PARAMETERS OF LOW FLOW AND DATA ON LOW FLOWS IN SELECTED IRISH RIVERS

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SUMMARY

Low flow conditions in Ireland are usually expressed in terms of (1) the dry weather flow and (2) the 95 percentile flow. This paper presents definitions of these terms and lists the available data at a large number of hydrometric stations in the country. These data can be downloaded in Excel format from the EPA web site (www.epa.ie).

1.0 COLLECTION OF HYDROMETRIC DATA

Hydrometric data for low flow conditions has only been collected systematically since about the early 1970's. Prior to that, any hydrometric data collected related to particular projects. In May 1922, Professor Purcell (University College Dublin) erected a recorder on the River Liffey at Burgage Bridge for the Royal Dublin Society. Dublin Corporation erected staff gauges at Pollaphouca and at New Bridge (near Celbridge) on the same river also in the 1920's.

In the 1930's, the Electricity Supply Board (ESB) erected recorders on rivers with a view to studying these rivers for the purposes of power generation. From the late 1940's, subsequent to the passage of the Arterial Drainage Act 1945, the Office of Public Works erected recorders at strategic locations on rivers and lakes in order to provide data for arterial drainage and flood relief design. Valuable information was collected on the 1949 (in the south-east), 1955 and 1959 droughts.

Information on flows in rivers and streams, and in particular on low flows, became a greater priority in the early 1970's based on the need to quantify our water resources, to protect them and to meet the data requirements of ongoing developmental needs. Since then, a great deal of hydrometric information has been assembled, particularly in the drought years 1975, 1976, 1984 (particularly in the west), 1989, 1990, 1991 and 1995. In particular, the low flows measured towards the end of the 1976 drought have become a standard for the comparison of the severity of droughts in Ireland.

Under the Local Government (Water Pollution) Act 1977, the needs of Local Authorities for data in relation to effluent licences gave rise to the need for more hydrometric data. Local Authorities, assisted by AFF, erected hydrometric stations in relation to conservation, environmental protection and water resources development.

With the passage of the Environmental Protection Agency Act 1992, the Agency must prepare a National Hydrometric Programme for the collection, analysis and publication of information on the levels, volumes and flows in rivers, lakes and groundwaters in the State.

With the advent of the Framework Directive on Water, the need for accurate and reliable hydrometric information, for both water quantity and water quantity purposes, has expanded.

1.2 SCOPE OF THIS PAPER

This paper details the hydrometric stations at which estimates of the dry weather flow and 95 percentile flow are available on the EPA web site. This list of stations will be expanded in the future.

1.3 GAUGING STATION NETWORK

The current hydrometric network comprises stations operated by the OPW, the ESB, Local Authorities and other bodies. Copies of the Register of Hydrometric Gauging Stations in Ireland are available from the EPA in digital (Excel) format.

1.4 HYDROGRAPH OF FLOW OF RIVERS IN IRELAND

The pattern of river flow in Ireland reflects the rainfall pattern and, in general, there is a prompt response to rainfall although the rate of response varies from catchment to catchment. Some catchments have a very quick response to rainfall and are regarded as flashy catchments, with little or negligible storage. In other catchments, the rate of increase in runoff resulting from rainfall may not be as severe as water goes into storage and then contributes to river flow from storage.

The normal pattern of flow in rivers in Ireland is that the groundwater recession commences in the Spring and continues at a steady rate until the Autumn. Rainfall in the late Spring/Summer does not alter the trend of the recession once it is established, although such rainfall may lead to an increase in river flows.

Recovery of groundwater flow to normal winter levels depends on the rainfall pattern after the end of the low flow period.

The total river flow hydrograph may be important in circumstances where the total river flow in a summer period has implications for water resource management.

1.5 RIVER FLOW

River flow can be divided into two main components:

a) surface runoff from rainfall and

b) baseflow recession from groundwater storage.

