

Hydrology-Based Environmental Flow Regime (HEFR) Potential Enhancements and Modifications

Prepared by TPWD Staff with Input from HEFR Workshop Attendees
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1. Hydrographic Separation

Issue

The IHA hydrographic separation routine is different from others in the literature. Hydrologists have developed numerous hydrographic separation algorithms, some of which might better distinguish episodic events (i.e., high flow pulses and overbank flows) from continuous flows (base flows and subsistence flows) than IHA. See Ward (February 25, 2009) technical memorandum for additional discussion. Unfortunately, there is no clear consensus in the literature regarding the best approach(es), there are few objective criteria by which to select optimal hydrographic separation methods, and the conceptual basis for the Texas Instream Flow Program (TIFP) flow regime components may be different from the conceptual model followed by traditional hydrographic separation routines. Misclassification of flow categories, if widespread and unbalanced, could lead to bias in HEFR results. It would be helpful if knowledgeable scientists could (1) clearly define a conceptual model describing components of the environmental flow regime in the context of the TIFP, SB 3, and desired hydrographic separation characteristics,¹ (2) identify quantitative and/or qualitative criteria by which to evaluate various hydrographic separation algorithms in light of the agreed to conceptual model, and (3) run one or more candidate algorithms through one or more gages in East Texas and evaluate the outputs.

Possible Solutions

An alternative algorithm, adapted for use in the SB 3 context. There are many to choose from, including BFI, BFLOW, PART, WHAT, Eckhardt, and HYSEP just to name a few. These typically assign both flow components (i.e., base flow and runoff) to a given day and more importantly do not identify subsistence and overbank flows. These are not insurmountable obstacles, but will take some thought.

Commitment

A small group may be necessary to establish a conceptual model of desired flow categorization and define criteria for evaluation. One or two hydrologists familiar with hydrographic separation tools and reasonable knowledge of the goals of SB 3 should evaluate alternative tools and determine if a viable replacement for IHA exists. This issue is largely independent of the HEFR algorithm, although some work would need to be done to link the new hydrographic separation outputs with HEFR. Finally, algorithms to define subsistence and overbank flows would be need to be developed and implemented.

¹ A key issue here is that hydrologists typically assign all blips in the hydrograph to "runoff," whereas biologists are interested in keeping the "high" in the "high flow pulse" category. Thus "runoff" may not be synonymous with "high flow pulses." Partly as a consequence, the term "baseflow" might have a different meaning for traditionally-trained hydrologists as compared to the instream flow community. To borrow a phrase from Ward (2009), "terminological concordance" may not equate to conceptual concordance.

2. Frequency Calculations

Issue

The hydrology literature has more sophisticated techniques for the quantification of flood frequencies than are currently employed in HEFR. These techniques could be applied to both overbank and high flow pulse frequency calculations. Also, the current algorithm constrains the number of qualifying high flow pulses to the extent that occasionally zero pulses are recommended per season, leading to less useful flow recommendations (see Section 5.3 of the SAC Hydrologic Methods document for more discussion).

Possible Solutions

Partial duration series calculations, filtered peaks over threshold, and other methods. Multi-year frequency (or return period) targets and/or loosening the qualification criteria could also be considered.

Commitment

One or two hydrologists familiar with flood frequency analysis and reasonable knowledge of the goals of SB 3. Any solution would have to be coded into HEFR using VBA, requiring an experienced VBA coder.

3. Enhanced Seasonal Flexibility

HEFR currently allows the user to select the month corresponding to the beginning of the winter season. HEFR then assigns months to four, three-month seasons. Additional flexibility (e.g., user-input number and length of seasons) could provide results that are more biologically meaningful and/or hydrologically sensible in different basins.

Possible Solutions

Add code to HEFR to allow this flexibility

Commitment

One experienced VBA coder. This work would be largely independent of scientific decisions. The coder would add the flexibility and then scientists would make the seasonal assignments during application of HEFR.

4. Automated Comparison to Freshwater Inflow Recommendations

Issue

There is no automated comparison to potential freshwater inflow recommendations.

Possible Solutions

Add code to HEFR to generate tables and figures for comparisons.

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Commitment

A freshwater inflow methodology and an experienced VBA coder to implement these enhancements.

5. Fix Multipeaks_Multiplier Anomaly in Overbank Flow Calculations

Issue

Currently, when the multipeaks_multiplier is used to disaggregate long overbank events, the separate pieces of the disaggregated event are all assigned to the overbank category. However, most of these "pieces" probably do not contain a flow in excess of the 1.5 year return flow. Thus, these pieces should probably be reclassified and tracked as high flow pulses.

Possible Solutions

Recode HEFR to process overbanks before high flow pulses and reclassify overbank days as high flow pulse days if/when they are identified as separate events but do not exceed the small flood threshold (default 1.5 year return flow). Another "solution" would be to conclude that disaggregating long overbank events is not necessary and to turn this function off for overbank events.

Commitment

One experienced VBA coder. This work may be dependent on the choice of hydrographic separation technique.

6. Enhance Warnings and Documentation

Issue

Some hydrologic data records exhibit behavior that results in erroneous and/or ambiguous results. Examples include: (1) HEFR should not be used where data gaps occur, but HEFR currently does not post a warning to the user, (2) flow recommendations can become zero if no flows of that category and month were identified by IHA (e.g., if IHA does not identify any extreme low flows in April because April is typically a wet month, but the user enters 0 for the 7Q2, the matrix will recommend a zero subsistence flow in that month), (3) automated read-in of the IHA analysis.ini file does not work on Vistas/Office2007 machines, (4) use of the published 7Q2 value may not be appropriate for subsistence flows at some locations but HEFR does not provide guidance on this issue, and (5) certain watersheds and/or hydrograph characteristics may prohibit the use of daily average flow data and if criteria can be developed, HEFR could post a warning to the user when such criteria are violated.

