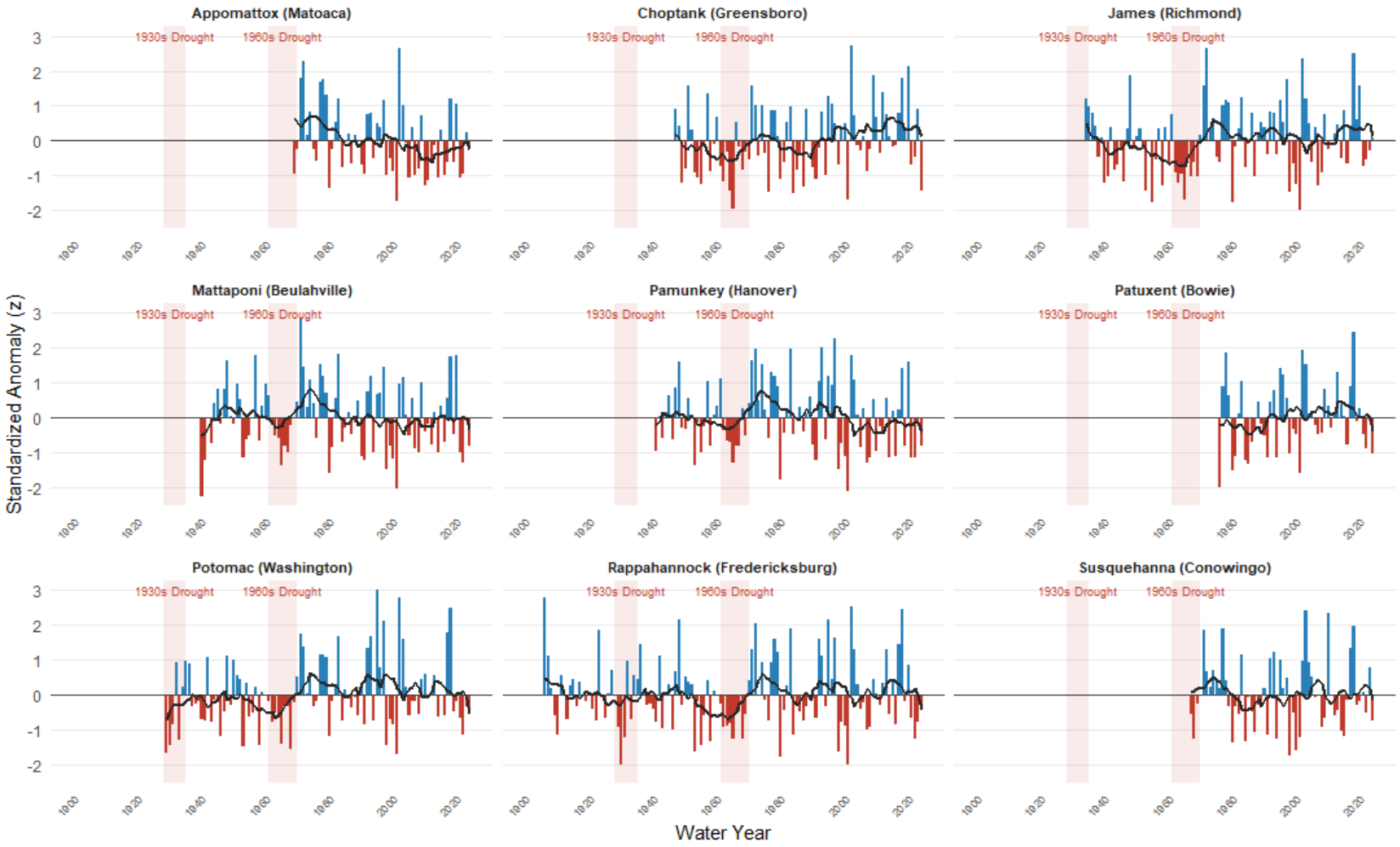
RIM station periods of record



Annual streamflow anomaly

1960s drought- largest recorded departure from normal freshwater flows

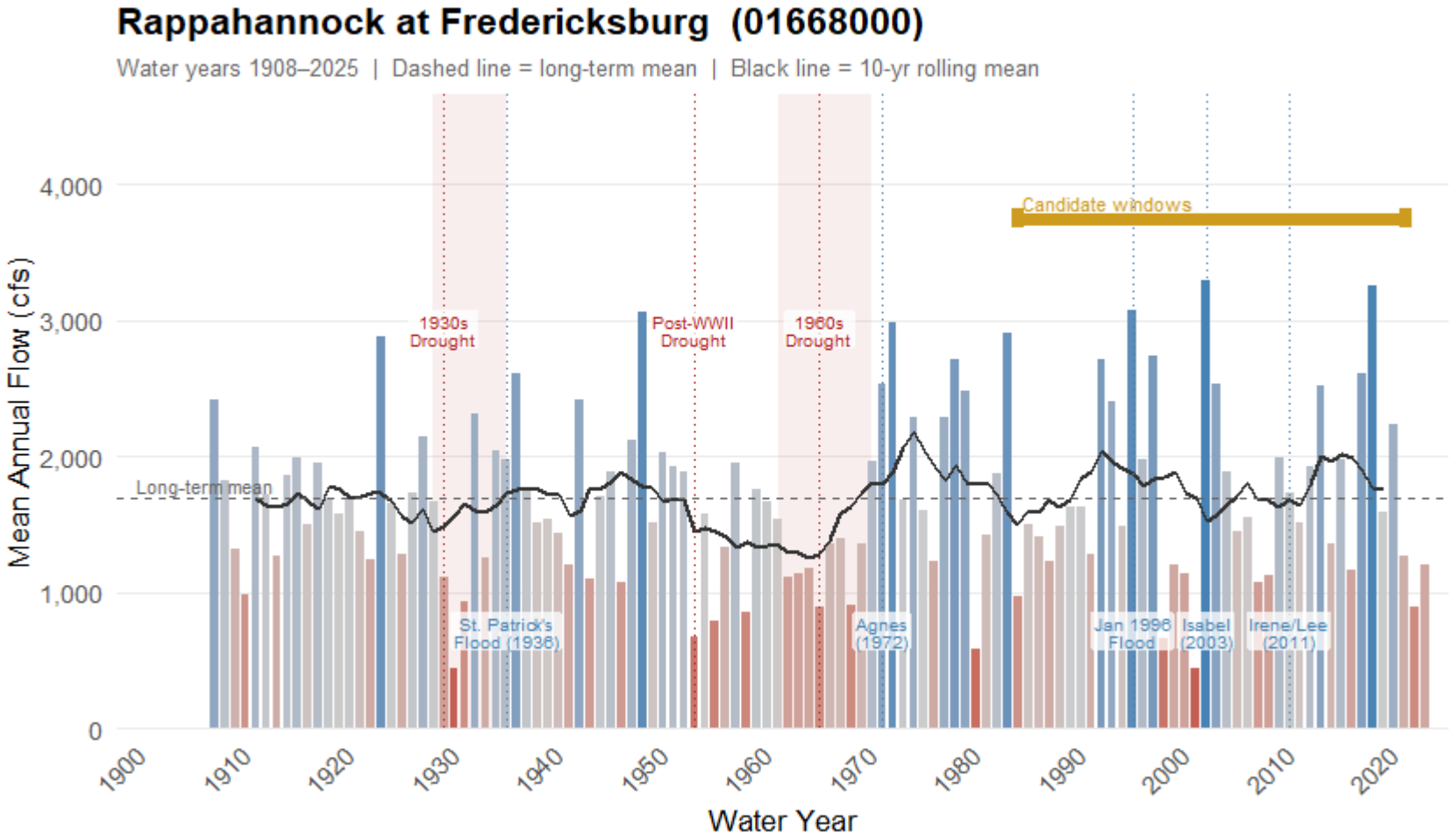
Longest sustained dry period in the Chesapeake's instrumental record



A closer look: Annual flows

Candidate windows will likely be limited to modeling constraints (1985-2022)

