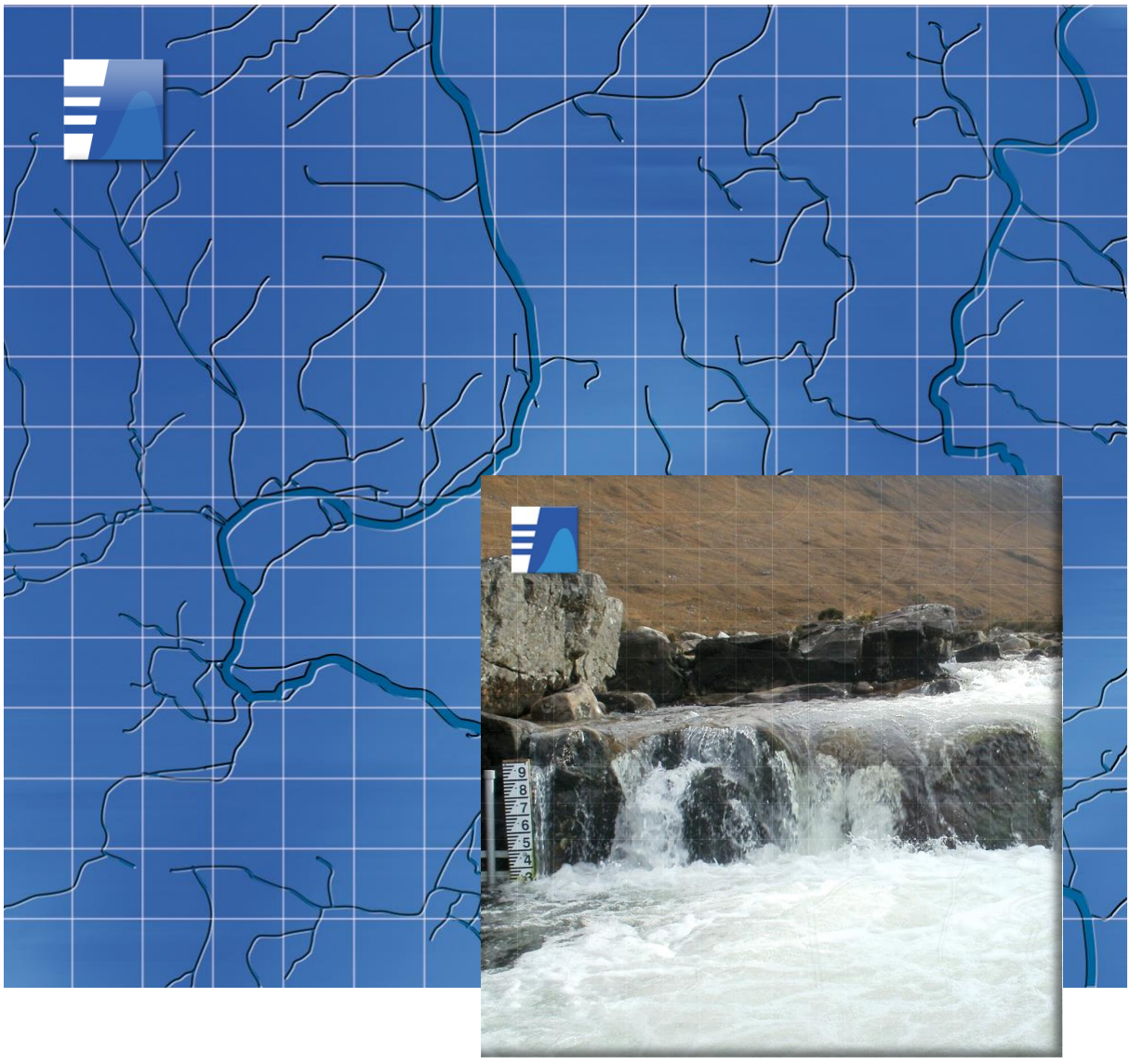
ReFH2 Technical Note: Adjusting BFIHOST in Scotland



WHS
Wallingford HydroSolutions Limited

The WHS Quality & Environmental Management system is certified as meeting the requirements of ISO 9001:2015 and ISO 14001:2015 providing environmental consultancy (including monitoring and surveying), the development of hydrological software and associated training.

