



Project: Example Report

Date: DD/MM/YYYY

Reference: AA/BB

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Wallingford
OX10 8BB
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For and on behalf of
Wallingford HydroSolutions Ltd.

Client:

Contact:

Prepared by:

Invoiced amount: £ (excl VAT)

The results within this report have been prepared by Wallingford HydroSolutions using the LowFlows software system. All reasonable skill, care and diligence has been taken although the Client is responsible for the interpretation of the results and the attention of the Client is drawn to sections of this report titled "Limitations" and "Warranty and Liability".

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1 Introduction

Consents to discharge, planning approvals, environmental impact statements, abstraction licences applications, reservoir planning and the assessment of hydropower potential are all examples of projects that require information on river flows. However, there is little or no measurement of river flow for the majority of river reaches within the UK.

In lieu of site specific observed data hydrologists are faced with the problem of estimating flows. The LowFlows software system was developed within the Centre for Ecology and Hydrology (CEH) to meet this challenge by integrating within a GIS framework the latest regionalised models for predicting for the estimation of natural and artificially influenced river-flows, as represented by flow duration statistics, within ungauged catchments.

The LowFlows software system is the standard software system used by the Environment Agency and the Scottish Environment Protection Agency for providing estimates of river flows within ungauged catchments. The software and underpinning science have been widely published in the scientific literature.

Wallingford HydroSolutions (WHS) is the sole appointed developer and distributor of the CEH LowFlows software system. The software is available for purchase as two versions; "LowFlows" and "LowFlows Enterprise". This report was developed as part of our cost effective retrievals service for the low volume user, or the user without experience in the estimation of river flows within ungauged catchments.

WHS is an environmental and information technology consultancy established by the Natural Environment Research Council. WHS was founded in 2004 as a specialist technology transfer company at the Centre for Ecology and Hydrology (CEH), the UK's Centre of Excellence for research in the land and freshwater environmental sciences. WHS provides a wide range of hydrological, water quality and aquatic habitat consultancy services with a focus on the assessment of resource availability, the potential impacts of development and the derivation of cost effective, mitigation measures. For further information on WHS please visit our website www.hydrosolutions.co.uk.

2 Project Details

Standard request for annual and seasonal flow statistics. Digital map supplied by the customer. Copies of the correspondence are contained within Annex 1.

3 Derivation of the Flow Estimates

The flow statistic estimates contained in this report have been produced by the LowFlows system (Young et al, 2003) using models and relationships that relate these flow statistics to the climatic and hydrological characteristics of the catchment of interest. The catchment area may be derived using a digital terrain model or an analogue river network based method. The digital method uses a Digital Terrain Model (DTM) to determine the topographic boundaries of the catchment. The analogue method associates grid squares (200m resolution) to the nearest stretch of river and defines the boundary by selecting grid squares which are assigned to river reaches upstream of the ungauged point. The digital method is the default option used in preference to the analogue method but may be misleading or not possible in some areas. The estimation method used to estimate the catchment boundary is identified within the report.

Descriptions of the variables predicted by LowFlows, henceforth referred to as "the results" and references for the methods within LowFlows used to predict the results are summarised below within the following sub-sections. In Section 1.1 the term annual is used to differentiate these flow statistics from the long term mean monthly statistics presented within section 3.2. If the statistics were calculated directly from a gauged flow record the annual statistics would be equivalent to those calculated using all of the daily flow data from all years of record and the monthly statistics for a month equivalent to those calculated from the gauged data for that month from all years.

3.1 Annual Flow Statistics

- Natural Base-Flow Index (BFI): The proportion of a hydrograph occurring as base flow, hence, varying between zero and unity. BFI is indicative of catchment permeability with values approaching unity associated with highly permeable systems. BFI is estimated from a revised form of the HOSTBFI multivariate linear regression equation developed by Boorman *et al.* (1994).
- Natural Mean Flow (MF): The estimation of Mean Flow is based on a grid of long term average annual runoff developed by CEH. This was derived using the outputs from a deterministic water balance model using observed data from over 500 gauged catchments (Holmes *et al.*, 2002a).
- Natural Flow Duration Curve (FDC) statistics for the following exceedence percentiles: 5, 10, 20, 30, 40, 50, 60, 70, 80, 90, 95, 99. The flow duration curve statistics are estimated using a procedure described by Holmes *et al.* (2002b) based on measured flow data from hydrologically similar gauged catchments.

