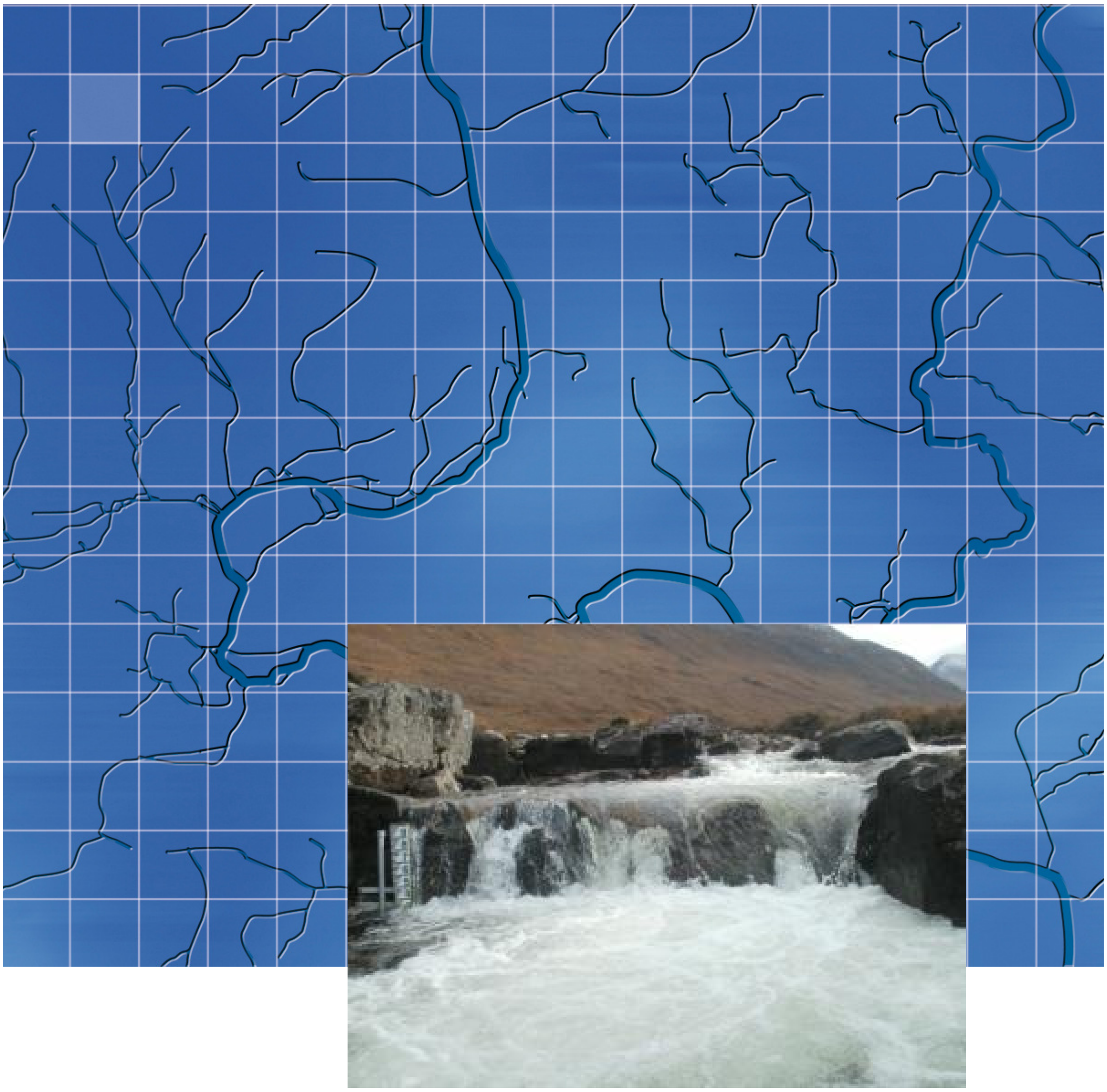
LowFlows Report 01/01

April 2011

Flow estimate for a Site in South Wales



Wallingford HydroSolutions Limited

For and on behalf of Wallingford HydroSolutions Ltd

Client	Click here to enter text.
Prepared by	Click here to enter text.
Approved by	Click here to enter text.
Position	Click here to enter text.
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This report has been produced in accordance with the WHS Quality Management system which is certified as meeting the requirements of ISO 9001:2008.