Surface runoff results from rainfall, resulting in an increase in river flow with rainfall and a reduction when rainfall ceases. When river flows are falling after a flood, the falling limb of the hydrograph is called the recession. The baseflow recession is that part of the river flow which comes from groundwater storage. In general there is a gradual decrease in groundwater discharge from late Spring and this decrease can be approximated by an exponential curve. When the recession is plotted on an arithmetic scale, it is shown as a master recession curve which is made up from a series of minor curves. On a semi-logarithmic scale, this recession curve is a straight line

1.6 LOW RIVER FLOWS

During a period of drought, as flows decrease, the proportion of river flow arising from surface runoff becomes negligible. In the absence of rainfall, the magnitude of the baseflow component also continues to decrease with time, but at a diminishing rate.

Minimum river flows occur when a prolonged dry period coincides with a time of year when groundwater levels are at their lowest.

In the smaller catchments or in the upland areas of larger catchments, very low river flows can occur irrespective of the duration of a dry period. On the other hand, in large catchments, short periods with little or no rainfall will reduce the surface runoff component of river flow but may have only a negligible effect on baseflow, depending on the time of year when the shortage of rainfall occurs.

The main determinants of the low flow at a particular location on natural streams (without lakes and unaffected by impoundments or abstractions) are:

- the catchment area contributing to the flow at the location (the greater the catchment area, the higher the flow per unit area);

- lack of rainfall;

- the variability in the geology and surface cover which can vary both within catchments as well as from catchment to catchment.

1.7 SEVERITY OF DROUGHTS

The severity of a drought is reflected in river flows and its effect on these flows can depend on a number of factors:

- the distribution, duration and time of year when the lack of rainfall occurs;

- the size, topography, surface cover and geology of catchments;

- antecedent groundwater (baseflow) conditions;

- any lag in the response time to rainfall events;

- soil moisture deficit.

One method of assessing the severity of a drought is by comparing it with a known drought which is recognised as an extreme event. The drought which occurred in 1976 was such an event and followed another extreme drought year of 1975.

1.8 CLASSIFICATION OF DROUGHT CONDITIONS

Droughts can be classified using rainfall and river flow conditions.

1.8.1 Meteorological Classification of Droughts

The following definitions of a drought have been used by the World Meteorological Organisation (WMO) are (1) a prolonged absence or poor distribution of precipitation and (2) a period of abnormally dry weather sufficiently prolonged for the lack of precipitation to cause a serious hydrological imbalance.

The terms used by Met Éireann to describe periods of little or no rain are absolute droughts, partial droughts and dry spell which are defined as follows:

- An absolute drought is a period of 15 or more consecutive days, on none of which 0.2 mm or more of rain fell;

- A partial drought is a period of at least 29 consecutive days, the mean daily rainfall of which does not exceed 0.2 mm i.e. 5.8 mm in 29 days and

- A dry spell is a period of 15 or more consecutive days, on none of which 1.0 mm or more of rain fell.

In practical terms, the Met Éireann definition is more useful and quantifiable for the conditions pertaining in Ireland than the WMO definition and is used in Ireland.

A difficulty which arises for hydrologists when using the meteorological classifications of a drought is that these definitions do not have regard to river flows or the effect of evapotranspiration.

From a meteorological perspective the order of dry spell/partial drought/absolute drought may be in the order of increasing severity. However, from a river flow point of view, the reverse order may be more significant. Small amounts of rainfall in a drought period may be lost in evapotranspiration, or used to decrease the soil moisture deficit, and have little effect on the flow regime in natural streams.

1.8.2 Classification of River Flows under Drought Conditions

There is no standard classification of droughts in regard to river flows. In the preparation of Water Quality Management Plans, use has been made of (1) the dry weather flow and (2) the 95 percentile flow. The 7-day sustained low flow with a 15 year return period has also been used to assess low river flows.