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1 Adjustment Procedure Summary

This technical note provides guidance on the appropriate estimation of a catchment descriptor value of Base Flow Index (BFI) for use within ReFH2 in Scotland. An estimate of BFI is required as input to the ReFH2 model parameters Cmax, BL and BR. The initial catchment average soil moisture content, Cini, is also estimated from BFI within ReFH2.

BFIHOST is an estimate of the BFI based on Hydrology of Soil Types (HOST)[1]. Research underpinning the development of the WHS LowFlows software within Scotland[2], identified a systematic bias in the BFIHOST model towards over prediction in many catchments across Scotland. A Scotland specific equation for estimating BFI, the BFIScot model, was therefore developed to address this bias problem.

The implementation of ReFH2 in Scotland is presented within the ReFH2 technical guidance document[3]. The parameter equations for the Scottish calibration dataset were developed using BFISCOT as a best estimate of BFI from HOST in Scotland. However, as discussed in the technical document the final ReFH2 parameter estimates are generally not sensitive to the choice of whether BFIHOST or BFISCOT is used.

Although values of BFISCOT can be obtained from the LowFlows software these estimates are not currently available within the exports from the FEH Web Service at the time of writing. This technical note provides a procedure for adjusting BFIHOST to approximate the differences between the two BFI models. Using this adjustment procedure, the user can adjust the BFIHOST values obtained from the FEH Web Service for use within ReFH2 as required.

The adjusted value of BFIHOST is estimated using:

$$BFIHOST_{adjusted} = BFIHOST\left(-0.063\frac{SAAR}{1000} + 1.043\right)^2,$$

Where SAAR is the (1961-1990) Standard Period Average Annual Rainfall estimate provided by the FEH Web Service. The development of this equation is described in detail within Appendix 1.

It is stressed that for the majority of applications in Scotland it is appropriate to use BFIHOST. The adjustment procedure is most appropriate for use in the wet, very flashy catchments in the north and west of the country. This adjustment procedure should not be used in England or Wales.

[1] Boorman, D.B., Hollis, J.M. and Lilly, A. 1994. Hydrology of Soil Types: a Hydrologically-based Classification of the Soils of the United Kingdom. IH Report 126.

[2] www.sepa.org.uk/science_and_research/idoc.ashx?docid=afb95859-0f25-4827-9210-411d2fae48ac&version= -1

[3] https://www.hydrosolutions.co.uk/software/refh-2/supporting_literature/

Appendix 1 The BFISCOT adjustment procedure

The differences between BFIHOST and BFISCOT estimates are summarised on Figure 1. The figure presents both estimates plotted against the BFI estimated directly from gauged records for the 156 Scottish catchments that are used within the LowFlows software for Scotland. The figure illustrates that there is little relationship between gauged BFI and BFIHOST in catchments with a BFI estimate from gauged records of less than 0.3.

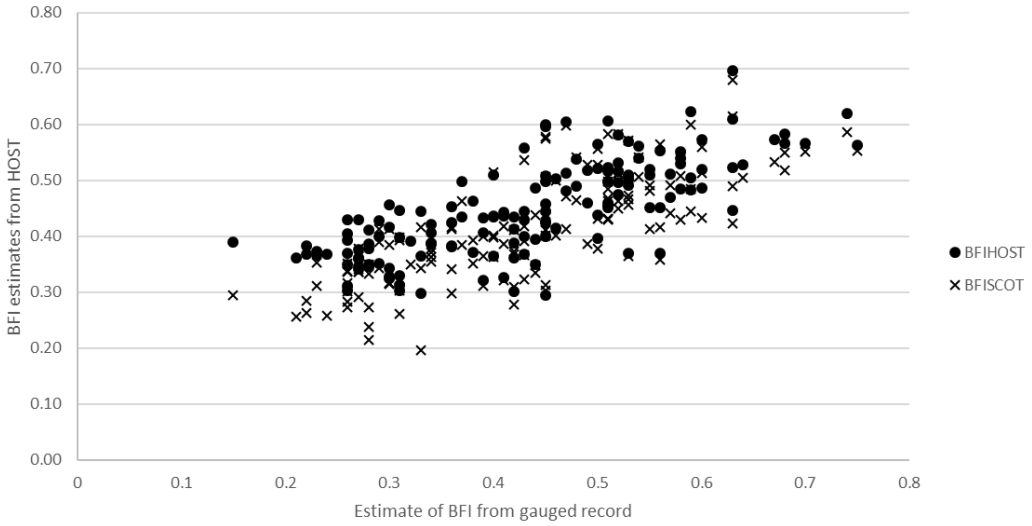

Figure 1 The relationships between HOST based estimates of BFI and the BFI estimated from gauged records for 156 Scottish catchments.