3.2 Monthly Flow Duration Statistics

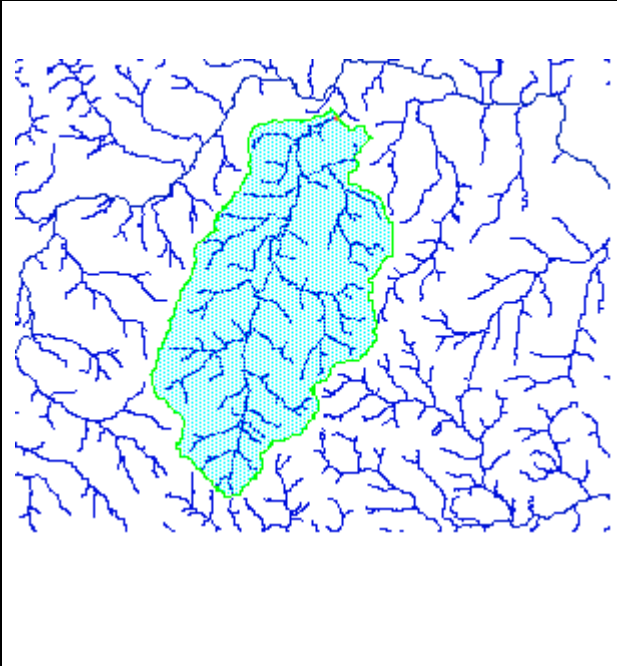
For each Month:

- Natural Mean Monthly Flows (MMF): The MMF for each month are derived from the natural MF estimate by distributing the total average flow volume for the year between the months of this year. This distribution is based upon observed data from hydrological similar gauged catchments (Holmes *et al.*, 2002c).
- Natural Mean Monthly Flow Duration Curves (MFDC): The MFDC for each month is estimated using gauged MFDCs from hydrologically and climatologically similar catchments and the estimate of MMF for that month, see Holmes *et al.* (2002c). The MFDC statistics are presented, by month for the following exceedence percentiles: 5, 10, 20, 30, 40, 50, 60, 70, 80, 90, 95, 99.

4 The Flow Statistics Results

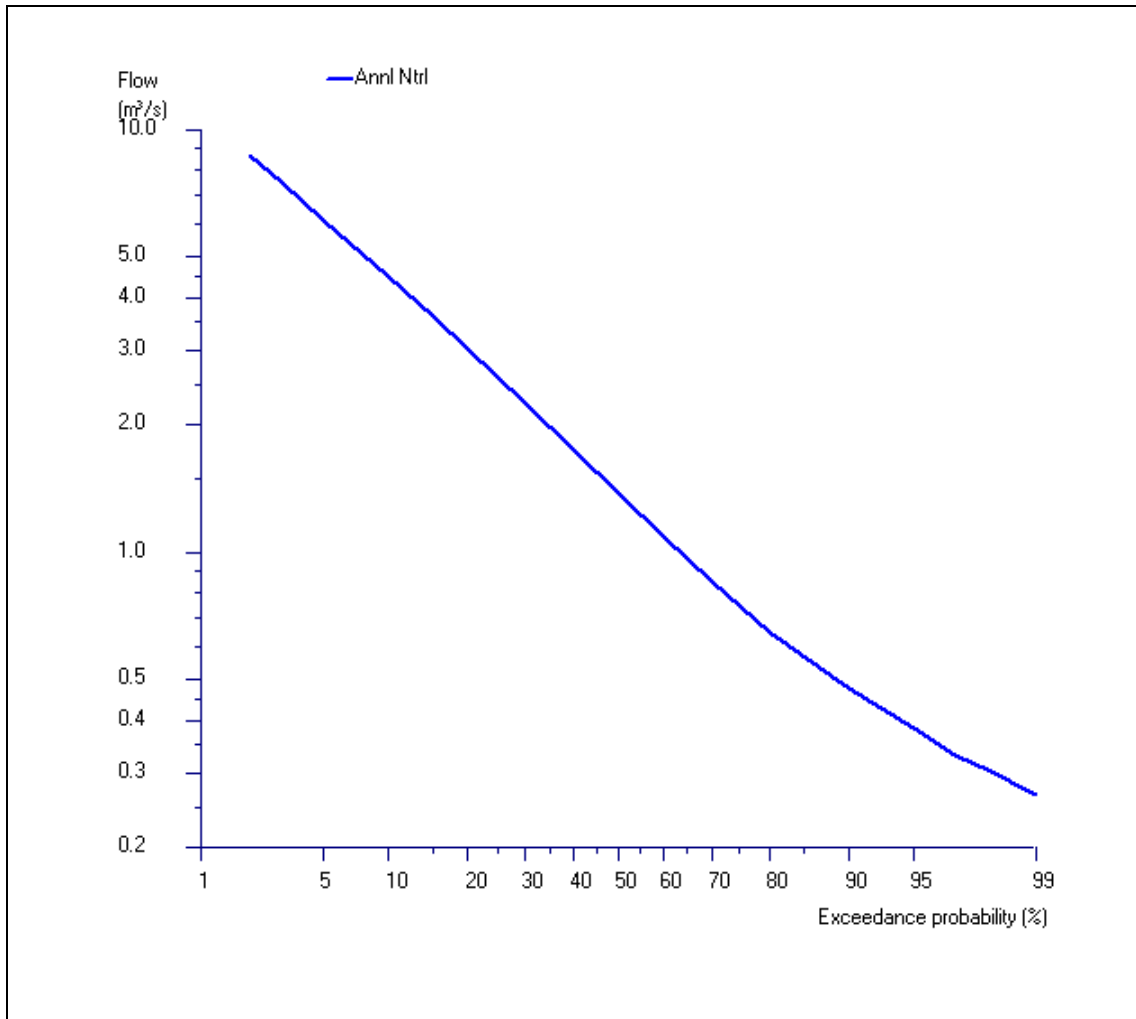
4.1 Annual Flow Statistics

4.1.1 Results – Long term annual natural flow statistics for Outlet at 323045, 638456

Hydrometric Area: HA21 Catchment definition method: Digital			
Basin details			
Basin area:	65.66 km ²		
Base-Flow Index:	0.46		
Annual mean flow:	2.093 m ³ /s		
	P (%)		Q (m ³ /s)
1	5		6.098
2	10		4.506
3	20		3.033
4	30		2.267
5	40		1.754
6	50		1.380
7	60		1.092
8	70	0.852	
9	80	0.649	
10	90	0.477	
11	95	0.382	
12	99	0.266	