WHS

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Contents

1 Introduction

This report presents the annual and seasonal flow statistics for the site(s) requested using the LowFlows Enterprise model. The site location(s) have been confirmed using a digital map and copies of the correspondence are contained within Annex 1.

The LowFlows software system is the standard software system used by the Environment Agency, the Scottish Environment Protection Agency and the Northern Ireland Environment Agency for providing estimates of river flows within ungauged catchments. The software and underpinning science have been widely published in the scientific literature. The LowFlows software system is available for purchase as two versions; LowFlows 2 and LowFlows Enterprise. Wallingford HydroSolutions (WHS) is the sole appointed developer and distributor of the LowFlows software system.

Section 2 of the report provides an overview of our consultancy services; specifically our hydrometry services for supplementing the flow statistics presented within this report with at site measurements and flood event estimation services. We also provide a range of software products ranging from the Flood Estimation Handbook (FEH) software through to Hydra 2 to support hydropower design.

Section 3 presents the methods for the derivation of catchment characteristics and the annual and monthly flow estimates. Following the results for each site, Sections 5 and 6 present the assumptions and uncertainties within the flow estimates, followed by the consideration for use in section 7 and the warranty and liability in section 8.

2 WHS Consultancy Services

WHS was founded by the Natural Environment Research Council (NERC) to deliver high quality consultancy services and environmental software systems. WHS has a team of experienced technical staff including leading UK scientists and specialists. We have a proven track record in provision of flood risk, water resources and Environmental (including EIA) consultancy services across the whole of the UK.

WHS has extensive project experience and can offer a service that meets any of your water resources requirements. Water resources and the estimation of river flows is a core WHS capability and we continue to develop methodologies for estimation of flow statistics within ungauged catchments. Our staff have authored all recognised design methods for estimating flow duration curves within the UK since the 1980s.

WHS also has a strong background of working directly with our clients to meet their requirements for field services. Our in-house field team is well equipped to undertake a wide range of field measurement services, ranging from hydrometric, topographic and geomorphological surveys through to aquatic habitat mapping. We provide hydrometric measurements for resource assessment (to include improving the estimation of flood risk) and WHS has substantial experience undertaking both continuous river flow gauging and event driven gauging at remote, rural and urban locations. We are currently operating hydrometric installations at over thirty sites on behalf of our private and public sector clients. Installations can include additional security measures and/or discrete installations to meet the specific requirements of your site. We offer telemetered data transfer and management to ensure data continuity and fast response to vandalism or equipment problems. Our expertise also includes ecology surveys and water quality measurement and analysis.

WHS is committed to continuously improving company performance and customer satisfaction. We are proud of our ISO 9001 certification for the provision of environmental consultancy services, development of hydrological software and associated training. For further information on all of our services and software, please visit our website www.hydrosolutions.co.uk.

3 Derivation of the LowFlows Results

Section 3.1 presents the methods used to define the catchment characteristics, and section 3.2 provides an overview of the long term annual and monthly flow statistics provided for the site(s). The flow statistic estimates contained in this report have been produced by LowFlows Enterprise(1) using models and relationships that relate these flow statistics to the climatic and hydrological characteristics of the catchment of interest. All flow statistics provided in this report are for natural flows, thus do not contain any artificial influences such as abstractions, discharges or impounding reservoirs.

3.1 Catchment Characteristics

The following catchment characteristics are provided in the results section of this report:

- **Catchment Area:** The catchment boundary may be derived using either a digital terrain model or an analogue river network based method. 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 results section for the site(s).
  - The digital method uses a Digital Terrain Model (DTM) to determine the topographic boundaries of the catchment.
  - The analogue method associates grid squares (200 m 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.
- **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 (2).

(1) 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).
(2) 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.

3.2 Long Term Natural Flow Statistics

The following long term flow statistics are provided in the results section of this report.