The relationships between the ratio of BFISCOT to BFIHOST and catchment descriptors were explored. The strongest relationships were found with BFIHOST (as would be expected) and SAAR. The relationship with BFIHOST is shown on Figure 2. This is not unique with the ratio taking a full range of values in low BFIHOST catchments converging towards a value of one in higher BFIHOST catchments.

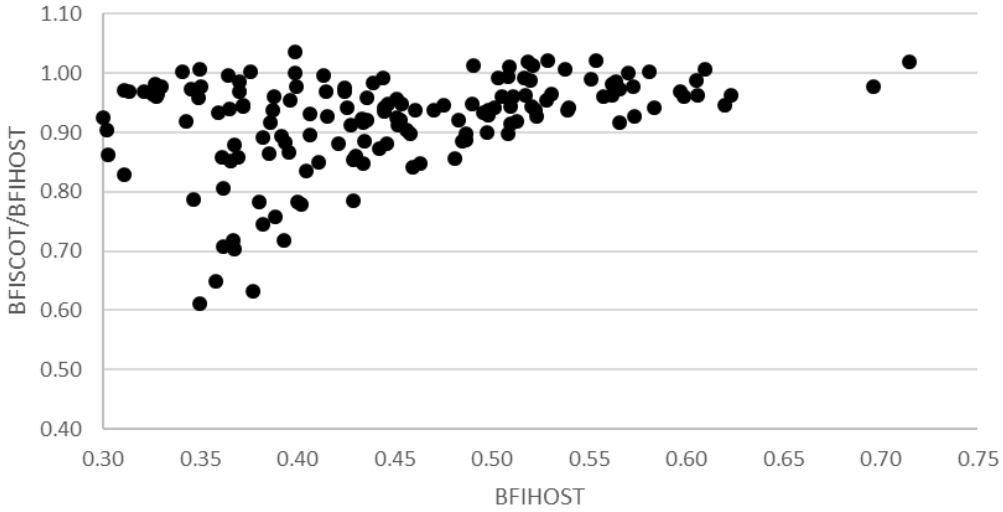

Figure 2 The relationship between the ratio of BFISCOT to BFIHOST and BFIHOST

The relationship with SAAR is presented within Figure 3. Taking the square root of the ratio of BFI estimates yields the linear relationship:

$$\sqrt{\frac{BFISCOT}{BFIHOST}} = -0.063\frac{SAAR}{1000} + 1.043$$

Thus enabling an adjusted value of BFIHOST to be estimated as:

$$BFIHOST_{adjusted} = BFIHOST\left(-0.063\frac{SAAR}{1000} + 1.043\right)^2$$

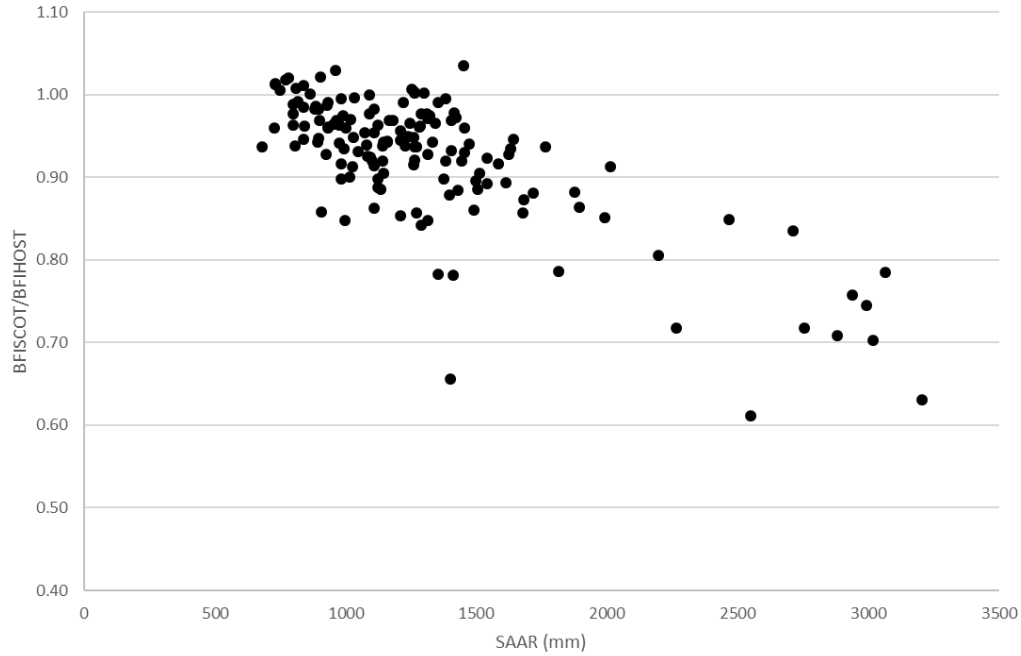

Figure 3 The relationship between the ratio of BFISCOT to BFIHOST and SAAR

A comparison of BFISCOT and BFIHOST adjusted is presented in Figure 4, which demonstrates that the adjustment removes the observed bias in low BFI catchments.

The fit of the three BFIHOST based models is summarised as the estimation bias and factorial standard error of estimate (f.s.e.) on Table 1. This demonstrates that the adjustment procedure corrects the bias within the BFIHOST model and the f.s.e is comparable to that for the BFISCOT model and is indeed (by statistical chance as the fit is to the BFIHOST – BFISCOT residuals) slightly lower than the BFISCOT model. The SAAR dependency is one that is also observed in the variation of normalised low river flows (Q95 expressed as a fraction of mean flow). Rainfall is strongly correlated with topography across Scotland and it is believed that the SAAR descriptor is a rolled-up analogue for both topographic effects and the complex interactions between topography and the influence on hillslope hydrology and weather.

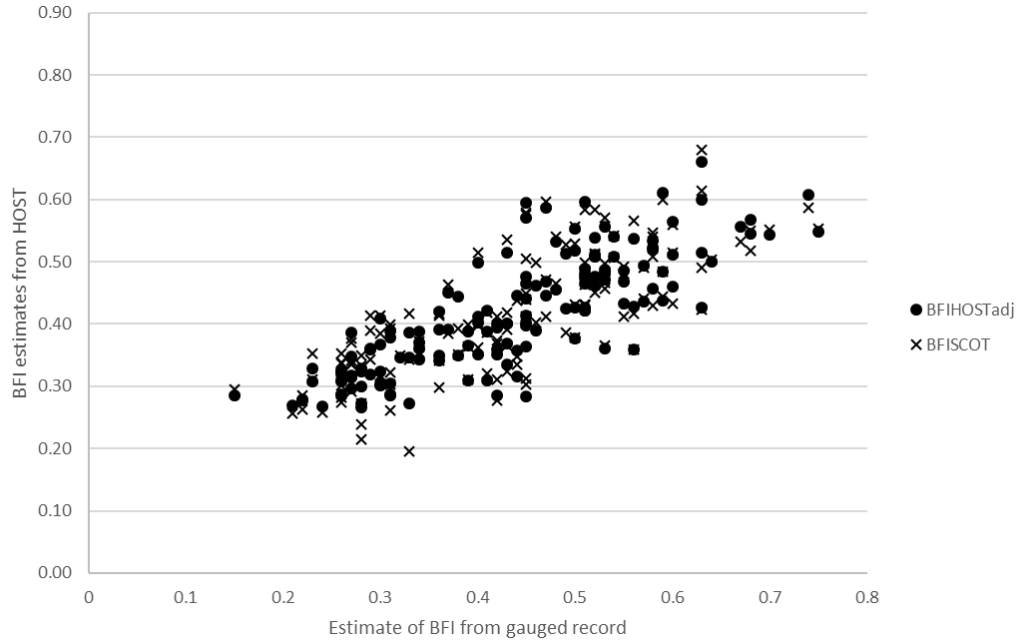

Figure 4 The relationships between the BFISCOT and adjusted BFIHOST and the BFI estimated from gauged records for 156 Scottish catchments.

Table 1 Summary of fit statistics for the three HOST based BFI estimates.

	BFIHOST	BFISCOT	$BFIHOST_{adjusted}$
BIAS	1.07	0.98	0.98
FSE	1.26	1.23	1.20