Long-term reference period: constrain by record length and hydrologic regime



Scoring Candidate Windows: A Two-Stage Process

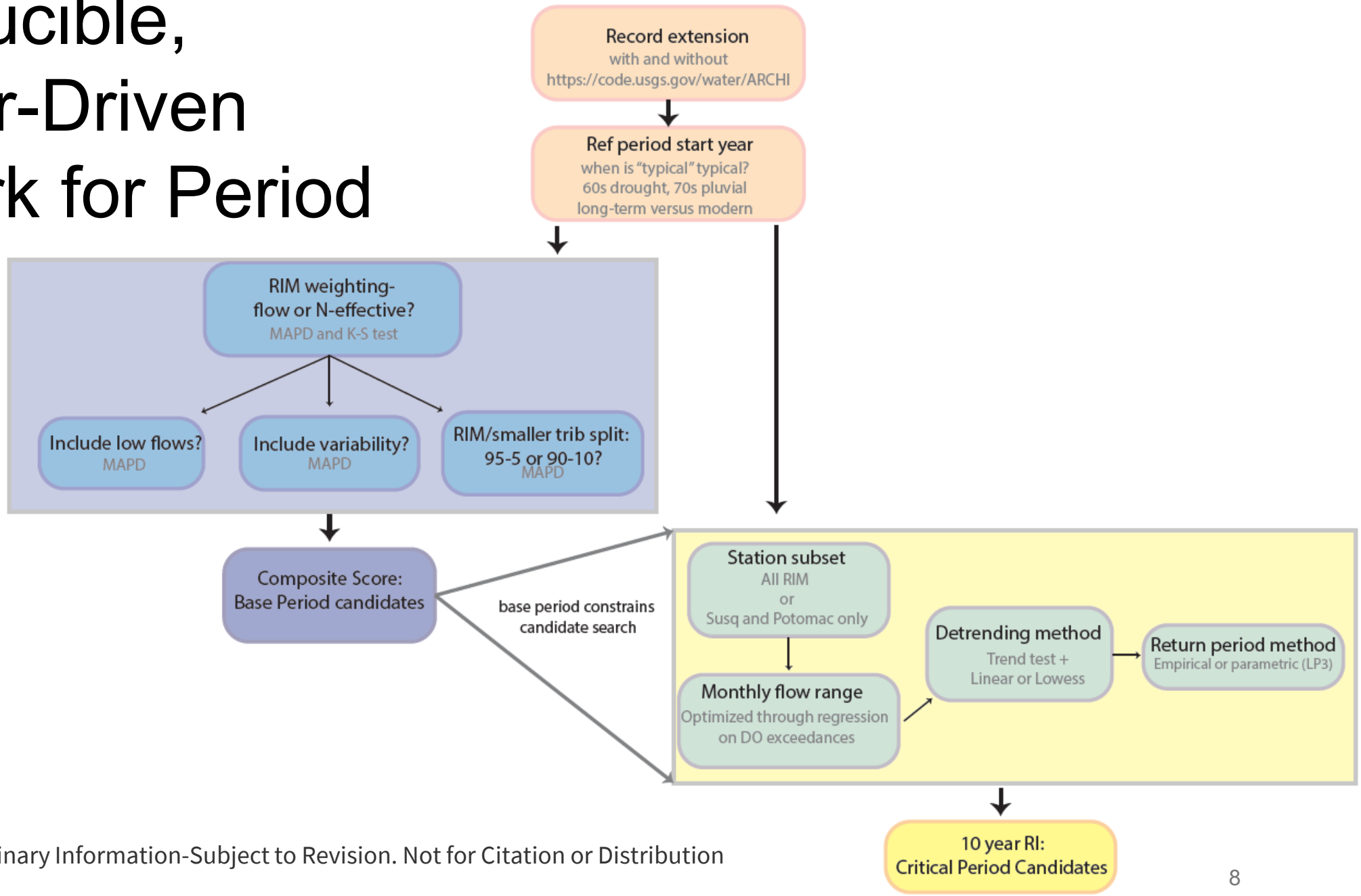
Base Period Scoring

- MAPD - mean absolute percent difference
- Statistics include mean flow, flow variability (CV), high flows (Q95), and optionally low flows (Q05)
- Kolmogorov-Smirnov (K-S) test evaluates whether the full flow distribution matches the reference period
- MAPD and K-S scores are normalized and combined into a composite score; RIM stations weighted by Phase 6 load effectiveness

Critical Period Scoring

- Compute composite Oct-June flow across RIM stations for each water year within the base period
- Calculate 3-year running averages; test for and optionally remove trend
- Fit a frequency distribution (Weibull) to identify the 10-year recurrence interval flow - the threshold for "anomalously high" conditions
- 3-year windows exceeding this threshold are critical period candidates

