Qube Report

Example Qube Flow Estimate

For and on behalf of Wallingford HydroSolutions Ltd.

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Prepared by	Click here to enter text.
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Registered Office Stables 4, Howbery Business Park, Wallingford, OX10 8BA
www.hydrosolutions.co.uk

Contents

1 Introduction

This report presents the annual and monthly flow statistics for the site(s) requested using the WHS Qube water resource modelling system. The site location(s) have been confirmed using a digital map and copies of the correspondence are contained within Annex 1.

Qube is the online evolution of the LowFlows Enterprise water resource modelling system to move beyond the estimation of natural and influenced flow statistics. Qube enables the seamless modelling of both flow statistics and time series anywhere in the UK and Ireland.

Developed by WHS in partnership with the Environment Agency, Qube is used as a best practice tool for the estimation of flows in ungauged catchments by the Environment Agency, Natural Resources Wales, Scottish Environment Protection Agency, Northern Ireland Environment Agency, Environmental Protection Agency and the UK water industry.

The Qube underpinning science has been widely published in the scientific literature.

Section 2 presents the methods for the derivation of catchment characteristics and the annual and monthly flow estimates. Following the results for each site, Sections 4 and 5 present the assumptions and uncertainties within the flow estimates, followed by the consideration for use in section 6 and the warranty and liability in section 7.

WHS is committed to continuously improving company performance and customer satisfaction. We are proud of our ISO9001 quality certification and ISO14001 environmental management 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.

2 Derivation of the Qube Flows Results

The flow statistic estimates contained in this report have been produced by Qube using models and relationships that relate these flow statistics to the climatic and hydrological characteristics of the catchment of interest. Qube is the evolution of LowFlows Enterprise[1]. 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.

The following catchment characteristics and flow statistics are provided:

- Catchment Area: The catchment boundary may be derived using either a Digital Terrain Model (DTM) to determine the topographic boundaries of the catchment or imported by the user.
- Annual Mean Flow (MF): The estimation of Mean Flow is based on a 1km grid of long term average annual runoff for the given period of record (POR). The POR runoff grids were modelled using the CERF rainfall runoff model and calibrated to the UK Centre for Ecology and Hydrology 1961-1990 runoff grid (an output of a deterministic water balance model using observed data from over 500 gauged catchments[2]).
- 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. The methodology was initially developed in 2002[3] and has been subsequently further refined. Where nested local data gauges (LDG) are available, the FDC is improved using naturalised gauged FDCs for the given period of record.
- 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. Where LDG have been used, the MFDC's are adjusted using the LDG improved annual FDC.
- 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 BFIHOST multivariate linear regression equation[4].

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.

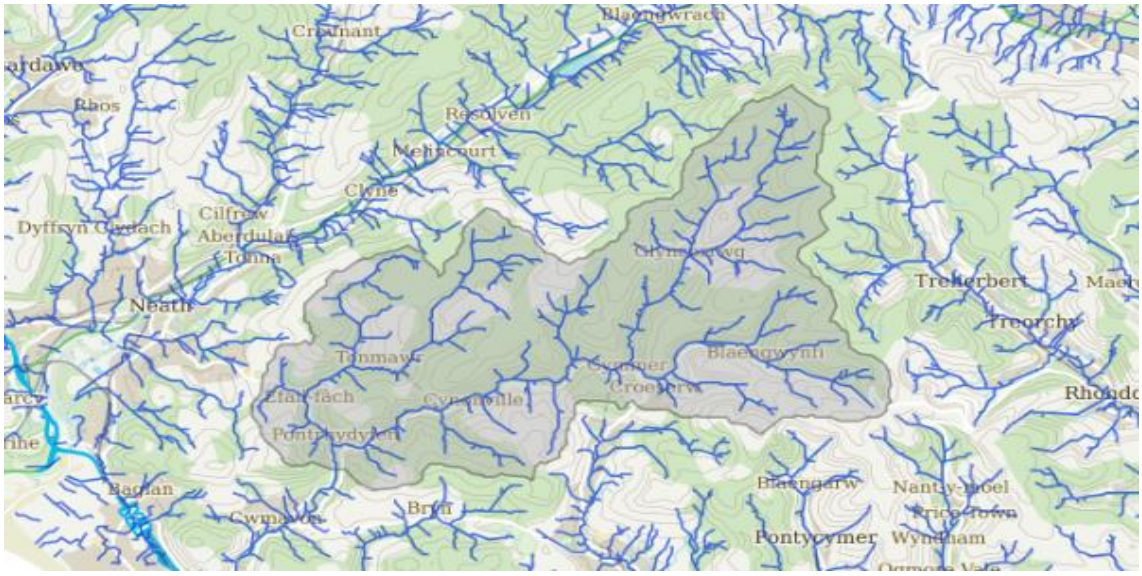
[1] Young A. R., Grew R. and Holmes M.G.R. 2003. Low Flows 2000: A national water resources assessment and decision support. Water Science and Technology, 48 (10).
[2] Holmes, M.G.R., Young, A.R., Gustard, A.G. and Grew, R. 2002. A new approach to estimating Mean Flow in the United Kingdom. Hydrology and Earth System Sciences. 6(4) 709-720.
[3] 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] 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 Flow Results