- **Annual Mean Flow (MF):** The estimation of Mean Flow is based on a grid of long term average annual runoff developed by the Centre for Ecology and Hydrology (CEH). This was derived using the outputs from a deterministic water balance model using observed data from over 500 gauged catchments(3).
- **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 hydrologically similar gauged catchments.
- **Annual Flow Duration Curve (FDC) statistics:** The flow duration curve statistics are estimated using a procedure based on measured flow data from hydrologically similar gauged catchments(4). This methodology was further updated by WHS in 2009. Flows are provided for the following exceedence percentiles: 5, 10, 20, 30, 40, 50, 60, 70, 80, 90, 95, 99.
- **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. The MFDC statistics are presented, by month for the following exceedence percentiles: 5, 10, 20, 30, 40, 50, 60, 70, 80, 90, 95, 99.

If these long term natural flow 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) Holmes, M.G.R., Young, A.R., Gustard, A.G. and Grew, R. 2002. A new approach to estimating Mean Flow in the United Kingdom. Hydrology and Earth System Sciences. 6(4) 709-720.
(4) Holmes, M.G.R., Young, A.R., Gustard, A.G. and Grew, R. 2002. A Region of Influence approach to predicting Flow Duration Curves within ungauged catchments. Hydrology and Earth System Sciences. 6(4) 721-731.

4 LowFlows Results for a Site in South Wales

4.1 Catchment Characteristics

The catchment characteristics and map for this catchment are presented in the table and figure below. Approximately half of this catchment comprises colluvium and hard fissured sandstone substrates overlain with mineral soils. The remaining catchment is composed of mineral soils underlain with impermeable hard coherent rock and slowly permeable substrates.

Table 4.1 Catchment Characteristics

Basin Details	
Outlet grid reference	xxxxxx, xxxxxx
Hydrometric area	61 (South East and South West)
Catchment definition method	Digital
Basin area (km²)	13.560
Base-Flow Index	0.65