A Reproducible, Parameter-Driven Framework for Period Selection



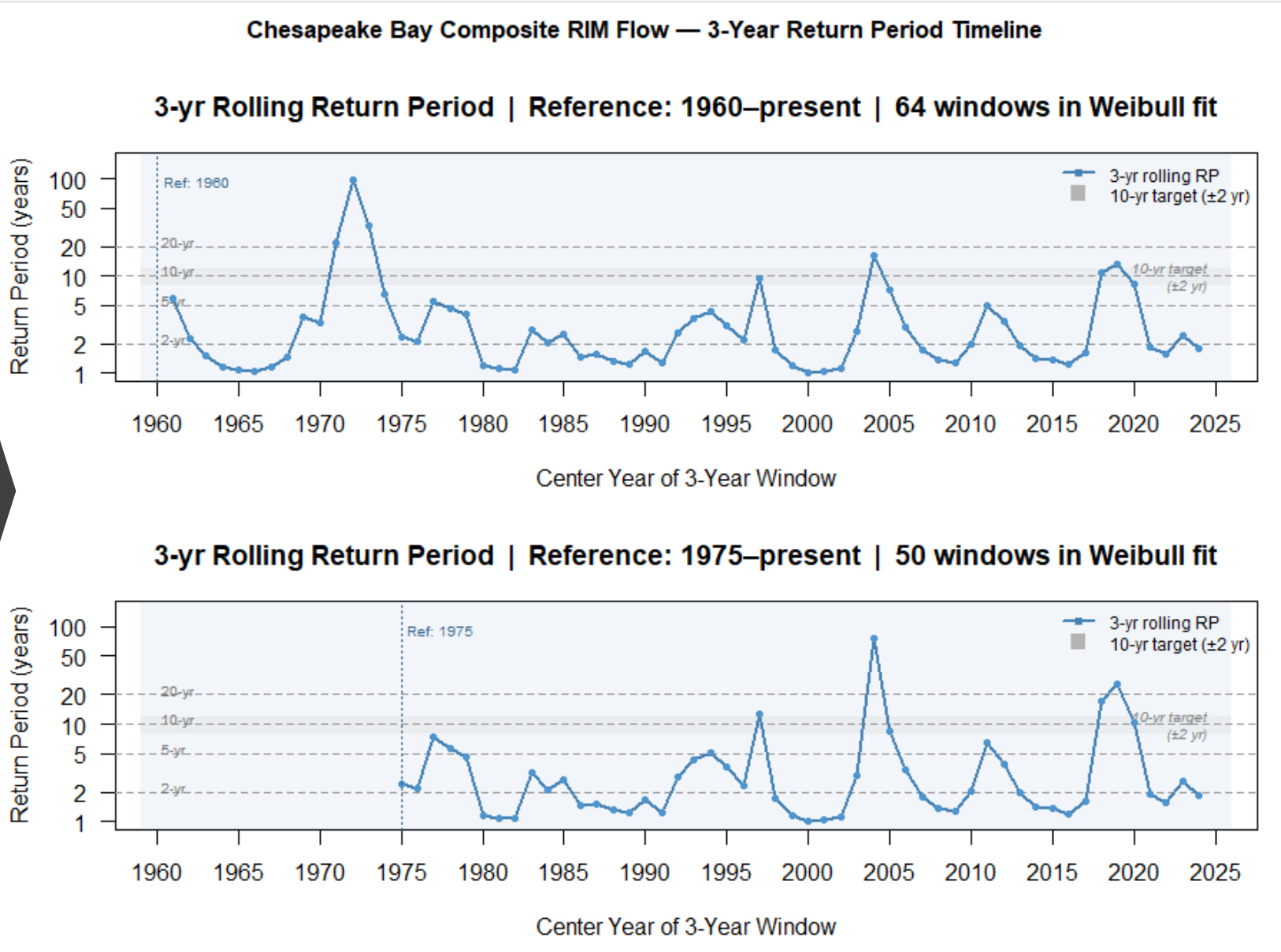
Decision space- hydrologic base period

Parameter	Options
Reference start year	1900, 1968, 1970, 1975, 1985
MAPD metrics	Mean, CV, Q05, Q95 (on/off)
MAPD metric weights	Equal or differential (1.0 default)
Station weighting	N/P Load effectiveness vs. raw flow
RIM/tributary split	95/5 or 90/10
Record extension	Standard or ARCHI-extended