Notes: Please note that the majority of this catchment is overlain by mineral soils over impermeable bedrock, with a small proportion of peat soils over a permeable substrate.

4.1.2 Long Term Annual Flow Duration Curve



4.2 Monthly Flow Statistics

Hydrometric Area: HA21			Catchment definition method: Digital					
January			February			March		
Monthly mean flow: 3.535 m³/s			Monthly mean flow: 2.985 m³/s			Monthly mean flow: 2.618 m³/s		
	P (%)	Q (m³/s)		P (%)	Q (m³/s)		P (%)	Q (m³/s)
1	5	9.215	1	5	8.306	1	5	6.971
2	10	7.072	2	10	6.415	2	10	5.232
3	20	5.161	3	20	4.179	3	20	3.747
4	30	4.030	4	30	3.261	4	30	2.943
5	40	3.293	5	40	2.602	5	40	2.430
6	50	2.754	6	50	2.121	6	50	2.031
7	60	2.279	7	60	1.716	7	60	1.670
8	70	1.868	8	70	1.426	8	70	1.378
9	80	1.481	9	80	1.171	9	80	1.144
10	90	1.131	10	90	0.953	10	90	0.882
11	95	0.935	11	95	0.830	11	95	0.761
12	99	0.722	12	99	0.663	12	99	0.619

April	May	June																																																																																																																					
Monthly mean flow: 2.001 m ³ /s	Monthly mean flow: 1.356 m ³ /s	Monthly mean flow: 0.928 m ³ /s																																																																																																																					
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5 Assumptions and Uncertainty

Assumptions implicit in the estimated flow estimates are:

- Only natural flow statistics have been estimated and the impact of any artificial influences (for example abstractions, discharges or impounding reservoirs) is not included.
- The topographic catchment area identified is assumed to accurately reflect the true catchment area contributing to flows at the catchment outlet.
- The flow estimates are based on long term average records.

The predictive uncertainty associated with the estimate of annual Q95 (m^3/s) is $1.32 \text{ l s}^{-1}\text{km}^{-2}$ and the uncertainty in the estimate of annual MF (m^3/s) is 11%. These quoted uncertainties are 68% confidence limits on the estimated natural values.

6 Limitations

The performance of the Mean Flow and FDC Estimation Models may vary according to local conditions. The following is a list of significant, but not comprehensive, issues that need to be considered when estimating flows within ungauged catchments:

- Care needs to be taken when interpreting the results in smaller groundwater catchments in which river flows may be strongly influenced by point geological controls (such as spring lines and swallow holes).
- A catchment water balance is assumed within the LowFlows software; this assumption may be incorrect in smaller groundwater fed catchments where part of the regional groundwater flow bypasses the surface water catchment.
- The estimation of Mean Flow is based on a grid of long term average annual runoff developed by CEH. This was derived using the outputs from a deterministic water balance model using observed data from over 500 gauged catchments. The predictive performance of the model may therefore be reduced in areas of low rainfall gauge density.
- Care needs to be taken when interpreting the result in very small catchments as the size of the catchment approached the spatial resolution

of the underlying catchment characteristic datasets within LowFlows (1km²)

- Where available local measured flow data should be used to corroborate the LowFlows software estimates. This is good practice when using any generalised hydrological model.

7 Warranty and Liability

1. The assumptions and uncertainties associated with the flow estimation methods must be considered when making use of flow estimates produced by the system.
2. You are responsible for the interpretation of the Results presented within this report and training in the use of the estimation methods is strongly recommended.
3. Subject to 1 and 2 above, WHS do not seek to limit or exclude liability for personal injury or death arising from our negligence.
4. Except for 3 above our entire liability for any breach of our duties, whether or not attributable to our negligence, is limited to the fee that you have paid for this report.
5. Except for 3 and 4 above, in no event will WHS be liable to you for any damages, including lost profits, lost savings or other incidental or consequential damages arising on your use of the results even if we have been advised of the possibility of such damages.

8 References

Holmes, M.G.R., Young, A.R., Gustard, A.G. and Grew, R. (2002a). A new approach to estimating Mean Flow in the United Kingdom. *Hydrology and Earth System Sciences*. 6(4) 709-720.

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Young A. R., Grew R. and Holmes M.G.R. (2003). Low Flows 2000: A national water resources assessment and decision support. *Water Science and Technology*, 48 (10).

Annex 1

Copies of key correspondence with the client