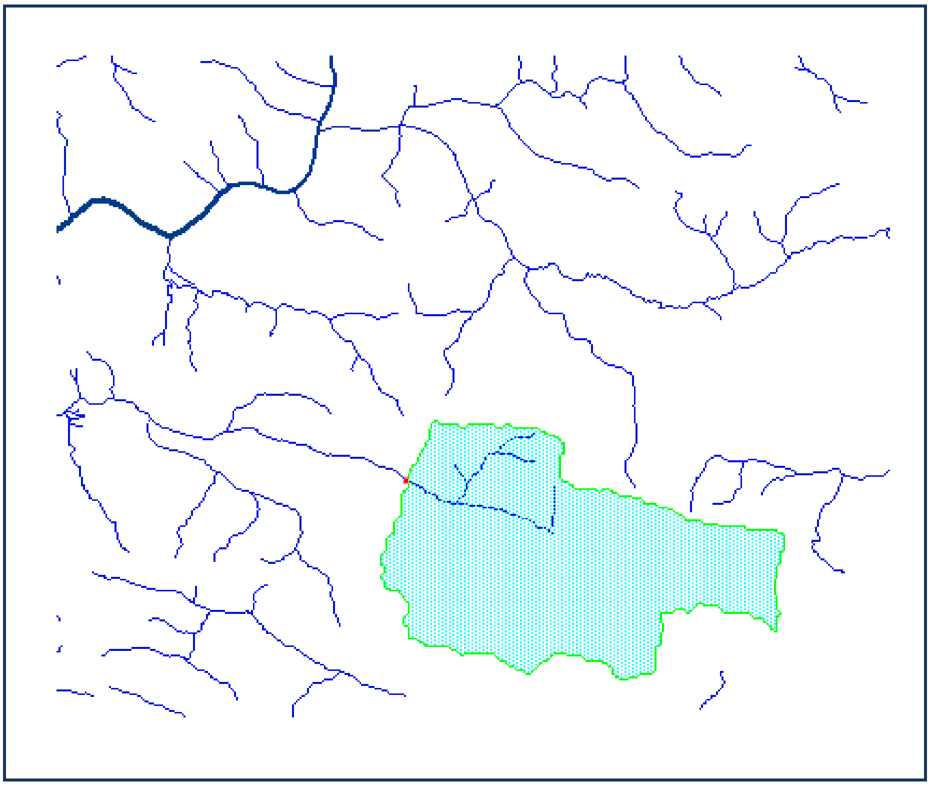

Figure 4.1 Catchment Boundary

4.2 Long Term Natural Flow Statistics

This section presents the long term natural flow statistics. The table below presents both the monthly mean flows and the annual flow duration statistics. The annual flow duration curve is also presented in the figure below, followed by a table displaying the monthly flow duration statistics.

Table 4.2 Mean Flows and Annual Flow Duration Curve Statistics

Mean Flows	Flow (m^3/s)
Annual	**0.229**
January	0.447
February	0.379
March	0.311
April	0.230
May	0.157
June	0.104
July	0.067
August	0.063
September	0.085
October	0.203
November	0.304
December	0.407

Percentile	Flow (m^3/s)
5	0.736
10	0.507
20	0.323
30	0.238
40	0.180
50	0.139
60	0.106
70	0.078
80	0.057
90	0.040
95	0.032
98	0.025
99	0.022