3.1 Catchment Characteristics

The catchment characteristics and map for this catchment are presented in the table and figure below.

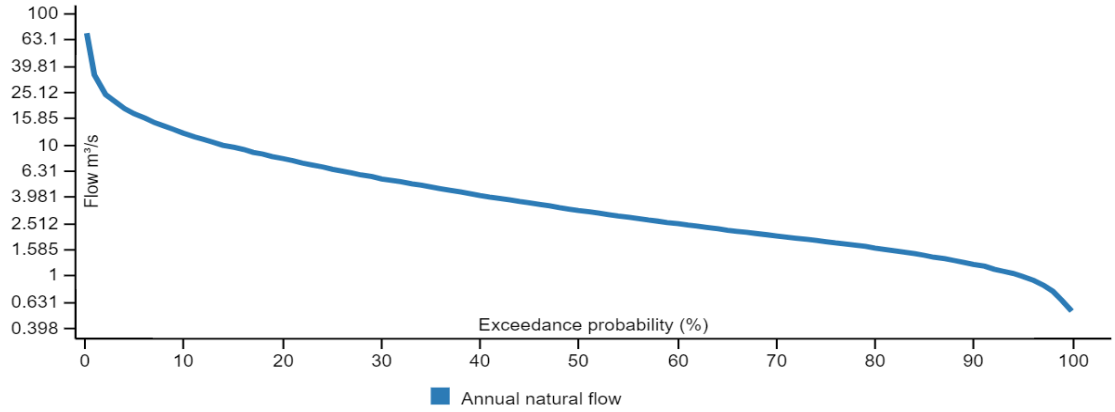
Catchment name	Catchment at XXXXXX,YYYYYY	Catchment area	80.73 km²
Location	XXXXXX,YYYYYY	Hydrometric area	58



Catchment Boundary Map (Contains Ordnance Survey data © Crown copyright and database right 2023)