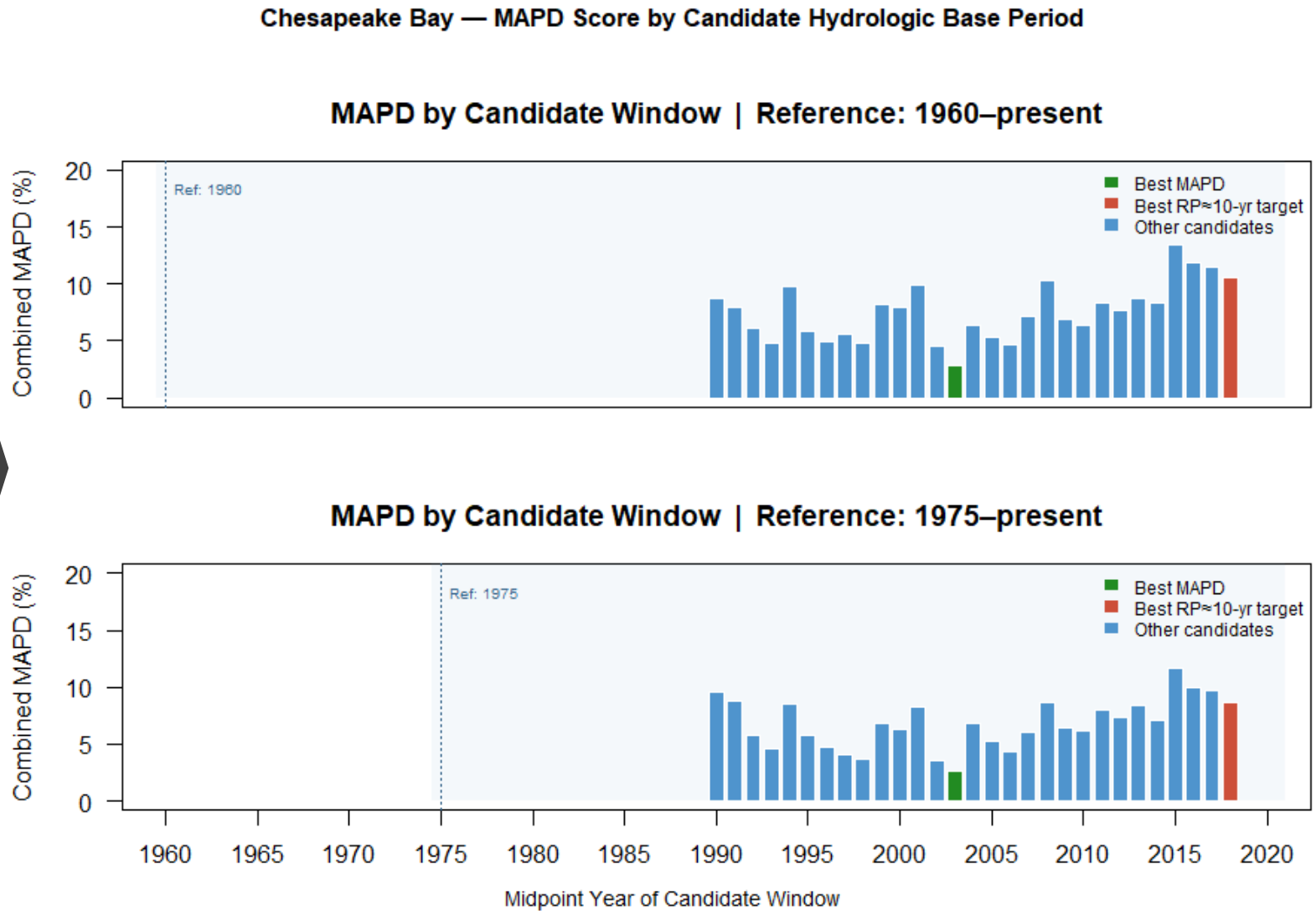
Decision space - critical period

Parameter	Options
Composite flow months	Oct–Jun (default; pending DO data)
Station subset	All 9 RIM vs. Susquehanna + Potomac
Detrending	None, linear, LOWESS
Return period method	Weibull (LP3 pending)
Target return period	10 years (±2 tolerance)
Window type	Overlapping vs. non-overlapping