1.9 DRY WEATHER FLOW

In the preparation of Water Quality Management Plans, use has been made of the Dry Weather Flow (DWF) which has been defined as the annual minimum daily mean flow rate with a return period of 50 years. Using this definition, it will be seen that the DWF is a statistical measure of low flow and usually requires reliable long term low flow data or sufficient information that would allow us to estimate the DWF.

Investigations of low flow data indicate that in large areas of the country, the return period of the 1976 drought had a return period of about 50 years.

Specific runoff i.e. dry weather flow per unit area can be stated for a particular location but there is no basis for a generalised rule of thumb for estimating dry weather flow.

1.10 95 PERCENTILE FLOW

Where pollution control is concerned, interest is more often centred on low flows of a more common occurrence. The practice in relation to the effects of an effluent discharge is that computation is based on detailed hydrometric data, the critical flow being that which is equalled or exceeded at least 95% of the time (or, on average, on all but 18 days per annum).

The 95 percentile flow is a statistical measure of flowrate and ideally should be based on the processing of water level records for a considerable period of time. This measure of flow may be sensitive to the length of record. Ideally, the selection of years used to produce the flow duration curve should include the extreme drought years 1975 and 1976.

In certain parts of the country, the low flow in the droughts in 1989, 1990, 1991 and 1995 approximated to the long term 95 percentile flowrate.

1.11 PRESENTATION OF DATA ON DRY WEATHER FLOW & 95 PERCENTILE FLOW

The data on dry weather flow and 95 percentile flow are available from the EPA web site. The stations are listed in station number order. The data is presented: station number, registered station name, the river on which it is located, a three letter code indicating the body responsible for the maintenance of the station, the Irish grid reference, the easting and northing of the location of the station, a code indicating whether the station is active or inactive, the catchment area to the station (in km^2), date of start of records, the estimated dry weather flow (in m^3/s) and the estimated 95 percentile flow (in m^3/s) and a comment (if provided). A sample of this data is presented in appendix 1.

1.12 VARIATION OF DRY WEATHER FLOW AND AREA

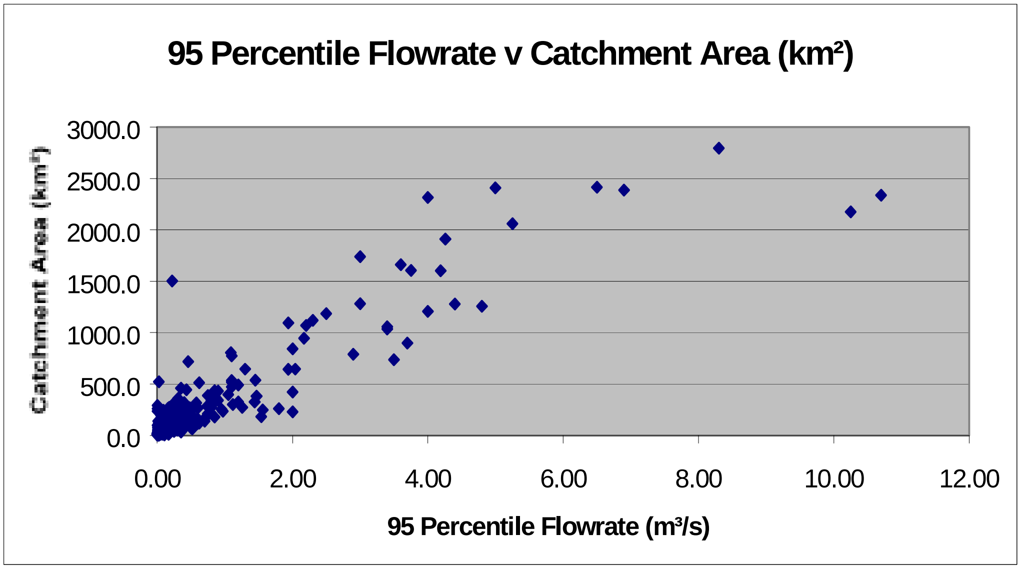

Figure 1 is a plot of dry weather flow versus area for the complete data set

From this, it can be seen that there is no fixed correlation between dry weather flow and catchment area. Features of the low flow in the rivers in Ireland are:

- the wide variations in the ratio of dry weather flow to average flow
- the dry weather flows vary from region to region and within regions and
- in absolute terms the flowrates are quite small.