Possible Solutions

Recode HEFR to include these enhancements and/or add text to the HEFR documentation.

Commitment

One experienced VBA coder and one person familiar with the needs of the BBESTs.

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OR
WARNING?

7. Enhance Graphical and Tabular Display of Outputs

Issue

More graphical and tabular displays of the outputs specific to the needs of the BBESTs would be helpful.

Possible Solutions

Recode HEFR to include these enhancements.

Commitment

One experienced VBA coder and one person familiar with the needs of the BBESTs.

The following list of potential enhancements and modification was prepared by Espey Consultants and is duplicated here without modification.

--FRAMEWORK--

1. HEFR strives to provide results that ascribe to the flow component framework of the Texas Instream Flow Program (as developed with input from the National Research Council). The flow components are categorized as Subsistence, Base Flow, High Flow Pulses (HFP) and Overbank Flows. HEFR further parses results for Dry, Average and Wet conditions (presumably to account for inter-annual variability) and parses results for months or seasons (presumably to account for intra-annual variability). The specific parsing (e.g., 25th percentile characterizes Dry) needs scientific justification; what guidance (other than "professional judgment") is available to relate HEFR's percentiles to these characterizations? Since the statistical accounting has yet to account for uncertainty in the solution and does not specifically yield an inference of a flow necessary for biological needs, consider implementing a user option within HEFR to evaluate more/fewer conditions or characterizations.

2. Consider changing the labels in the output table from "Wet, Avg, Dry" to "75 pctl, median, 25 pctl." This more accurately characterizes the HEFR analysis results, and it also removes an implied tie between HFP and baseflows, where wet HFP are implied to be coincident with wet baseflow conditions. For example at Evadale, no pulses were classified as wet in 1924, 1946 and 1950; these are years where total annual flow is among the highest (each higher than 85% percent rank) of annual flows during the period 1922-1964. Similarly, no pulses were classified as dry in 1956, 1936, 1925 which are among the driest years in that period.

3. Related to implementation or usability: Is there any guidance on how one determines when you are in a dry/avg/wet condition?

--BASEFLOW SEPARATION--

4. Consider alternative hydrograph separation techniques and provision to incorporate those into HEFR. We have evaluated the BFI program and it appears to better capture the rising limb of a pulse than IHA (e.g., at Evadale during 1935). Guidance would be useful on quantitative measures to develop and evaluate the parameters utilized in separating the hydrograph.

--HIGH FLOW PULSES (HFP)--

5. Consider an alternative method of determining HFP peak flow (Q_p), volume (V), duration (D), frequency (F) where V , D and F are not considered independently, but are rather closely tied to one of the parameters (Q_p) since some correlation is known to exist.

6. An alternative method for estimating the frequency of pulse events (having a particular Q_p) might be to use the flood frequency approach using a partial duration series. Some alternative discussion is available here:

Claps, P and Laio F. 2003. Can continuous streamflow data support flood frequency analysis? An alternative to the partial duration series approach. Water Resources Research 39(8)

7. Consider additional seasonality options for HFP, including options for a 4-month, 6-month window and an annual window.

8. Do high flow pulses classified into 12 categories result in too small of a sample to parameterize the pulses? Particularly frequency of pulses?

9. In classifying HFP events as dry, average, or wet, a substantial number of events are not classified. It seems that "dry" events might be those having a peak flow, duration, or volume near or below the 25th percentile, not an event exceeding those thresholds. An alternative method might be to classify periods as dry, average, or wet based on some criteria (such as the 30- or 180-day moving/trailing average of flow). Would it be possible to give the user the capability to modify these categorizations as user inputs to HEFR, giving the user greater flexibility where it comes to the specification of what classifies as Dry, Avg, and Wet?

10. As a corollary to the previous question, can user inputs be made in HEFR to adjust the percentiles that characterize the dry, avg, and wet conditions?

11. The multi-peak multiplier creates new "events" that are not characterized by the original flow separation algorithm (currently IHA). Currently in HEFR, there is no mechanism for backchecking that these new events have pulse characteristics consistent with those used in the original flow separation algorithm.

12. If the multi-peak splitting algorithm is used on overbank flow events, many of the new events have peak flows much less than the IHA flood flow threshold and should be re-classified as HFP events. To include these in the overbank flow category skews the overbank event statistics downward. The partial duration series frequency analysis method can also include the overbank events.

13. Consider incorporating this function: Identification of when the multi-peak multiplier (HFP/Overbank) has been applied (During the HEFR workshop, Praveen performed an ad-hock modification of HEFR on Tony Smith's laptop of this).

14. In an early version of the HEFR software: In the table that counts the number of HFP events in each season/hydrologic condition, December events are counted in the same year, not the following year (eg, HFP events that occurred in January, February, and December of 1918 are counted together). These events are properly counted elsewhere in HEFR.

--SOFTWARE BUGS--

15. IHA would not install on at least one of our computers, so the Nature Conservancy sent us a zip file with the files. They said it was a common problem. HEFR gets the location of the IHA working folder from the Windows registry, so we hard-coded the folder path in VBA.

16. Excel does not properly format dates prior to year 1900, and unfortunately this affects HEFR in its current form. The result of using pre-1900 data is incorrect evaluation of pulse frequency, and possibly other errors.

17. Fix or work around the HFP designation that appears for first few days of record (eg, January 1 1922 at Evadale).