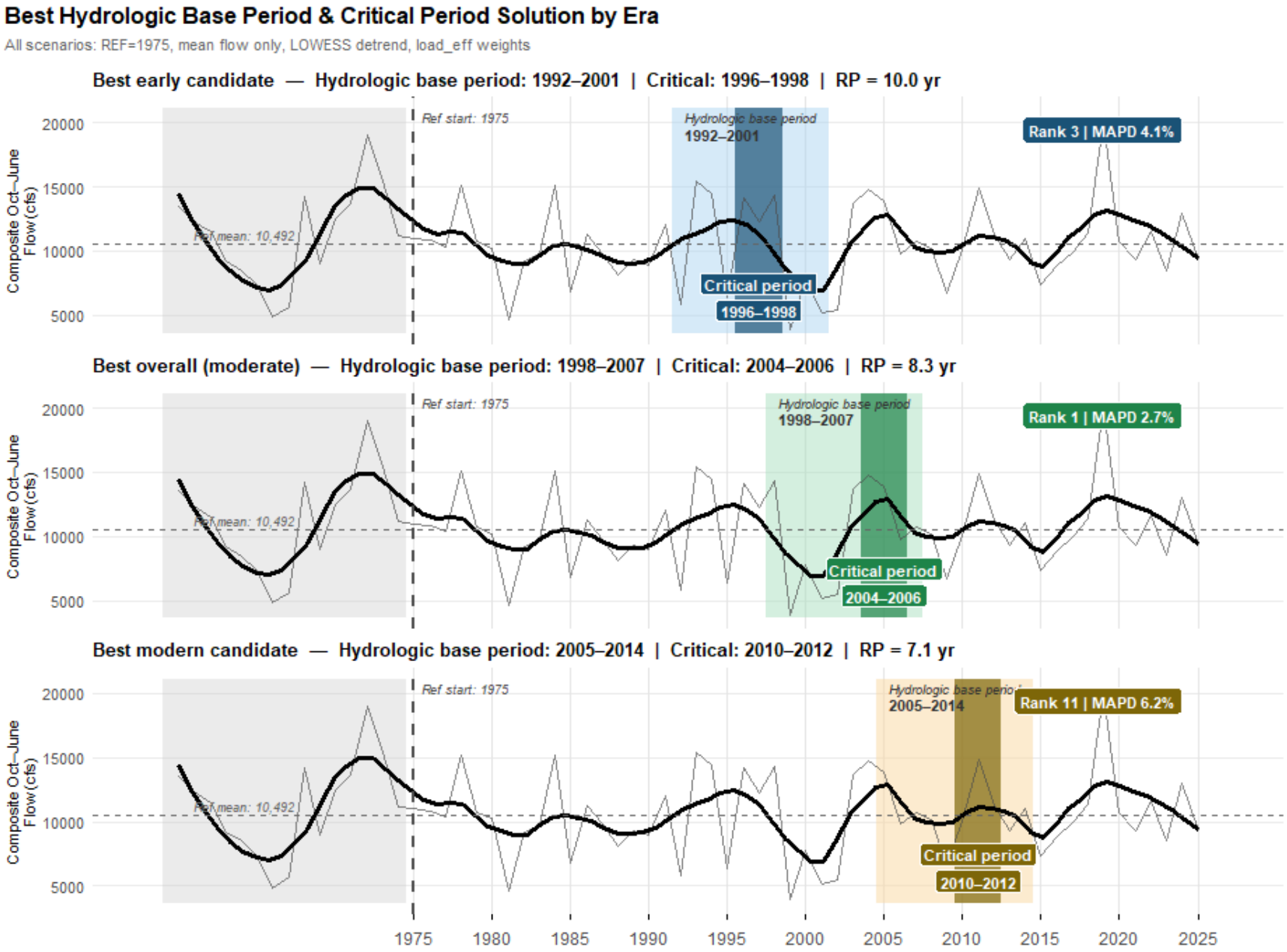
How does the critical return period evolve with a varied reference start year?



Corresponding MAPD scores



What Does "Typical" Mean? Example Solutions with reference year 1975



Summary

What the analysis does

- Scores all 10-year candidate windows on flow representativeness (MAPD) and distribution shape (K-S test) across 9 weighted RIM plus upstream stations
- Identifies 3-year critical periods using a Weibull return period fit, targeting ±2 years of the 10-year recurrence interval

What we found

- Reference period start year is the dominant sensitivity lever - it shifts both the MAPD benchmark and the 10-year RP threshold simultaneously
- Recent windows score poorly on both metrics - but because they are **anomalously wet**, not dry, relative to the reference period

What remains open

- Full sensitivity analysis across all parameters: September deliverable
- DO exceedance correlation to optimize monthly flow window (data pending)
- Whether post-2010 hydrology reflects a new regime or a transient wet cycle

Discussion

1. Representativeness vs. recency - which takes priority?
2. Low flows and variability - noise or signal for nutrient loading?
3. Post-2010 anomalously wet - new normal or transient?
4. 10-yr RP as critical period threshold - still appropriate?
5. RIM/trib weighting and N-P effectiveness - needs revisiting?