1.13 VARIATION OF 95 PERCENTILE FLOW AND AREA

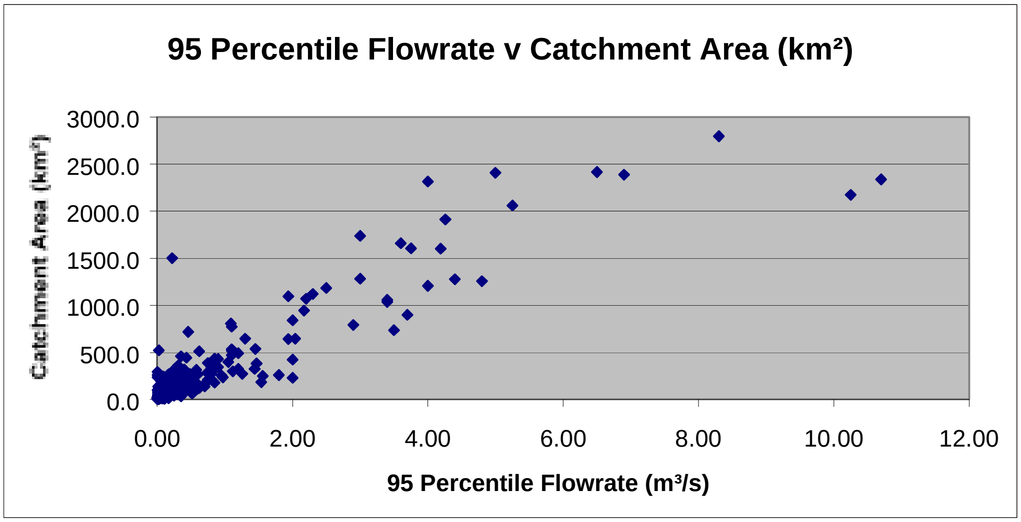

Figure 2 is a plot of 95 Percentile Flowrates versus area for the complete data set

Again it can be seen that there is no fixed correlation between 95 percentile flow and catchment area.

1.14 SUMMARY AND CONCLUSIONS

1. Data on the dry weather flow and 95 percentile flow are available through the EPA web site. Data on additional hydrometric stations and revisions to this dataset will be provided from time to time.

2. The minimum flow rates measured in the 1976 drought are among the lowest flows on record and can be used as a benchmark drought against which other droughts can be compared. However, the hydrographs of flow over the summer period need to be available to get an overall picture of the severity of the drought.

3. In many areas of the country, extreme low flows were measured at the end of the drought in 1995 which were comparable to the low flows measured at the end of the drought in 1976. However, in the south-east and parts of the north east, flows at the end of the 1995 drought approximated to the 95 percentile flowrate.

4. The information available to date on low river flows in these years indicates that, in general, river flows are not getting lower in Ireland.

5. The low flow in all the drought years examined appears to be independent of the previous year's low flows and were due to the lack of rainfall in each of these drought years.

6. The groundwater recession commences in most rivers in Ireland early in Spring and once its trend is established, the slope of the recession appears to be unaffected by rainfall in late Spring/Summer.

7 In general, a substantial period of insignificant rainfall ending in September will result in low river flows. Low river flows will occur in catchments with limited groundwater resources after a period of insignificant rainfall, irrespective of the time of year at which it occurs.

1.15 ACKNOWLEDGEMENTS

The collection of hydrometric data is essentially a field activity. The reliability of hydrometric data reflects the channel conditions found in our rivers and depends on the field work carried out at each hydrometric station by technical hydrometric staff. The author would like to acknowledge the work and contribution of his colleagues in the EPA and local authorities, in the ESB, and OPW in this important work.

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