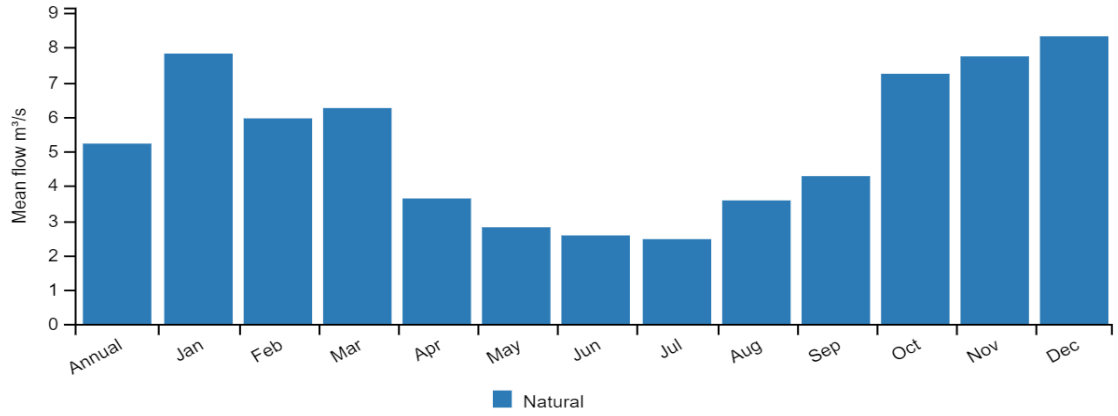
3.2 Long Term Flow Statistics

Period of record	Full period of record	Runoff (Period of record)	1789.8 mm
BFIHOST	0.434		



Annual Flow Duration Curve

Example Qube Flow Estimate



Annual and Monthly Mean Flow

Annual Flow Duration Curve Statistics (m³/s)

Percentile	Natural Flow
5	17.08
10	12.15
20	7.76
30	5.429
40	4.053
50	3.118
60	2.473
70	1.992
80	1.612
90	1.209
95	0.979
99	0.638

Annual and Monthly Mean Flows (m³/s)

	Natural Flow
Annual	5.202
January	7.801
February	5.931
March	6.228
April	3.618
May	2.787
June	2.551
July	2.445
August	3.562
September	4.263
October	7.218
November	7.721
December	8.300

Region of Influence Stations

Reference number	Weight (%)	Q95 % MF
58012	43.4	16.68
65007	15.7	8.335
54022	14.1	15.13
58005	13.5	13.94
21017	13.3	10.49

Local Data Gauges - On

Gauge	Location	Area km²	MF m³/s	Q95 m³/s
Afan at Cwmafan	downstream	81.63	5.238	0.986

Natural Monthly Flow Duration Curve Statistics (m³/s)

Percentile	January	February	March	April	May	June
5	20.12	16.81	17.66	11.04	8.421	7.774
10	16.07	12.55	12.75	7.87	5.994	5.287
20	11.13	8.567	8.441	4.928	3.802	3.529
30	8.857	6.249	6.379	3.746	2.895	2.642
40	7.062	4.866	5.199	3.092	2.345	2.137
50	5.727	3.763	4.128	2.601	1.986	1.835
60	4.663	3.007	3.29	2.246	1.745	1.604
70	3.737	2.472	2.691	1.965	1.510	1.379
80	2.973	2.088	2.228	1.677	1.291	1.170
90	2.171	1.769	1.823	1.383	1.077	0.943
95	1.804	1.595	1.585	1.202	0.975	0.837
99	1.315	1.271	1.329	0.994	0.768	0.710

Percentile	July	August	September	October	November	December
5	8.017	12.82	14.43	20.77	20.33	21.8
10	5.368	8.631	9.972	15.67	16.27	17.28
20	3.299	4.887	6.076	10.53	11.22	11.77
30	2.412	3.52	4.214	7.64	8.713	8.967
40	1.924	2.648	3.233	5.795	6.843	7.158
50	1.661	2.061	2.578	4.541	5.484	5.839
60	1.439	1.682	2.077	3.635	4.469	4.640
70	1.247	1.35	1.718	2.818	3.427	3.629
80	1.08	1.073	1.415	2.188	2.637	2.845
90	0.903	0.76	1.083	1.601	1.962	2.206
95	0.752	0.648	0.897	1.301	1.64	1.901
99	0.592	0.582	0.609	0.874	1.215	1.527

4 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.

5 Model Uncertainty

The figures for factorial standard error of estimate for long term mean flow and Q95 are shown in Table 3.2.1. 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 6. 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.

If these estimates are to be used for high value decision making we would recommend that the estimates are corroborated through appropriate local flow measurement. For advice on flow measurement please contact us at info@hydrosolutions.co.uk.

Table 3.2.1 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

6 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, which 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 1km grid of long term average annual runoff, derived using the CERF rainfall runoff model and calibrated 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

(1 km²). For very small catchments it is recommended that the topographic contributing catchment is confirmed by a site walkover to identify any unmapped features that might modify the catchment area.

- Where available local measured flow data should be used to corroborate the flow estimates, which 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.
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