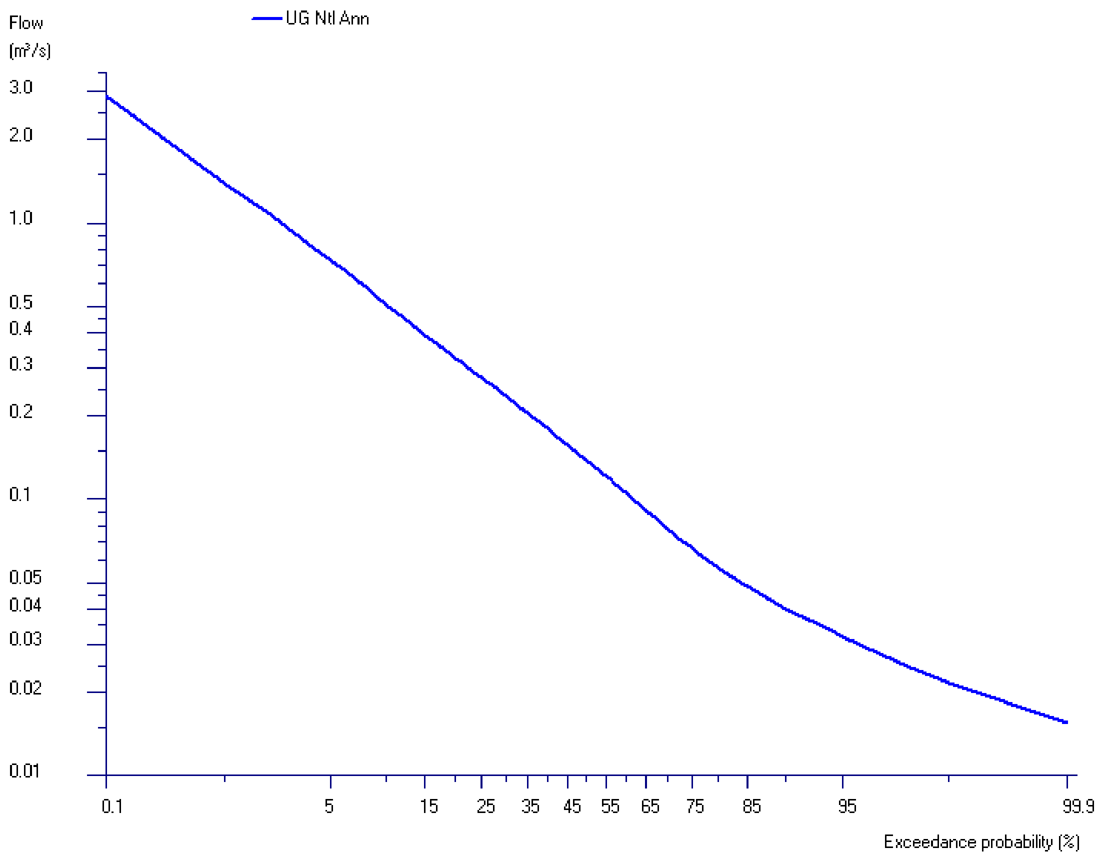

Figure 4.2 Annual Flow Duration Curve

Table 4.3 Monthly Flow Duration Curve Statistics

January		February		March		April	
Percentile	Q (m^3/s)	Percentile	Q (m^3/s)	Percentile	Q (m^3/s)	Percentile	Q (m^3/s)
5	1.005	5	0.942	5	0.770	5	0.583
10	0.804	10	0.698	10	0.559	10	0.428
20	0.601	20	0.500	20	0.391	20	0.288
30	0.469	30	0.384	30	0.310	30	0.225
40	0.387	40	0.312	40	0.265	40	0.190
50	0.325	50	0.264	50	0.231	50	0.164
60	0.279	60	0.226	60	0.199	60	0.143
70	0.233	70	0.191	70	0.169	70	0.124
80	0.192	80	0.163	80	0.142	80	0.106
90	0.148	90	0.134	90	0.117	90	0.086
95	0.123	95	0.113	95	0.098	95	0.071
99	0.072	99	0.086	99	0.069	99	0.053

May		June		July		August	
Percentile	Q (m^3/s)	Percentile	Q (m^3/s)	Percentile	Q (m^3/s)	Percentile	Q (m^3/s)
5	0.364	5	0.247	5	0.141	5	0.170
10	0.277	10	0.182	10	0.104	10	0.115
20	0.201	20	0.133	20	0.081	20	0.079
30	0.158	30	0.110	30	0.070	30	0.064
40	0.136	40	0.095	40	0.062	40	0.054
50	0.119	50	0.084	50	0.055	50	0.046
60	0.107	60	0.073	60	0.050	60	0.041
70	0.095	70	0.064	70	0.045	70	0.036
80	0.082	80	0.056	80	0.040	80	0.032
90	0.069	90	0.047	90	0.034	90	0.025
95	0.057	95	0.040	95	0.028	95	0.021
99	0.041	99	0.028	99	0.022	99	0.017

September		October		November		December	
Percentile	Q (m^3/s)	Percentile	Q (m^3/s)	Percentile	Q (m^3/s)	Percentile	Q (m^3/s)
5	0.259	5	0.679	5	0.783	5	1.066
10	0.167	10	0.451	10	0.597	10	0.790
20	0.103	20	0.271	20	0.412	20	0.524
30	0.077	30	0.186	30	0.321	30	0.410
40	0.062	40	0.134	40	0.258	40	0.334
50	0.052	50	0.101	50	0.207	50	0.280
60	0.043	60	0.075	60	0.171	60	0.235
70	0.038	70	0.056	70	0.137	70	0.196
80	0.032	80	0.045	80	0.103	80	0.158
90	0.026	90	0.036	90	0.067	90	0.120
95	0.023	95	0.031	95	0.049	95	0.093
99	0.019	99	0.027	99	0.036	99	0.059

5 Assumptions

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.

6 Model Uncertainty

The figures for factorial standard error of estimate for long term mean flow and Q95 are shown in Table 6.1. So, as an example the uncertainty in the estimate of mean flow in Scotland will generally be less than 11%. These standard errors are presented as a general guide only and should be considered in the context of the information presented within section 7. These errors are broadly comparable to the sampling errors that might be expected if mean flow was calculated from two to three years of error free gauged data and Q95 for in the order of five years error free gauged data.

Table 6.1 Model Factorial Standard Error (FSE)

Regions of the UK	FSE Mean Flow	FSE Q95
England and Wales	16	42
Scotland	11	35
Northern Ireland	11	30

7 Consideration for Use

The predictive 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 (1 km²).
- 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.

8 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.
6. Should any of these provisions be ruled invalid under any law or Act of Parliament, they shall be deemed modified or omitted only to the extent necessary to render them valid and the remainder of these provisions shall be upheld.

Annex 1: Copies of key correspondence with the client